WEST

Technical Documentation

MDR-339-P-IO

Two-channel pressure control module with integrated power amplifiers, commissioning assistant and IO-Link interface

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CONTENTS

1 General Information

1.1 Product Name

MDR-339-P-IO Two-channel pressure control module with integrated power amplifiers, Commissioning assistant and IO-Link interface

Alternative products

MDR-337-P - pressure control module with integrated power output stage up to 2,6 A and analog interface with comissioning assistant

MDR-133-P - pressure control module with integrated power stage and higher signal resolution for test benches and applications with a signal resolution < 0.01 %.

1.2 Scope of supply

The scope of supply includes the module plus the terminal blocks which are part of the housing.
The Profibus plug, interface cables and further parts which may be required should be ordered separately.
This documentation can be downloaded as a PDF file from www.w-e-st.de.

1.3 Accessories

WPC-300 - Start-Up-Tool (downloadable from our homepage – products/software)

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

1.4 Symbols used

General information

Safety-related information

1.5 Legal notice

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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 assembly is intended for pressure control in hydraulic systems, but can also be used for a variety of other applications where the combination of a PID controller, pilot control and unidirectional output stage is required.

The unit comprises two completely independent channels.

Two power output stages for proportional pressure valves are integrated. Various setting parameters enable optimal adaptation to the respective valve. The control loop operates with a control cycle time of 1 ms and the integrated power output stage with a cycle time of 0.125 ms for solenoid current control.

The setpoints are specified via IO-Link, and the actual values as well as status and diagnostic information is available via this connection.

The controlled variables are read in via 0...10 V signals (or 4...20 mA with cable break monitoring). The output current is closed-loop controlled and therefore independent of the supply voltage and the solenoid resistance. The output stage is monitored for cable breaks and overcurrent (short circuit) and switches off in the event of a failure.

The operation is simple and problem-oriented, which ensures a very short training period.

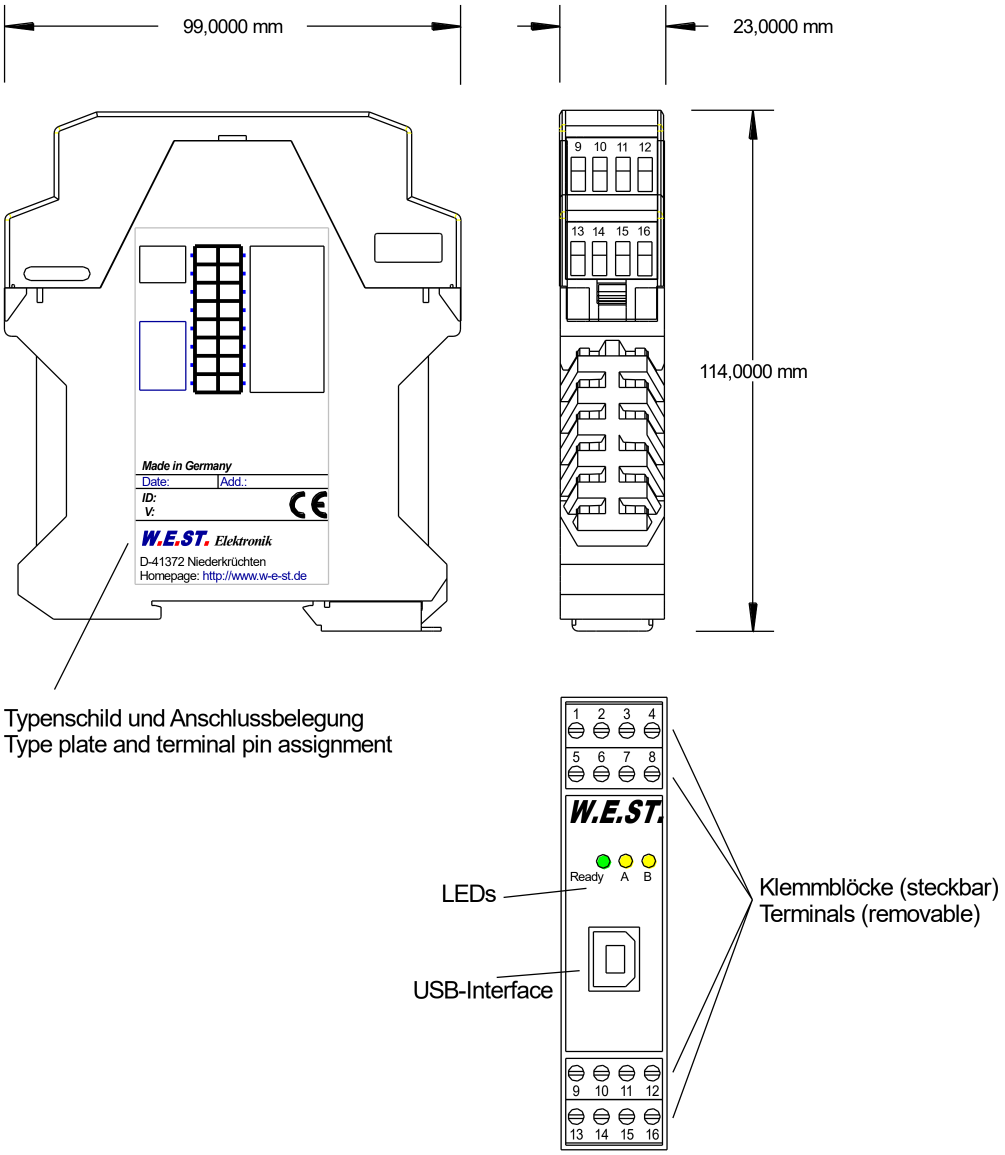
Typical applications: General pressure control with pressure valves (direct or via a variable displacement pump) and speed control with analogue speed sensors.

The device is intended for control via IO-Link and has a port compatible with the Class A.

Features

- **Activation of pressure reducing valve and pressure control valve**
- **IO-Link port class A, with internal galvanic isolation of the additional supply voltage for the output stage and control function.**
- **Meets specification V1.1, data rate COM3 = 230.4 kBaud**
- **Compact housing**
- **Digital reproducible adjustments**
- **Universal PID controller**
- **Commissioning assistant for determining an optimum feedforward control characteristic and for dynamic controller setting**
- **Free parameterization of ramps, MIN and MAX, DITHER (frequency, amplitude) and PWM frequency**
- **Current ranges (parameterisable via software) up to 2.6 A**
- **Application orientated parameter settings**
- **Fault diagnosis and extended function checking**
- **Simplified parameterization with WPC-300 software or via IO-Link**

2.1 Device description



2.2 *Use and application*

2.2.1 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 analog inputs and outputs are fitted with filters and surge absorbers in the device.

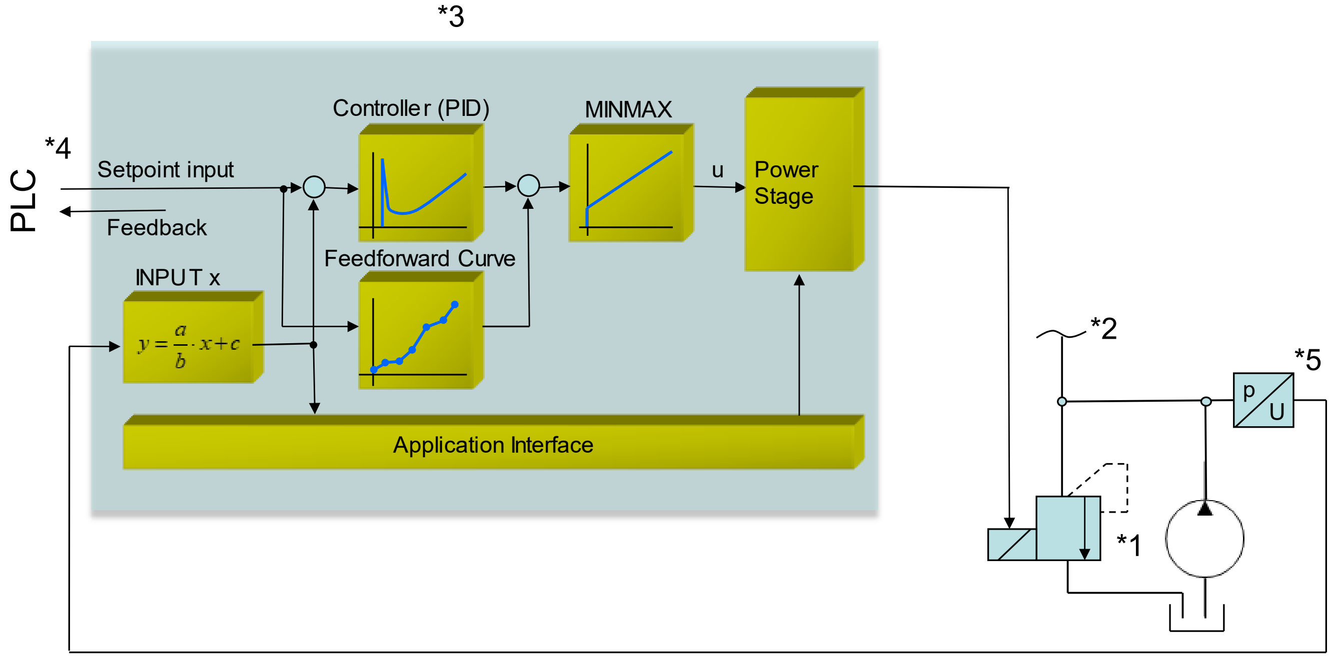
- The module should be installed and wired in accordance with the documentation bearing in mind EMC principles. If other consumers are operated with the same power supply, a star-shaped ground wiring scheme is recommended. The following points must be observed when wiring:
  - The signal cables must be laid separately from power cables.
  - Analog 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 IEC 60364-4-41 / VDE 0100-410, 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 <u>always</u> be provided with appropriate overvoltage protection directly at the coil.

2.2.2 **Typical system structure**

The unit has two independent channels. The common feature is the IO link interface. The following explanation refers to each of the two channels. It is also possible to use only one of the two channels.
The minimal system consists of the following components:

(*1) Pressure relieve valve (alternative: pressure controlled servo pump or pressure control valve)
(*2) Pressure line to the consumers
(*3) One channel of the MDR-339-P-IO pressure control module with integrated power amplifier
(*4) IO-Link interface to the PLC
(*5) Pressure sensor (0… 10 V or 4… 20 mA)



2.3 Method of operation

This module is useful for pressure control in very different applications. The output signal (up to 2.6 A) controls various pressure valves (pressure relieve valves and pressure control valves). No OBE electronics is necessary.
Because of the very high stability of the pressure control structure, this module is recommended where open loop applications are not sufficient concerning the accuracy.
Pressure controls with constant pumps or remote controllable servo pumps and for force and torque controls with cylinders and motor drives are typical applications.
The pressure control is realized by a PID controller optimized for this application.
ENABLE: This digital input signal initializes the application. Error messages are deleted. The power stage gets active and the **READY** signal indicates that all components are working correctly. Now the controller can be driven by the command value as simple power amplifier. The PID controller is activated by the **START** input. The feedback input will be evaluated and the output will be adapted according to the control deviation and the parameterization.

3 Commissioning

Commissioning of a closed-loop electronic pressure control system is relatively simple, as basic control of the internal pressure control loop is already provided by the pressure control valve or pressure relief valve.

However, it is usually advantageous to improve the linearity of the valve by adapting the control signal upstream via a linearisation curve.

Deficiencies of the hydraulic-mechanical pressure control loop in the valve or in the pump are compensated by the module's superimposed electronic controller, the setting of which is relatively uncritical.

3.1 Hydraulic system

Three general control structures have to be taken in consideration.

1. Pressure control with a pressure relieve valve
2. Pressure control with a servo pump controlled by a pressure relieve valve
3. Pressure control with a pressure control / reducing valve

In all cases the same control structure can be used. Only the pressure control with the pump can result (in critical cases) in a slightly instable behavior. The internal damping (pump design) and the hysteresis of the valve require an accurate PWM/Dither setup[1].

3.2 Preferences

The preferences include in particular the compilation of the electrical data of the sensor signals and of the proportional valve. The most important points are summarized in the following checklist.

Table 1 (Necessary for the basic parameterization)

Point	Info
Valve data "**n**" here stands for channel 1 or 2 respectively	Solenoid current (**CURRENT_1/_2**), the **DITHER_1/_2 / PWM_1/_2** adjustment and - if available - the degree of overlapping (dead zone). **MAX_1/_2** parameter to adapt the valve pressure range and the working pressure range.
Sensor data	Nominal pressure of the sensors (**N_RANGE_1/_2**) and the signal type (**SIGNAL_1/_2:X**)
System data	Working pressure range (**SYS_RANGE_1/_2**) and thereby the upper limit for the setpoint.

3.3 Start-up procedure

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 module 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

[1] The reason of instabilities is often an insufficient compensation of the hysteresis. The correct setup of the PWM frequency or the Dither amplitude and frequency have to be checked first.

Step	Task
	device. If it is higher than specified, there is an error in the wiring. Switch the device immediately off and check the wiring.
Setting up communication	Once the power input is correct, the PC (notebook) should be connected to the serial interface. Please have a look at the WPC-300 program documentation for how to set up communication. Further commissioning and diagnosis are supported by this software.
Pre-parameterization	Now set the following parameters (based on the system design and the circuit diagrams): The SYSTEM PRESSURE and the analog INPUTS. This is done according to the system specification and the sensor data. The OUTPUT CURRENT and the valve typical parameters like DITHER or alternatively the PWM - frequency (depending on the specification). This pre-parameterization is necessary to minimize the risk of uncontrolled movement. The parameters MIN, MAX and TRIGGER do not necessarily have to be used and can be left at their default values. If the valve has a greater overlap or the maximum current is to be reduced to a value < CURRENT, this can optionally be set in advance using these parameters. If this is not done, the algorithm will determine the linearization curve so that the effect is comparable to this manual input. The parameter "SYS_RANGE" is used to scale the analog setpoint and at the same time to limit the maximum pressure setting during the runtime of the commissioning assistant. Set a value here below the opening pressure of the fixed pressure relief valve.
Switching on the hydraulics	The hydraulics can now be switched on. The module is not yet generating a signal. The pressure should be on a low level (depending on the hydraulic minimum pressure)
Activating ENABLE	**CAUTION!** The output stages are activated when ENABLE is activated via the hardware signal and additionally via IO - Link. The system behaves like a normal power amplifier. Proportionally to the input signal, the solenoid current and thus the pressure should change.
Start the commissioning assistant and let it run.	This can be done in one or two steps, see next chapter. **CAUTION:** The module runs through a measuring program in which the system pressure changes automatically. More detailed information is given in the following section.

3.4 Remote Control

For starting-up independent of the PLC (machine control unit), a REMOTE CONTROL mode is implemented. In this mode (**Enable Remote Control (1)**), switching inputs and analog inputs can be simulated by the WPC commissioning software.

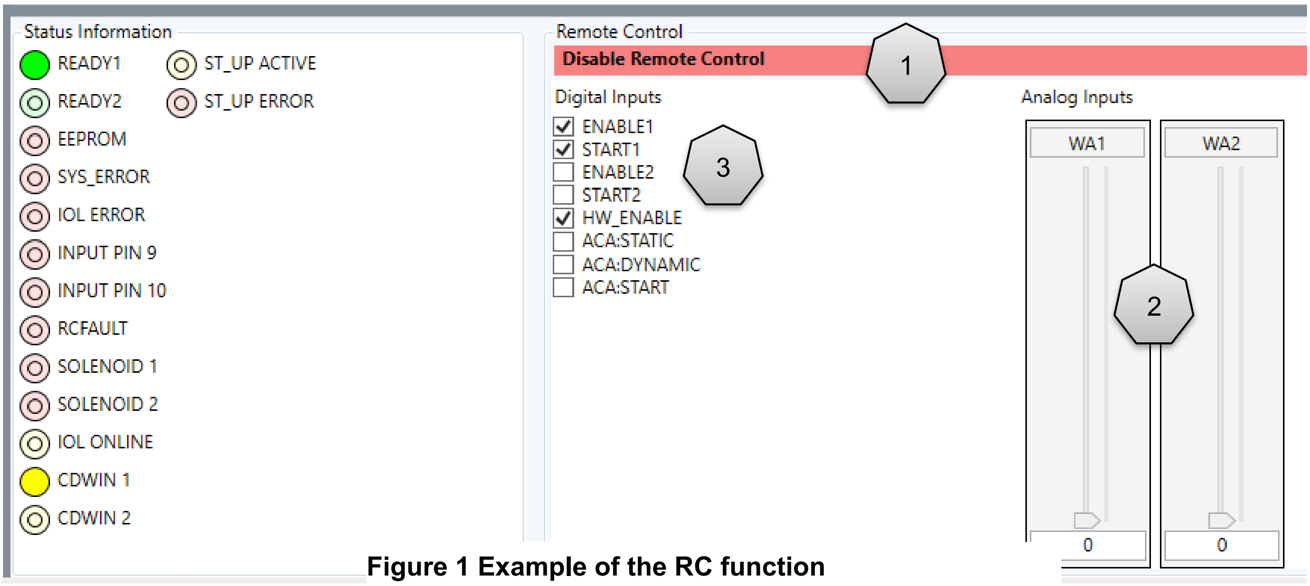


Figure 1 Example of the RC function

Analog inputs are:

WA1/2 (2) the command values, 0… 10000 is corresponding to 0… 100 % of the full range.

Control bits **(3)** are:

ENABLE1/2

Enable of the controller and activation of the output. The module is working like a simple power amplifier, as long as the “START” input is not set.

HW_ENABLE

This simulates the input at PIN6.

In addition to the ENABLE1/2, this signal is required for the release.

START1/2:

The belonging PID controller is active

ACA:STATIC / ACA:DYNAMIC / ACA:START

Control of the commissioning assistant, see next chapter.

The axis can be simply controlled via these input signals. The behavior is monitored by the different process values.

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.

3.5 Comissioning assistant

The device has an assistance function for automated commissioning. The use of this function is optional. As a user, you can decide whether this function should automatically determine a pilot curve and the PID settings. It is still possible to parameterise the unit manually. The use of the assistant requires a WPC connection. The parameters determined can later be uploaded to the master via IO-Link.

3.5.1 Operating principle

The assistance system determines an optimum feedforward curve in order to linearize the control of the valve or pump and compensate for any overlap (zero offset).

The function consists of two parts, namely the determination of the steady-state system curve and a dynamic measurement for controller adjustment.

These two sub-functions can be started separately, because the steady-state measurement gives the best results when the hydraulic system has only a minimum capacity. For this purpose, if possible, accumulators should be disconnected and existing valves to the consumer system should be closed.

The dynamic optimisation can then take place under conditions that are as normal as possible, so that the situation in standard operation can be identified.

For steady-state identification (ACA:STATIC), the valve control is ramped up and then reduced again to detect the hysteresis and take it into account when determining the linearisation curve.

In the dynamic measuring sequence (ACA:DYNAMIC) the control is changed abruptly to test the time response of the controlled system.

Of course, consumers will usually not be active during these setting procedures. However, all parts of the pressure line should be connected. If accumulators are used, the lower pressure value for the optimization program must be higher than their charging pressure. For this reason, the lower step value can be influenced via parameter PL:DYN. See below.

The control algorithm is parameterized based on the now known system properties.

A status LED in the monitor of the WPC program shows the activity of the assistant program. If an error occurs, this is also displayed in the monitor via an error LED.

3.5.2 Operation

Step	Activity
PREPARATION	If it is possible to hydraulically "reduce" the system for stationary measurement (see above) this should be done. The stationary and dynamic measurement will then be started one after the other.
SELECT CONTROL LOOP	In the SYSTEM group you will find the parameter ACA:LOOP. Here you select the control loop that you want the wizard to set.
Enable Remote Control	Activate the remote control mode in the monitor of the WPC program. All external control signals are ignored and the WPC program takes over the operation of the controller.
ENABLE Set hardware activation	Activate the hardware enable at PIN 6 to release the function. This permits an emergency stop independent of the software.
Determine the scope of the first measuring cycle	For separate measurement, now check "ACA:STATIC" in the "Digital Inputs / Outputs" field of the monitor window. If the two measurements are to follow directly one after the other, the "ACA:DYNAMIC" item can be activated additionally.

ACA:START Activate assistance function	Now start the commissioning assistant also in the monitor of the WPC by activating the entry "ACA:START". The condition is that the Enable is not set there, i.e. the valve is not actively controlled. As soon as the assistant starts its work, this is signalled by the LED "ST_UP ACTIVE". If errors occur that prevent the assistant from working properly, this is indicated by a red error LED in the monitor window of the WPC. This display is reset after 30 seconds or after a successful restart of the assistant. If there are problems e.g. the assistant does not start, check whether the HW-Enable signal is actually present. If necessary the SR-command in the terminal window can give further hints. When the activity is completed, the yellow LED „ST_UP ACTIVE“ will turn off.
SR Request Status Report	Enter this command in the terminal window of the WPC program. Warnings may have been generated despite successful execution.
If necessary, prepare and start the second step (dynamic identification).	If separate measurements should be made, the hydraulic system can now be prepared for the second part. Afterwards only hook ACA:DYNAMIC and start the measurement by ACA:START. The yellow LED "ST_UP ACTIVE" indicates that the program is running. Afterwards, a status report can be requested in the terminal again, which may provide further information.
Control of the parameters Transition to normal operation	In the parameter list of the WPC the set values can be examined. Of particular interest is the linearization curve, which can be called up under "CCSET_1/_2". The values should be saved using the "Save" button. Then remove the Hardware-Enable temporarily, deactivate Remote Control -> The device is set for normal use. Alternatively: Test the controller function in RC mode beforehand by setting Enable and Start as well as setpoint setting via the slider (WA1/2). Please observe the safety notes.
Adjust second control loop	Switch to the other control loop via ACA:LOOP and, if necessary, repeat the previous steps to set it.

3.5.3 **Parameters**

The following parameters are changed by the assistant:

Parameter	Beschreibung	Änderung:
`C_1/_2:P`	P Gain	Is set according to the T - summation method.
`C_1/_2:I`	I part, integration time	Is set according to the T - summation method.
`C_1/_2:D`	D part, derivative time	Is deactivated (value „0“, pure PI-Controller)
`C_1/_2:I_LIM`	Integrator limitation	Is set depending on the valve hysteresis
`C_1/_2:I_ACT`	Integrator activation threshold	Is set to "0" -> integrator always active
`CCMODE_1/_2`	Characteristics linearization	Is switched on if previously inactive.
`CCSET_1/_2`	Operational Curve	Is optimally adjusted based on the measured valve characteristics.

3.5.4 R (Status Report)

By entering this command in the terminal window of the operating program, the status report of the commissioning assistant is requested. In case of an error, its cause is displayed. Warnings are possible despite successful execution of the measurements; these are output in plain text. Furthermore, it is also indicated whether the assistant has not yet been used or whether it was interrupted manually.

Possible output is:

Message:	Meaning, possible measures:
Aborted by user	The measurement has been terminated because the user has withdrawn either the hardware enable signal, the remote control mode or the activation of the wizard during the measurement. Remedy: Restart the assistant and let it run through completely.
No activation of the function since restart or loop change	Since the last time the module was switched on, the assistant has not been started or the parameter ACA:LOOP has been changed or written to. The latter happens, for example, when a parameter set is loaded via WPC or IO-Link.
Finished sucessfully	Next: Check parameter entries and test control function.
Finished sucessfully. No controller tuning was performed (as selected).	Next: Prepare and perform dynamic measurement.
Finished sucessfully the static measurement, no controller tuning possible.	This message indicates that the dynamic measurement could not make any adjustment to the controller. The following causes are possible: • The system reacted much too slowly. A time constant > 5s was detected. An automatic parameterization is not advisable. • The specified jump width does not allow dynamic optimization. It must apply: PLDYN < 0.6 * SYS_RANGE. If necessary, reduce PLDYN. • Disturbances in the hydraulics during the measuring process.
Finished, warning: high hysteresis!	The settings have been made, but it is recommended to check the valve data again with regard to PWM frequency or dither. Assembly errors can also become noticeable by this. With very slow systems, a "dynamic" hysteresis can occur, i.e. the lag error is interpreted as hysteresis. This usually has no great influence on the quality of the feedforward curve, because the mean value of both measurements is used there. Thus the lag errors cancel each other out. If the function of the system is satisfactory, this warning has no further significance.
Call of the dynamic optimisation is only possible, if the static measurement has been done before!	Before processing the dynamic optimization, the assistant checks whether the stationary measurement has been performed. This must have happened since the last time the unit was switched on or the loop was changed (cf. above: " no call of the function...").
Aborted: wrong polarity	The program has detected that the pressure has dropped when the valve is activated. If the valve has a falling characteristic, this must be entered using the command "SIGNAL:U". Then restart the assistant.
Aborted: pressure increase low (< 0.25 x SYS_RANGE)	Even at maximum current, the pressure increase is too low in relation to the parameterized maximum value. This can have various causes: • The parameter "SYS_RANGE_1/_2" is set too high. Here, it is

	not the measuring range of the sensor that must be specified, but the upper limit of the range that is to be controlled. • Hydraulic problem: No pressure build-up because, for example, a neutral circulation is open or the pump is not running. In this case, various causes are possible. • Electrical problem, fault in the wiring of the valve or pressure sensor. • The nominal current of the valve was specified incorrectly (too low), parameter "CURRENT_1/_2". • Incorrect parameterization of the sensor input (SIGNAL_1/_2:X, N_RANGE_1/_2:X).
Aborted: full pressure with u < 50.00	The program has determined that the full pressure is already present at low valve actuation. If there is no other problem (see previous point), the problem can be solved by reducing the "CURRENT_1/_2" parameter. This is necessary if a valve with a relatively high maximum pressure is used, but less than half of this pressure is to be used.
Aborted: fluctuating pressure	The measured value of the pressure fluctuates so strongly that no meaningful evaluation is possible. This can be an electrical or a hydraulic problem. The following must be checked: • Wiring of the sensor, cable routing, shielded cables used? • Installation of the sensor in the system, pressure pulsations? • Check correct de-airing of all system components.

In addition to this text information, two measured values from the dynamic measurement are displayed (if this was carried out).

The first value is "Hyst. = measured hysteresis, i.e. how large the maximum pressure difference was during the characteristic curve measurement between the rising and falling actuation. The value is displayed in [0.01%], based on SYS_RANGE. This value can be compared with data sheet information, for example.

The second value "T - Sum" indicates the so-called sum time constant.

This value in [ms] gives a hint for evaluating the system dynamics. In general, automatic adjustment of the controller parameters only takes place with time constants < 5s.

3.5.5 **Options for post-optimization by the user**

If in an individual case the dynamic behaviour has to be further improved based on the automatically determined parameters, the following measures can be taken:

1.) The dynamics of the compensation of disturbance influences is not sufficient
- ➔ Increase the proportional gain (C_1/_2:P)
- ➔ Reduce the reset time (C_1/_2:I)
- ➔ Carefully activate the D - component (C_1/_2:D and C_1/_2:D_T1)

2.) The reaction to setpoint changes is too slow
- ➔ Check and, if necessary, change the setpoint ramp (RA_1/_2:UP, RA_1/_2:DOWN)
- ➔ Increase the proportional gain (C_1/_2:P)
- ➔ Reduce the reset time (C_1/_2:I)

3.) Pressure overshoot
- ➔ Increase the integrator activation threshold (C_1/_2:I_ACT)
- ➔ Reduce the integrator limitation (C_1/_2:I_LIM)
- ➔ Increase the reset time (C_1/_2:I)
- ➔ Increase the setpoint ramp (RA_1/_2:UP, RA_1/_2:DOWN)

4.) Remaining control deviation
- ➔ Increase the integrator limitation (C_1/_2:I_LIM)

As can be seen, the parameter changes sometimes also have an effect on several properties and must be determined as a compromise with regard to the application. For example, lengthening the setpoint ramp leads to less overshoot with setpoint changes, but also limits the dynamics.

The controller's setting parameters, namely proportional gain, integral time, and derivative time, must be changed carefully, especially with regard to the stability of the control loop. The adjustment should be tested at various operating points, because hydraulic pressure control circuits generally exhibit non-linear behaviour and a change in dynamics between different operating states.

Important note:

All measures on the pressure controller module have their physical limits, which are given by the design of the hydraulic system and by the selection of the valve or pump.

By using this module, these limits cannot be exceeded, but the best of the existing possibilities can be achieved!

4 Technical description

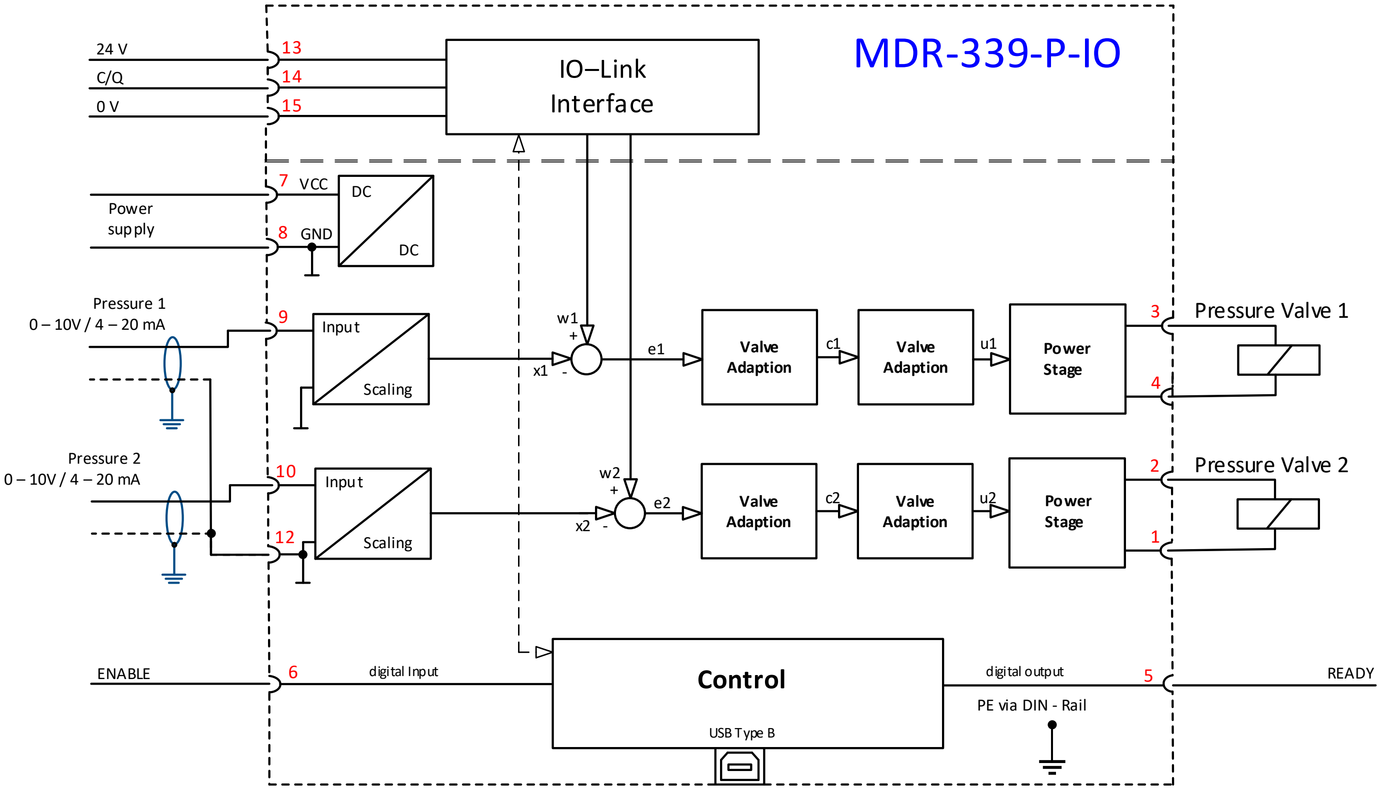
4.1 Input and output signals

IO - Link	**Port class „A“, isolated**
PIN 13	Power supply 24 V
PIN 14	Communication line (C/Q)
PIN 15	0 V (GND)
Connector	**Supply**
PIN 7	Power supply (see technical data)
PIN 8	0 V (GND)
Connector	**Analog Signals**
PIN 9	Actual pressure value (X1), signal range 0...10 V or 4...20 mA., scalable
PIN 10	Actual pressure value (X2), signal range 0...10 V or 4...20 mA., scalable
PIN 12	0 V (GND) for the signal inputs
PIN 2 / 1	PWM output for driving the solenoid valve 2
PIN 3 / 4	PWM output for driving the solenoid valve 1
Connector	**Digital IO**
PIN 6	**ENABLE Input:** General enabling of the device, additionally "AND"-linked to enable via IO-Link.
PIN 5	**READY Output:** **ON:** At least one channel is enabled, there is no recognisable error. **OFF:** Enable is deactivated or an error (solenoid error, current input error or internal error) has been detected.

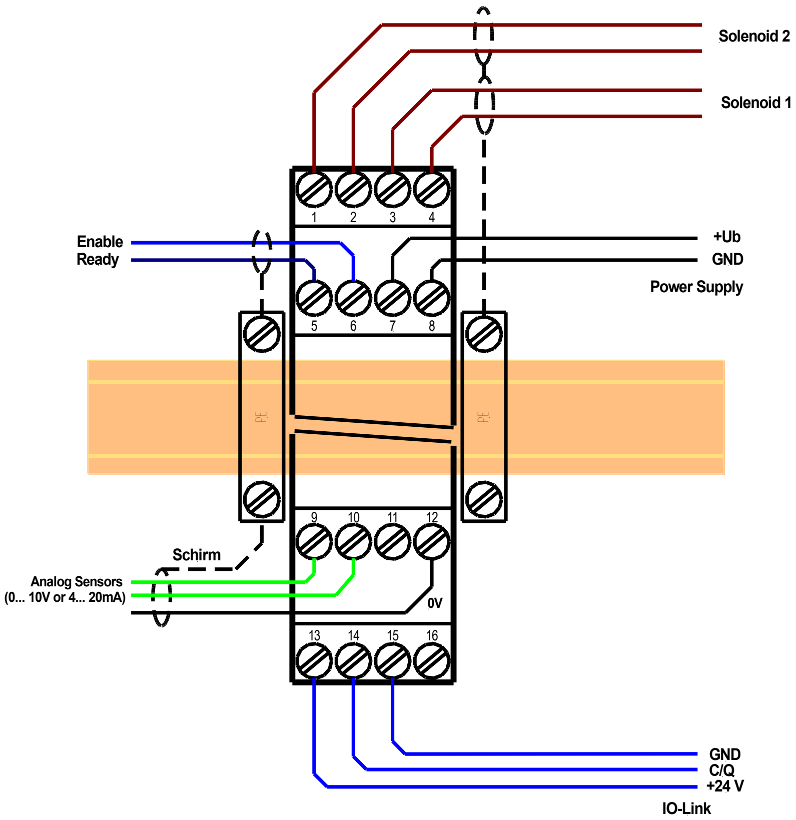
4.2 LED definitions

LEDs	**Description of the LED function**
GREEN	Identical to the READY output. **OFF:** No power supply or ENABLE is not activated **ON:** System is ready for operation with at least 1 channel ***Flashing:*** Error condition (e.g. valve solenoid or 4... 20 mA setpoint input). Not active if SENS = OFF.
YELLOW (MIDDLE)	**ON:** The IO-Link interface is connected. ***Flashing:*** Power supply IO-Link present, but no data connection.
YELLOW (RIGHT)	**ON:** At least one channel is driven with a signal > 5%.
GREEN + 2 X YELLOW	***All LEDs flashing:*** Bootloader is active! No normal functions are possible.
2 X YELLOW	**The two yellow LEDs flash alternately in 1 s cycles:** The non-volatile stored parameter data is inconsistent! To acknowledge this error, the data must be saved in the WPC using the SAVE command / button.

4.3 Block diagram



4.4 Typical wiring



4.5 Technical data

Supply voltage (U_b) Current requirement External protection	**[VDC]** **[mA]** **[A]**	12… 30 (incl. ripple) 30 + solenoid current 3 medium time lag
IO - Link Port Data rate	 **[kBaud]**	according to specification V1.1 Class A with internal galvanic isolation 230.4 (COM3)
Electrical isolation of control functions + output stage / bus connection		500 V AC 50 Hz 1 min
Digital input OFF ON Input resistance	 **[V]** **[V]** **[kOhm]**	 < 9.5 > 12.5 46
Digital output OFF ON Max. output current	 **[V]** **[V]** **[mA]**	 < 2 max. V_{cc} 50
Analog inputs: Voltage Input resistance Current Burden Signal resolution	 **[V]** **[kOhm]** **[mA]** **[Ohm]** **[%]**	Unipolar 0… 10 min. 32 4… 20 240 0.006
PWM output Max. output current Frequency	 **[A]** **[Hz]**	Wire break and short circuit monitored 2,6 61… 2604 selectable in defined steps
Controller cycle times Solenoid current control Signal processing	 **[µs]** **[ms]**	 125 1
Serial interface Transmission rate	**-** **[kBaud]**	USB-virtual COM Port 9.6… 115.2
Housing Material Flammability class	 **-** **-**	Snap-on module acc. EN 50022 PA 6.6 polyamide V0 (UL94)
Weight	**[kg]**	0.19
Protection class Temperature range Storage temperature Humidity Vibration resistance	**[IP]** **[°C]** **[°C]** **[%]** **-**	20 -20… 60 -20… 70 < 95 (non-condensing) IEC 60068-2-6 (Category C)
Connections Communication Plug connectors PE	 **-** 	 USB type B 4 x 4-pole terminal blocks via the DIN mounting rail
EMC		EN 61000-6-2: 8/2005 EN 61000-6-4: 6/2007 + A1:2011

5 Parameters

5.1 Parameter overview

Group	Command	Default	Unit	Description	IO-Link
Basic parameter					
	MODE	STD	-	Scope of the parameter view	
System parameters (MODE = SYSTEM)					
	LG	EN	-	Language switching	
	SENS	ON	-	Malfunction monitoring	1000/1
Channel 1					
	EOUT_1	0	0.01 %	Output signal if not ready	1001/2
	SYS_RANGE_1	100	bar	System pressure	1002/2
	CDWIN_1	2000	mbar	Deviation monitoring window	1003/2
Channel 2					
	EOUT_2	0	0.01 %	Output signal if not ready	1101/2
	SYS_RANGE_2	100	bar	System pressure	1102/2
	CDWIN_2	2000	mbar	Deviation monitoring window	1103/2
Comissioning assistant					
	ACA:LOOP	1	-	Selected control loop	
Input parameters (MODE = IO_CONF)					
Sensor scaling channel 1					
	SIGNAL_1:X	U0-10	V	Type of input	1004/1
	N_RANGE_1:X	100	bar	Sensor nominal pressure	1005/1
	OFFSET_1:X	0	mbar	Sensor offset	1006/1
Sensor scaling channel 2					
	SIGNAL_2:X	U0-10	V	Type of input	1104/1
	N_RANGE_2:X	100	bar	Sensor nominal pressure	1105/2
	OFFSET_2:X	0	mbar	Sensor offset	1106/4
Controller settings (MODE = CONTROL)					
Channel 1					
Ramp generator					
	RA_1:UP	100	ms	Times of the setpoint ramp	1011/4
PID controller					
	C_1:P	50	0.01	P gain	1013/2
	PLDYN1	0	bar	Lower pressure for dynamic measurement	

Channel 2				
Ramp generator				
RA_2:UP	100	ms	Times of the setpoint ramp	1111/4
PID controller				
C_2:P	50	0.01	P gain	1113/2
PLDYN2	0	bar	Lower pressure for dynamic measurement	
Valve linearisation (MODE = VALVE)				
Channel 1				
CCMODE_1	OFF	-	Characteristics linearisation	1021/1
CCSET_1	X	-	Operational curve, X - Coordinates (ascending order),	12308 –
MIN_1	0	0.01 %	Deadband compensation	1022/2
MAX_1	10000	0.01 %	Output scaling	1023/2
TRIGGER_1	200	0.01 %	Deadband compensation trigger point	1024/2
SIGNAL_1:U	+	-	Output polarity	1025/1
Channel 2				
CCMODE_2	OFF	-	Characteristics linearisation	1121/1
CCSET_2	X	-	Operational curve, X - Coordinates (ascending order),	12372 –
MIN_2	0	0.01 %	Deadband compensation	1122/2
MAX_2	10000	0.01 %	Output scaling	1123/2
TRIGGER_2	200	0.01 %	Deadband compensation trigger point	1124/2
SIGNAL_2:U	+	-	Output polarity	1125/1
Power stage parameters (MODE = POWERSTAGE)				
Channel 1				
CURRENT_1	1000	mA	Nominal solenoid current	1031/2
DFREQ_1	121	Hz	Dither frequency	1032/2
DAMPL_1	500	0.01 %	Dither amplitude	1033/2
PWM_1	2604	Hz	PWM frequency	1034/2
ACC_1	ON	-	Automatic solenoid current controller adjustment	1035/1
PPWM_1	7	-	P gain solenoid current controller	1036/2
Channel 2				
CURRENT_2	1000	mA	Nominal solenoid current	1131/2
DFREQ_2	121	Hz	Dither frequency	1132/2
DAMPL_2	500	0.01 %	Dither amplitude	1133/2
PWM_2	2604	Hz	PWM frequency	1134/2
ACC_2	ON	-	Automatic solenoid current controller adjustment	1135/1
PPWM_2	7	-	P gain solenoid current controller	1136/2

[2] The indices of the coordinates are assigned in the order X0/Y0/X1/Y1...X10/Y10.

5.2 *Basic parameters*

5.2.1 MODE (Scope of the parameter view)

Command	Parameters	Unit	Group
MODE x	x= SYSTEM|IO_CONFIG|CONTROL|VALVE|P_STAGE	-	**BASIC**

This command is used to switch between parameter groups.

--- No display (default)
SYSTEM System parameters
IO_CONF Definition of the input signals
CONTROL Parameterisation of the pressure controllers
VALVE Parameters for valve adjustment
P_STAGE Parameterisation of the output stages

5.3 *System Parameters*

5.3.1 LG (Language switching)

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

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

5.3.2 SENS (Malfunction monitoring)

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.

5.3.3 EOUT (Output signal if not ready)

Command	Parameters	Unit	Group
EOUT_1/_2 X	x= 0… 10000	0.01 %	**SYSTEM**

Output value in case of a detected error or a deactive ENABLE input. A value (degree of valve opening) for use in the event of a sensor error (or the module is disabled) can be defined here. This function can be used if, for example, the pressure valve is to be controlled with a fixed signal in the event of a sensor error.

|EOUT| = 0 The output is switched off in the event of an error. This is normal behavior.

CAUTION!
The output value defined here is stored permanently (independently of the parameter set). The effects should be analyzed by the user for each application from the point of view of safety.

5.3.4 SYS_RANGE (System pressure)

Command	Parameters	Unit	Group
SYS_RANGE_1/_2 X	x= 10… 1000	bar	**SYSTEM**

This command is used to set the maximum system pressure. Incorrect specifications lead to an incorrect system setting and dependent parameters cannot be calculated correctly.

5.3.5 CDWIN (Deviation monitoring window)

Command	Parameters	Unit	Group
CDWIN_1/_2 X	x= 100… 50000	mbar	**SYSTEM**

The module monitors whether the specified setpoint is reached and issues status information if the corresponding controller is activated and the deviation is within the tolerance range specified here. This monitoring has no influence on the actual control.

5.3.6 ACA:LOOP (Selected control loop)

Command	Parameters	Unit	Group
ACA:LOOP X	x= 1|2	-	**SYSTEM**

This parameter determines which control loop the commissioning assistant sets when you activate it. In normal operation, this value has no effect. Note that with write access to this value, all temporarily stored intermediate results, such as the measured characteristic curve of the system or the status information of the assistant, are reset.

5.4 Input Signal Definition

5.4.1 **SIGNAL (Type of input)**

Command	Parameters	Unit	Group
SIGNAL_1/_2 X	OFF(1)|U0-10(2)|I4-20(3)|U10-0(4)|I20-4(5)	-	**IO_CONFIG**

This command defines the type of sensor signals (current or voltage). At the same time, the signal direction can be reversed.

5.4.2 **N_RANGE:X (Sensor nominal pressure)**

Command	Parameter	Unit	Group
N_RANGE_1/_2:X X	x= 10… 10000	bar	**IO_CONFIG**

This command defines the nominal pressure of the sensor at which the full signal (10 V or 20 mA) is present.

5.4.3 **OFFSET:X (Sensor offset)**

Command	Parameter	Unit	Group
OFFSET_1/_2 X	x= -1000000… 1000000	mbar	**IO_CONFIG**

Adjustment of the zero point of the sensor.

5.4.4 **Using of the commands SYS_RANGE, N_RANGE:X and OFFSET:X**

With these commands, the feedback sensor is scaled. Suppose you have a pressure control with the following characteristics:

- The system pressure is 350 bar
- The pressure sensor has a 4-20mA current output
- The nominal pressure of the sensor is 600bar (20mA at 600bar)
- The sensor has an offset of 3bar (at 0bar real pressure 3bar are displayed)

To scale this sensor correctly the following settings should be made:

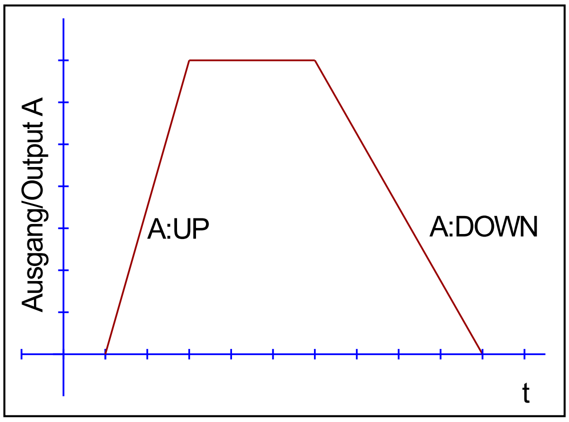
- SYS_RANGE 350 bar
- SIGNAL:X I4-20
- N_RANGE:X 600 bar
- OFFSET:X -3000 mbar

5.5 Controller setting values

5.5.1 RA (Times of the setpoint ramp)

Command	Parameter	Unit	Group
RA_1/_2I X	i= UP|DOWN x= 1… 600000	ms	**CONTROL**

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



5.5.2 PID controller

Command	Parameter	Unit	Group
C_1/_2:I X	I= P|I|D|D_T1|FF :P x= 0… 10000 :I x= 0… 30000 I_LIM x= 0… 10000 I_ACT x= 0… 10000 :D x= 0… 1200 :D_T1 x= 0… 1000 :FF x= 0… 10000	 0.01 0.1 ms 0.01 % 0.01 % 0.1 ms 0.1 ms 0.01 %	**CONTROL**

The control function will be parameterized via this command.
The P, I and D gain are similar to a standard PID controller.
Value 0 deactivates the integrator.
The following commands are used to parameterise the activation threshold and the control range of the I component of the controller:

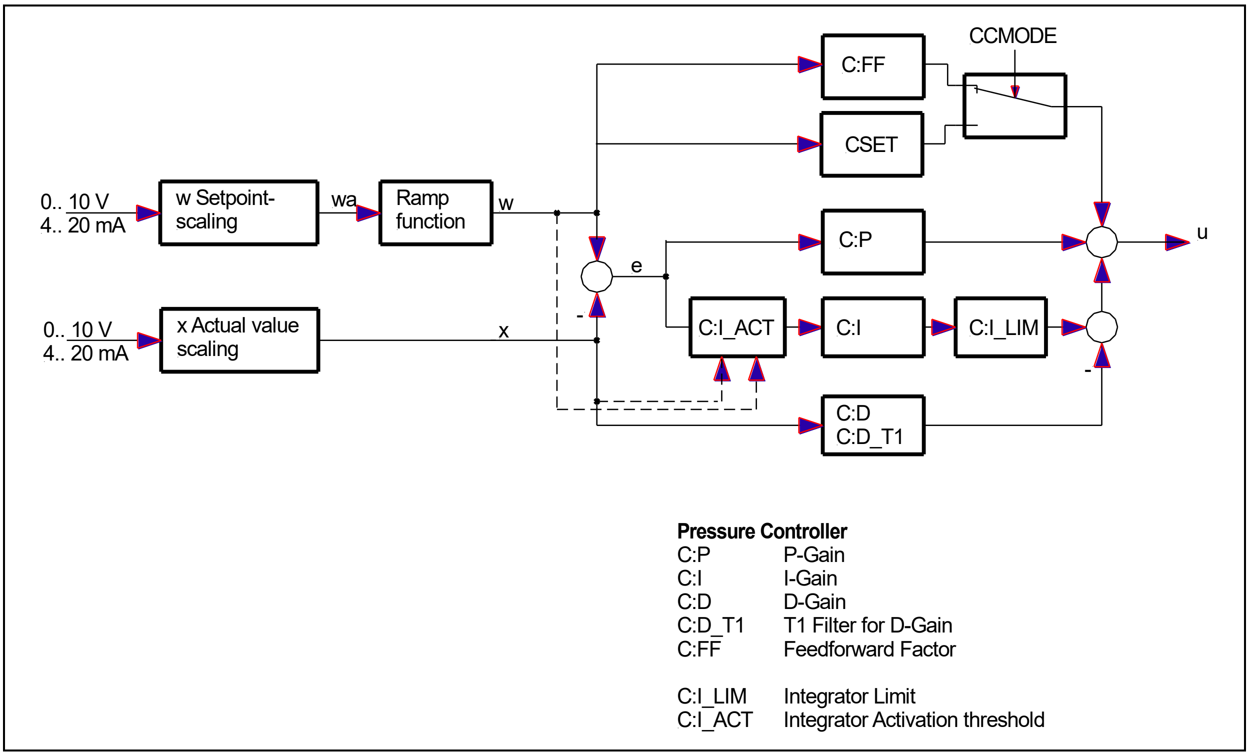
C:I_LIM limits the operating range of the I-component so that the controller can control the process faster without major overshoots. If the value is selected too small, the effect may be that the non-linearity of the valve can no longer be compensated completely.

C:I_ACT controls the activation of 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.

The D_T1 factor is a filter for the D-component to suppress high-frequency noise.

In this module an intelligent characteristic linearization is used, therefore the parameter C:FF listed here is normally not visible.
Via the feedforward function, the setpoint is converted into an output signal that approximately generates the correct pressure via the hydraulic control of the connected proportional valve or pump pressure control, even without controller intervention.
By this way, the controller only has to correct deviations which can result from various effects such as hysteresis, operating point-dependent flow forces, etc.
This leads to a stable control behaviour and at the same time to dynamic response.

This diagram shows the structure of the controller:



5.5.3 **PLDYN (Lower pressure for dynamic measurement)**

Command	Parameter	Unit	Group
PLDYN_1/_2	x= 0… 1000	bar	**STD**

During the dynamic measurements of the commissioning assistant, setpoint jumps are carried out. It is important that the system can reach the lower step value and that this value is above the precharge pressure of an accumulator in the pressure line.
Usually a pressure of 20% of the pressure set at SYS_RANGE is selected as the lower step value. If a higher pressure is to be used, it must be specified here. The assistant selects the maximum from 0.2 * SYS_RANGE and the input value.

5.6 Valve adaptation

5.6.1 **CCMODE (Characteristics linearisation)**

Command	Parameter	Unit	Group
`CCMODE_1/_2   X`	`ON(1)|OFF(0)`	-	**VALVE**

This command is used to enable or disable the linearisation function.

5.6.2 **CCSET (Operational curve)**

Command	Parameter	Unit	Group

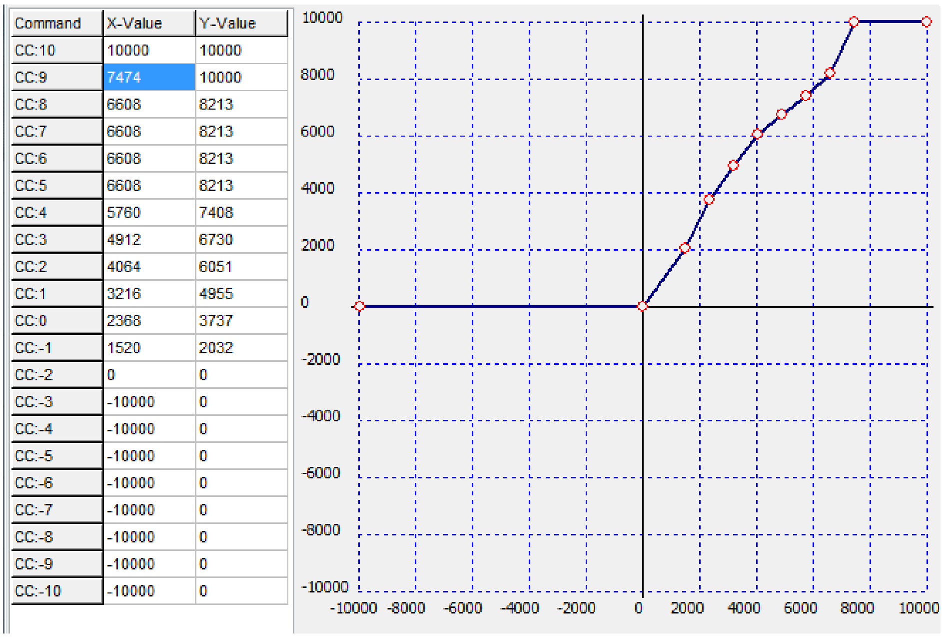
`CCSET_1/_2`
`:I   X   Y`
	`i=    -10…    10`
	`x= -10000… 10000`
	`y= -10000… 10000`
		-
		0.01 %
		0.01 %
			VALVE
			CCMODE=ON

At this point the set characteristic curve can be displayed. The X-axis corresponds to the pressure, the Y-axis to the necessary control signal. This display is mirrored in comparison to a normal valve characteristic curve.

The curve is always located in the first quadrant. Negative pressures do not occur, therefore the corresponding Y - coordinates are set to "0".

The result is calculated by linear interpolation: **y=(x-x1)*(y1-y0)/(x1-x0)+y1**.

The effects of linearization can be evaluated via the process data in the monitor or oscilloscope.



Command	X-Value	Y-Value
CC:10	10000	10000
CC:9	7474	10000
CC:8	6608	8213
CC:7	6608	8213
CC:6	6608	8213
CC:5	6608	8213
CC:4	5760	7408
CC:3	4912	6730
CC:2	4064	6051
CC:1	3216	4955
CC:0	2368	3737
CC:-1	1520	2032
CC:-2	0	0
CC:-3	-10000	0
CC:-4	-10000	0
CC:-5	-10000	0
CC:-6	-10000	0
CC:-7	-10000	0
CC:-8	-10000	0
CC:-9	-10000	0
CC:-10	-10000	0

5.6.3 MIN (Deadband compensation)

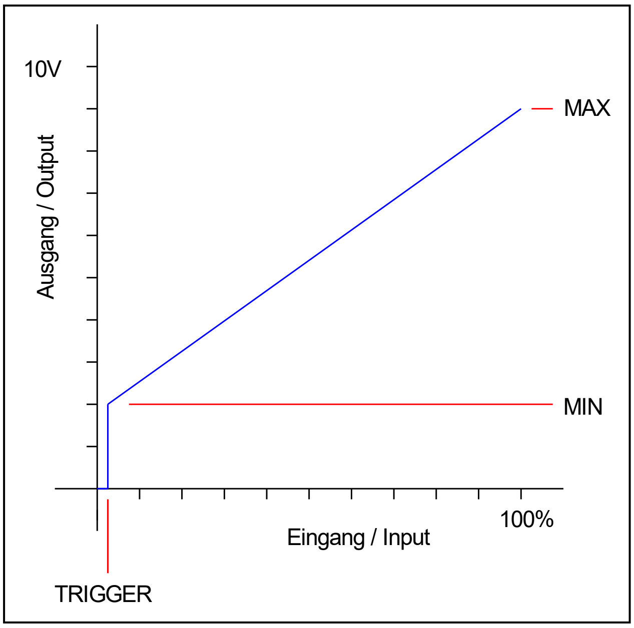
5.6.4 MAX (Output scaling)

5.6.5 TRIGGER (Deadband compensation trigger point)

Command	Parameters	Unit	Group
MIN_1/_2 X MAX_1/_2 X TRIGGER_1/_2 X	x= 0… 6000 x= 4000… 10000 x= 0… 3000	0.01 % 0.01 % 0.01 %	**VALVE**

With this command, the output signal is adjusted to the valve characteristics. With the MAX value the output signal (the maximum valve current) will be defined. With the MIN value the overlap (dead band of the valve) will be compensated. Via the TRIGGER the activation point of the MIN function is set and so a non-sensitive range around the zero-point[3] can be specified.

CAUTION: If the MIN value is set too high, it influences the minimal pressure, which cannot be adjusted any longer. In extreme case this causes to an oscillating at small input values.



Important note: MIN / MAX / TRIGGER in interaction with the commissioning assistant

The function described here acts on the output signal of the controller, including the feedforward control. The assistant itself has the possibility to achieve a similar effect by adjusting the characteristic curve accordingly, namely compensation of the overlap and limitation of the maximum output signal. The use of the parameters described here is therefore optional and must in any case be carried out before starting the assistant, as the measured characteristic curve is only valid if MIN / MAX and trigger are not changed.

If you change these parameters after the first run of the assistant, it must be restarted afterwards!

[3] This dead band is necessary, in order to avoid unrequested activations caused by small variations of the input signal. If this module is used in a position controls, the TRIGGER value should be reduced (typical: 1…10).

5.6.6 SIGNAL:U (Output polarity)

Command	Parameter	Unit	Group
SIGNAL_1/_2:U	+(0)|-(1)	-	**VALVE**

This command is used to define the output polarity in case of inverse working pressure valves.

+ 0 % to 100 %, normal output
- 100 % to 0 %, changed output polarity

5.7 Power stage parameters

5.7.1 CURRENT (Nominal solenoid current)

Command	Parameters	Unit	Group
CURRENT_1/_2	x= 500… 2600	mA	**P_STAGE**

The nominal output current is set. Dither and also MIN/MAX always refer to this current range.

5.7.2 DFREQ (Dither frequency)

5.7.3 DAMPL (Dither amplitude)

Command	Parameters	Unit	Group
DFREQ_1/_2 DAMPL_1/_2	x= 60… 400 x= 0… 3000	Hz 0.01 %	**P_STAGE**

The dither[4] 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 (see: CURRENT command). The dither frequency is defined in Hz. Depending on the internal calculations, the frequency is adjustable in steps.

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

[4] The dither is a triangle signal which is superimposed on the current set point and is defined by the amplitude and frequency: the dither frequency and the PWM frequency. The dither frequency should not be confused with the PWM frequency. In some documentations the PWM frequency is described as a dither. This can be recognized by the lack of the dither amplitude.

5.7.4 PWM (PWM frequency)

Command	Parameter	Unit	Group
PWM_1/_2	x= 61… 2604	Hz	**P_STAGE**

The frequency can be changed in defined steps (61 Hz (1), 72 Hz (2), 85 Hz (3), 100 Hz (4), 120 Hz (5), 150 Hz (6), 200 Hz (7), 269 Hz (8), 372 Hz (9), 488 Hz (10), 624 Hz (11), 781 Hz (12), 976 Hz (13), 1201 Hz (14), 1420 Hz (15), 1562 Hz (16), 1736 Hz (17), 1953 Hz (18), 2232 Hz (19), 2604 Hz (20)). The optimum frequency depends on the valve.

5.7.5 ACC (Automatic solenoid current controller adjustment)

Command	Parameter	Unit	Group
ACC_1/_2 X	ON(2)|OFF(1)	-	**P_STAGE**

Operation mode of the closed loop current control.

ON: In automatic mode PPWM and IPWM are calculated depending on the preset PWM-frequency.

OFF: Manual adjustment.

5.7.6 PPWM (P gain solenoid current controller)

5.7.7 IPWM (I gain solenoid current controller)

Command	Parameters	Unit	Group
PPWM_1/_2 IPWM_1/_2	x= 0… 30 x= 1… 100	- -	**P_STAGE** **ACC = OFF**

The PI current controller for the solenoids is parameterized with these commands.

CAUTION: These parameters should not be changed without adequate measurement facilities and experience.

Attention, if the parameter ACC is set to ON, these adjustments are done automatically.

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

5.8 *Special commands*

5.8.1 AINMODE (Scaling mode)

Command	Parameter	Unit	Group
AINMODE x	x= EASY|MATH	-	**TERMINAL**

This command is used to switch over the kind of input scaling.

The AINMODE is used to define the kind of parameterizing of the analog inputs. The EASY mode (DEFAULT) supports a simple and application oriented input scaling.

The MATH mode supports the free input scaling by a linear equation. This mode is compatible to our older modules.

Attention: This command can be executed in the terminal window only. In case of switching back, DEFAULT data should be reloaded.

5.8.2 DIAG (Query of the last switch-off causes)

If you enter the command "DIAG1" or "DIAG2" in the terminal window,, the last 10 shutdowns (loss of Ready when Enable is present) of the corresponding channel are displayed. However, the causes of the shutdown are not stored when the supply voltage is switched off. The last cause is displayed in the bottom line of the list. Entries "---" indicate unused memory cells.

An example:

```
>DIAG1
---
---
---
---
---
---
---
---
INPUT PIN 9
SOLENOID 1
System Faillure State:
0
>
```

5.8.3 AIN (Analog input scaling)

Command	Parameters	Unit	Group
AIN:I	i= W|X		**MATH**
A	a= -10000… 10000	-	
B	b= -10000… 10000	-	
C	c= -10000… 10000	0,01 %	
X	x= V|C	-	

This command offers an individual scalable input. The following linear equation is used for the scaling.

$$Output = \frac{a}{b}(Input - c)$$

The ***"C" value*** is the offset (e.g. to compensate the 4 mA in case of a 4… 20 mA input signal).
The variables ***A*** and ***B*** are defining the gain factor with which the signal range is scaled up to 100 % (e.g. 1.25 if using 4… 20mA input signal, defined in default current settings by A = 1250 and B = 1000). The internal shunt for the current measuring is activated with switching the ***X*** value.

The gain factor is calculated by setting the usable range (***A***) in relation to the real used range (***B***) of the input signal. Usable are 0… 20mA, means (***A***) has the value **20**. Really used are 4… 20mA, means (***B***) has a value of **16** (20-4). Not used are 0… 4mA. In a range of 20mA this is an offset of 20%, means a value of **2000** for (***C***). Last but not least (***X***) has to be set to **C** choosing current signal.

In this case AIN command would look like this:

AIN:I 20 16 2000 C or AIN:I 1250 1000 2000 C (see below)

Typical settings:

Command	Input	Description
AIN:X 1000 1000 0 V	0… 10 V	Range: 0… 100 %
AIN:X 10 8 1000 V OR **AIN:X 1250 1000 1000 V**	1… 9 V	Range: 0… 100 %; 1 V = 1000 used for the offset and gained by 10 / 8 (10 V divided by 8 V (9 V -1 V))
AIN:X 10 4 500 V OR **AIN:X 1000 400 500 V** OR	0,5… 4,5 V	Range: 0… 100 %; 0,5 V = 500 used for the offset and gained by 10 / 4 (10 V divided by 4 V (4,5 V -0,5 V))
AIN:X 20 16 2000 C OR **AIN:X 2000 1600 2000 C** OR **AIN:X 1250 1000 2000 C**	4… 20mA	Range: 0… 100 % The offset will be compensated on 20 % (4 mA) and the signal (16 mA = 20 mA – 4 mA) will be gained to 100 % (20 mA). Each of this parameterization for 4… 20 mA is setting the range to 0… 100 %.

5.8.4 CCMVIS (Visibility of the measured characteristic)

Command	Parameter	Unit	Group
CCMVIS x	x= ON|OFF	-	**TERMINAL**

If this parameter is set to "ON", an additional entry is displayed in the SYSTEM group as follows:

5.8.5 CCM (measured characteristic curve)

Command	Parameter	Unit	Group
CCM:I X Y	i= -10… 10 x= -10000… 10000 y= -10000… 10000	- 0,01 % 0,01 %	**SYSTEM** **CCMVIS=ON**

This parameter is used to display the currently measured valve characteristic. The values are not stored permanently. The measured characteristic curve has no effect on the behaviour of the unit after the commissioning assistant has been completed.

5.9 PROCESS DATA (Monitoring)

Command	Description	Unit
WA1/2	Setpoint input signal	bar
W1/2	Internal setpoint	bar
X1/2	Feedback value	bar
E1/2	Control error	bar
U1/2	Output	%
I1/2	Solenoid current[5]	mA

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

[5] The display of the solenoid current (in WPC-300 program) is damped in order to be able to bring out a stable signal.

6 IO–Link Interface

The process data are the variable values that are cyclically exchanged via IO-Link.

The process data length is 6 bytes in the direction from master to device and 10 bytes in the direction from device to master.

6.1 Setpoints from master to slave

Nr.	Byte	Function	Range	Unit
1	0	Control word High	-	-
2	1	Control word Low		
3	2	Setpoint 1 High	0 - 10000	0.1 bar
4	3	Setpoint 1 Low		
3	2	Setpoint 2 High	0 - 10000	0.1 bar
4	3	Setpoint 2 Low		

Definition of the control word:

Byte 0 – Control word 1 High			
Nr.	**Bit**	**Function**	
1	0	---	
2	1	---	
3	2	---	
4	3	---	
5	4	---	
6	5	---	
7	6	START 1	Activation of the pressure controller 1
8	7	ENABLE 1	Enabling the channel 1

Byte 1 – Control word 1 Low			
Nr.	**Bit**	**Funktion**	
1	0	---	
2	1	---	
3	2	---	
4	3	---	
5	4	---	
6	5	---	
7	6	START 2	Activation of the pressure controller 2
8	7	ENABLE 2	Enabling the channel 2

6.2 Process data from the device to the master

Nr.	Byte	Function	Type	Range	Unit
1	0	Status word High	int	-	-
2	1	Status word Low			
3	2	Actual pressure 1 High	int	0 - 10000	0.1 bar
4	3	Actual pressure 1 Low			
5	4	Actual pressure 2 High	int	0 - 10000	0.1 bar
6	5	Actual pressure 2 Low			
7	6	Solenoid current 1 High	int	0 - 2600	mA
8	7	Solenoid current 1 Low			
9	8	Solenoid current 2 High	int	0 - 2600	mA
10	9	Solenoid current 2 Low			

Definition of the status word:

Byte 0 – Status Word High			
Nr.	**Bit**	**Function**	
1	0	$\overline{\text{I1 ERROR}}$	Error valve solenoid 1
2	1	$\overline{\text{XP1 ERROR}}$	Error pressure sensor 1
3	2	$\overline{\text{APILOWVERR}}$	Error: Supply voltage of the controller too low
4	3	$\overline{\text{ERROR}}$	Common error flag
5	4	---	reserved
6	5	---	reserved
7	6	PRESSWIN 1	Pressure 1 in the monitoring window
8	7	READY 1	General operational readiness message, channel 1

Byte 1 – Status Word Low			
Nr.	**Bit**	**Function**	
1	0	$\overline{\text{I2 ERROR}}$	Error valve solenoid 2
2	1	$\overline{\text{XP2 ERROR}}$	Error pressure sensor 2
3	2	$\overline{\text{DERROR}}$	Internal data error
4	3	$\overline{\text{SYSERROR}}$	System error
5	4	---	reserved
6	5	---	reserved
7	6	PRESSWIN 2	Pressure 2 in the monitoring window
8	7	READY 2	General operational readiness message, channel 2

Important: Error flags are inverted. Logical "1" means "no error".

6.3 Parameterisation via IO – Link

The device can be fully parameterised via the IO - Link as well as via the USB interface with the WPC programme.

It should be noted that these two methods are not locked against each other, i.e. if both variants are used at the same time, the offline project of the PLC or a WPC file may not reflect the correct content of the online parameters if the procedure is used incorrectly.

If parameters are written via IO-Link while WPC is connected, the parameter table in this progam will not update itself automatically. The change of a parameter written via IO - Link will only be reflected in the WPC after pressing the "ID" button again, possibly also after changing the parameter groups.

Each write operation of the IO - Link interface leads to the entire parameterisation being saved in the EEPROM, as otherwise only happens after pressing the "SAVE" button. If you change parameters in the WPC and then write other values via IO-Link, you should proceed with particular care and consideration.

Conclusion: It is recommended not to use the two methods of parameterisation simultaneously, even if this is theoretically possible.

For parameterisation via IO-Link, either the engineering system of the master can be used, or index-based access to individual parameters from the PLC software via corresponding system functions is possible.

If you want to use the latter variant, the parameter indices and their byte length can be taken from the table in Chapter 5.1 / Parameter overview.

The numerical values of the selection parameters are assigned in colour to the respective selection options in the descriptions of the previous chapters, for example "(1)".

In the case of numerical parameters, the units and value ranges specified there apply in each case.

7 Appendix

7.1 Failure monitoring

Following possible error sources are monitored continuously when SENS = ON/AUTO:

Source	Fault	Behaviour
IO-Link	Communication failure	Both output stages are deactivated or the corresponding substitute values are switched on.
Actual value PIN 9, 4...20 mA	Current loop error	Output stage 1 is deactivated or the substitute value EOUT_1 is switched on.
Solenoid 1 PIN 3 / 4	Solenoid current error	Output stage 1 is deactivated.
Actual value PIN 10, 4...20 mA	Current loop error	Output stage 2 is deactivated or the substitute value EOUT_1 is switched on.
Solenoid 2 PIN 1 / 2	Solenoid current error	Output stage 2 is deactivated.
RC-Fault	Error in remote control operation, e.g. loss of USB connection or termination of WPC before remote control operation is switched off.	Both output stages are deactivated or the corresponding substitute values are switched on.
EEPROM (when switching on)	Data error	Both output stages are deactivated or the corresponding substitute values are switched on. The module can only be activated by saving the parameters again!
Commissioning assistant	Error commissioning assistant, various causes. Signalled as ST_UP ERROR	The commissioning assistant is terminated; more detailed information can be called up in the terminal via the command "SR". Otherwise, the error display has no effect on the function of the device and resets itself automatically.

CAUTION: Take care of the EOUT command. Changes will influence the behavior.

7.2 Troubleshooting

It is assumed that the device is in an operable state and that 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.

ATTENTION: When working with the RC (Remote Control) mode, all safety aspects must be thoroughly checked. In this mode, the module is controlled directly and the machine control cannot exert any influence on the module.

FAULT	CAUSE / SOLUTION
ENABLE is active, the module does not respond and the READY LED is off.	Probably the power supply is not available or the ENABLE signal (PIN 6 and at the same time the control bit belonging to the channel via IO - Link) is not present. Other faults are signalized with a flashing READY LED.
ENABLE is active, the READY LED is flashing.	The flashing READY LED signals that a fault is detected by the module. The fault could be: • A cable break or no signal at the inputs (PIN 9 or PIN 10) if 4… 20 mA signals are parameterized. • A cable break or an incorrect cabling to the solenoids. • Internal data error: press the SAVE button to delete the data error. The system reloads the DEFAULT data. With the WPC-300 operating program the fault can be localized directly via the monitor.
ENABLE is active; the READY LED is active; no current to the solenoid (no pressure-build-up).	To locate errors in the pressure-control-circuit, it is useful to start with the open loop pressure control (deactivated pressure controller, no start - control bit). In this case, the module works like a power amplifier. • No pressure command input is available or the parameterization is incorrect. With the WPC-tool you can check if a command input is available If not, check the IO link connection or the setpoint setting. • If the command input is correct, you have to check the valve control parameter. If the current is set too low (parameter CURRENT), the output current and the expected pressure are too low. • Wrong configured pressure sensor: If the input-scaling is set to voltage (V) and the pressure sensor supplies a current signal (4... 20mA), the measured pressure value is always high. The output signal to the valve is therefore low. For further checking: disable the START signal. • The pressure valve is controlled correctly (the output is going up to the nominal current). In this case, you may have a hydraulic problem or you are using free-wheeling-diodes in the solenoid plug. Please remove the free-wheeling-diodes to allow a correct current measurement.
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. • 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).

FAULT	CAUSE / SOLUTION
ENABLE and START are active, READY LED is ON, the pressure control works, but the pressure is not equal to the command input.	Basically, the system works, but undesired deviations still occur due to incorrect adjustments of the signals or the controller setting. Since both pressure sensors and pressure valves are only available in certain pressure levels, the signals must be scaled accordingly. Check the basic settings (see chapter 3.2.).
ENABLE and START are active, the READY LED is active, the pressure control loop works, but the pressure is oscillating or the pressure UP and DOWN time is too low.	The capability of the hydraulic system has to be checked. Deactivate START for open loop control and check the pressure build up and down time. If the system is in open loop still instable, check the hydraulic and the dither/ PWM setup first. 1. Check the parameters C_n:I, C_n:P and C_n:FF. The parameter C_n:FF has the following relevance: With this parameter you can increase or decrease the feed forward gain to the valve. C_n:FF 8000 (80 %) means, the remaining control signal of 20 % must be set by the PID compensator. Therefore, the integrator limitation should be set to 2500... 3500 (25 % ... 35 %)[6]. 2. The C_n:P (P-gain) is to increase in steps[7] to the point where the pressure is going to be instable. At this point, C:P should be decreased for 30… 50 % to get an effectual stability margin. Alternatively, the C:P can improve the sensitivity of the valve and the control loop will be stabilized (typical with small values of 10… 50) 3. The integrator time constant C_n:I fixes the static error. Typical values are: 100 ms to 1200 ms. Optimize this parameter by monitoring the step response.
ENABLE and START are active, the READY LED is active, and the pressure control loop works, but there are high errors mainly at lower or higher command pressure.	The non-linearity of the valve is higher than the output range of the integrator. The parameter C_n:I_LIM should be increased. Otherwise the parameter MIN and MAX have to be checked and readjusted.
ENABLE and START are active, the READY LED is active, and the pressure control loop works. Lower pressure at the beginning causes that the system is not actuated and that no pressure build-up occurs.	In this case, the integrator threshold (activation point of the integrator) in combination with the controller setting is too high. The parameter C_n:I_ACT should be reduced.

[6] The limit value should be higher than the remaining control range (100 % - C:FF), additionally you have to add a value to compensate the non-linearity of the valve.

[7] Optimizing in steps is a general description. Our experience: you can change the parameters in steps from +20 % or rather -20 % for a rough adjustment of the actual value. For a fine adjustment you can select smaller steps.

8 Notes