WEST

Technical Documentation

MDR-137-P

Pressure control module with integrated power amplifier

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1 General Information

1.1 Order number

MDR-137-P - pressure control module with integrated power output stage up to 2,6 A and analog interface

Alternative products

MDR-133-U - with programmable output (±10 V differential output or 4… 20 mA) and a higher signal resolution (for test plant and applications with < 0,01 %)

MDR-133-P - with integrated power stage and higher signal resolution (for test plant and applications with < 0,01 %)

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

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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Date: 10.05.2022

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 has been developed for controlling pressure and force (and optionally speed, too) in hydraulic systems. The controller structure is optimized for pressure closed-loop control systems with typical pressure valves (pressure reducing or pressure relieve valves and also for pressure controlled servo pumps). An integrated power stage and high dynamic control loops offer a simple and powerful solution.

The control loop is designed as bypass control function, where the input signal is linked via a control parameter directly to the control output (pressure valve) and the PID compensator has to control the linearity deviation only. In many cases the optimization can be carried out without further test equipment (only a pressure sensor is needed).

The output signal is available as an integrated PWM power signal from 0,5 to 2,6 A. This output is over-current and short-circuit protected.

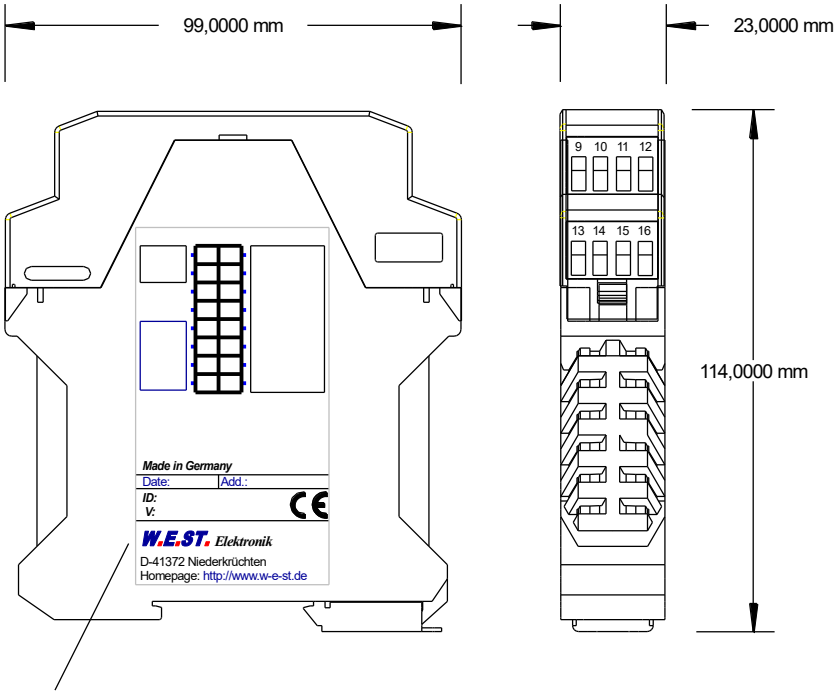
Because of the easy handling a very short training period is guaranteed.

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

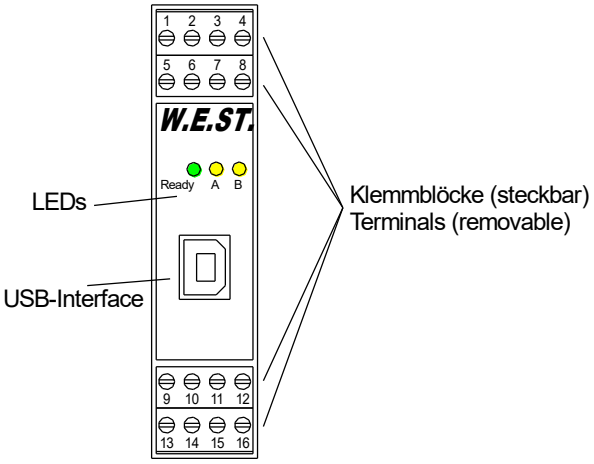
Features

- **Activation of pressure reducing valve and pressure control valve**
- **Compact housing**
- **Digital reproducible adjustments**
- **Universal PID actuator**
- **Free parameterization of ramps, MIN and MAX, DITHER (frequency, amplitude) and PWM frequency**
- **Nominal current from 0,5 A up to 2,6 A**
- **Application orientated parameter settings**
- **Fault diagnosis and extended function checking**
- **Simplified parameterization with WPC-300 software**

2.1 Device description



Typenschild und Anschlussbelegung
Type plate and terminal pin assignment



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.

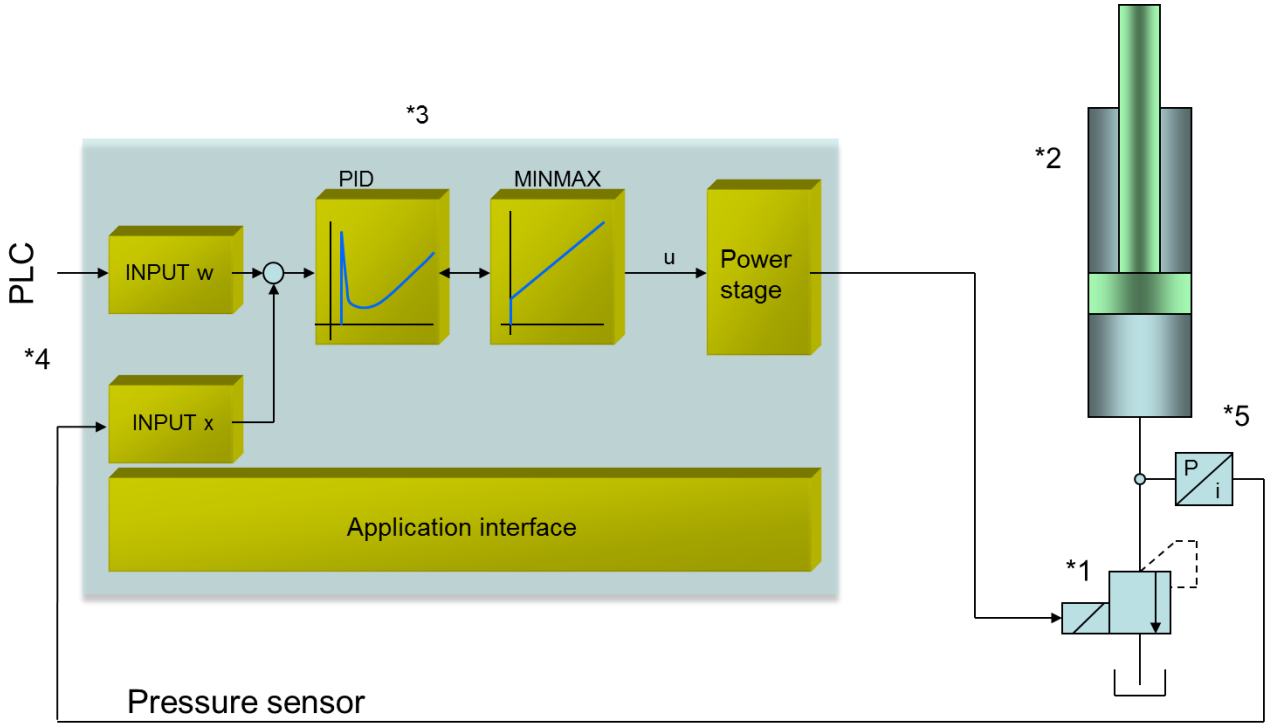
- **Typical installation location:** 24 V control signal area (close to PLC)
  The devices must be arranged in the control cabinet so that the power section and the signal section are separate from each other.
  Experience shows that the installation place close to the PLC (24 V area) is most suitable. 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 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.

2.2.2 Typical system structure

This minimal system consists of the following components:



(*1) Pressure relieve valve (alternative: pressure controlled servo pump)
(*2) Cylinder / actuator
(*3) MDR-137-P pressure control module with integrated power amplifier
(*4) Interface to PLC with analog and digital signals
(*5) Pressure or force 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

The commissioning of an electronic closed loop pressure control system is relatively easy, because the inner pressure loop control is done by the pressure control or pressure relieve valve. Only the linearity of the valve has to be optimized by a simple bypass control.

3.1 Hydraulic system

Two (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 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 Preliminaries

The preliminaries include in particular the compilation of the electrical data of command and actual 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	Solenoid current (**CURRENT**), the **DITHER / PWM** adjustment and - if available - the degree of overlapping (dead zone). - **MAX** parameter to adapt the valve pressure range and the working pressure range.
Sensor data	Nominal pressure of the sensor (**N_RANGE**) and the signal type (**SIGNAL:X**)
System data	Working pressure range (**SYS_RANGE**) to define 100 % of the command input signal range and the signal type (**SIGNAL:W** current or voltages).

3.3 Start-up procedure

Table 2 (General procedure for the start-up)

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 device. If it is higher than specified, there is an error in the wiring. Switch the device immediately off and check the wiring.

[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
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	By setting the parameters described in “TABLE 1” a general pressure control should be possible. 1. Deactivate PIN 6 and PIN 15, the PID compensator and the power stage are switched off.
Control signal	Check the control signal (output signal). The control signal (PIN 3 and PIN 4) should be in the range of 0... 2,6 A (depending on the parameter CURRENT). In the current state it should show around 0 A. **CAUTION!** This signal depends on the EOUT setting.
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 power stage gets activated. With active ENABLE the module works as a simple power amplifier. The output current to the valve (and also the pressure) will follow the input signal proportionally. The maximum pressure should be limited by app. 80 % (default setup).
Activating START (PIN 6)	Activation of the START input will activate the closed loop controller. With the correct pre-adjustment the system works in closed loop mode. The behavior of the pressure loop can be controlled with WPC-300 (MONITOR). If there are ranges without accurate pressure control, the setup of MIN and MAX should be checked.
Controller optimization	The DEFAULT adjustment of the module (C and LIM parameter) works satisfactorily in many cases. To improve the performance of the pressure control loop, the different PID parameters have to be adjusted depending on the application. **RAMP:UP / RAMP:DOWN**: Please set application relevant times. Not faster than the system can react. **C:FF**: a typical value is 8000 (80%). If the maximum pressure is limited (cannot be controlled), please increase this value up to 85… 100 % **C:I**: a typical value is 4000 (400 ms). Depending on the dynamic behavior, longer or shorter times should be used. **Further optimizations:** **C:P**: a typical value is 25 (Gain = 0,25). The P-Gain can be used to eliminate oscillations (not to improve the dynamic response, because the dynamic response is defined by the internal pressure loop of the valve). Typically small values have to be used. **C:D and C:T1**: a typical value is 10 (1 ms). The D-gain has to be used carefully. In some cases (pressure control with servo pumps) the D-gain can damp overshoot and can stabilize oscillations. **C:I_LIM**: a typical value is 2500 (25 %). In case of high valve linearity, a smaller value can be used. This can result in lower pressure overshoots. **C:I_ACT**: one typical value is 2500 (25 %). To avoid pressure overshoots, the integrator shout be activated depending on an adjustable pressure value. A value which is higher than the normal response behaviour leads to the result that the integrator is never activated and consequently to a permanent control deviation.

3.4 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.

Table 3

FAULT	CAUSE / SOLUTION
ENABLE is active, the module does not respond and the READY LED is off.	There is presumably no power supply or no ENABLE signal (PIN 15) 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 14) if 4… 20 mA signals are parameterized. • A cable break or an incorrect cabling to the solenoids (in the P version only). • 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 (PIN 6 is not activated). 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, you should check the wiring and/or the command set-point (in the PLC for example). • 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 PIN 6 is active). 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 PIN 6. • 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 (PIN 6) are active, READY LED is ON, the pressure control works, but the pressure is not equal to the command input.	The system works generally, but wrong control loop settings or wrong adjustment of the input signals cause control errors. 1. Please set the basic parameter (described in chapter 3.2).
ENABLE and START (PIN 6) 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 PIN 6 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:I, C:P and C:FF. The parameter C:FF has the following relevance: With this parameter you can increase or decrease the feed forward gain to the valve. C: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 %)[2]. 2. The C:P (P-gain) is to increase in steps[3] 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:I fixes the static error. Typical values are: 100 ms to 1200 ms. Optimize this parameter by monitoring the step response.
ENABLE and START (PIN 6) 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 controlled range of the integrator. The parameter C:I_LIM should be increased. Otherwise the parameter MIN and MAX have to be checked and readjusted.
ENABLE and START (PIN 6) 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:I_ACT should be reduced.

[2] 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.

[3] 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.

3.5 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.

Analog inputs are:

PIN 9/10 (2) the command value, 0… 10000 is corresponding to 0… 100 % of the full range.

Digital inputs **(4)** are:

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

RUN (START):
The PID compensator is active.

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

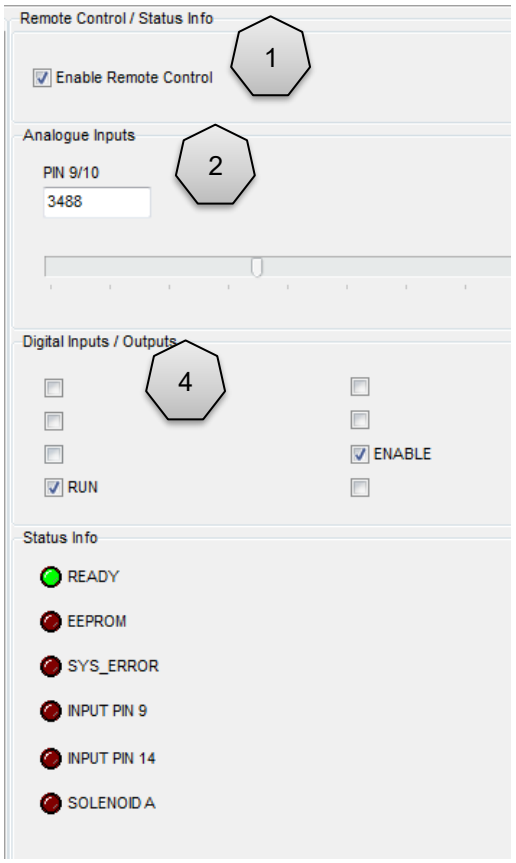


Figure 1 Example of the RC function

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.

4 Technical description

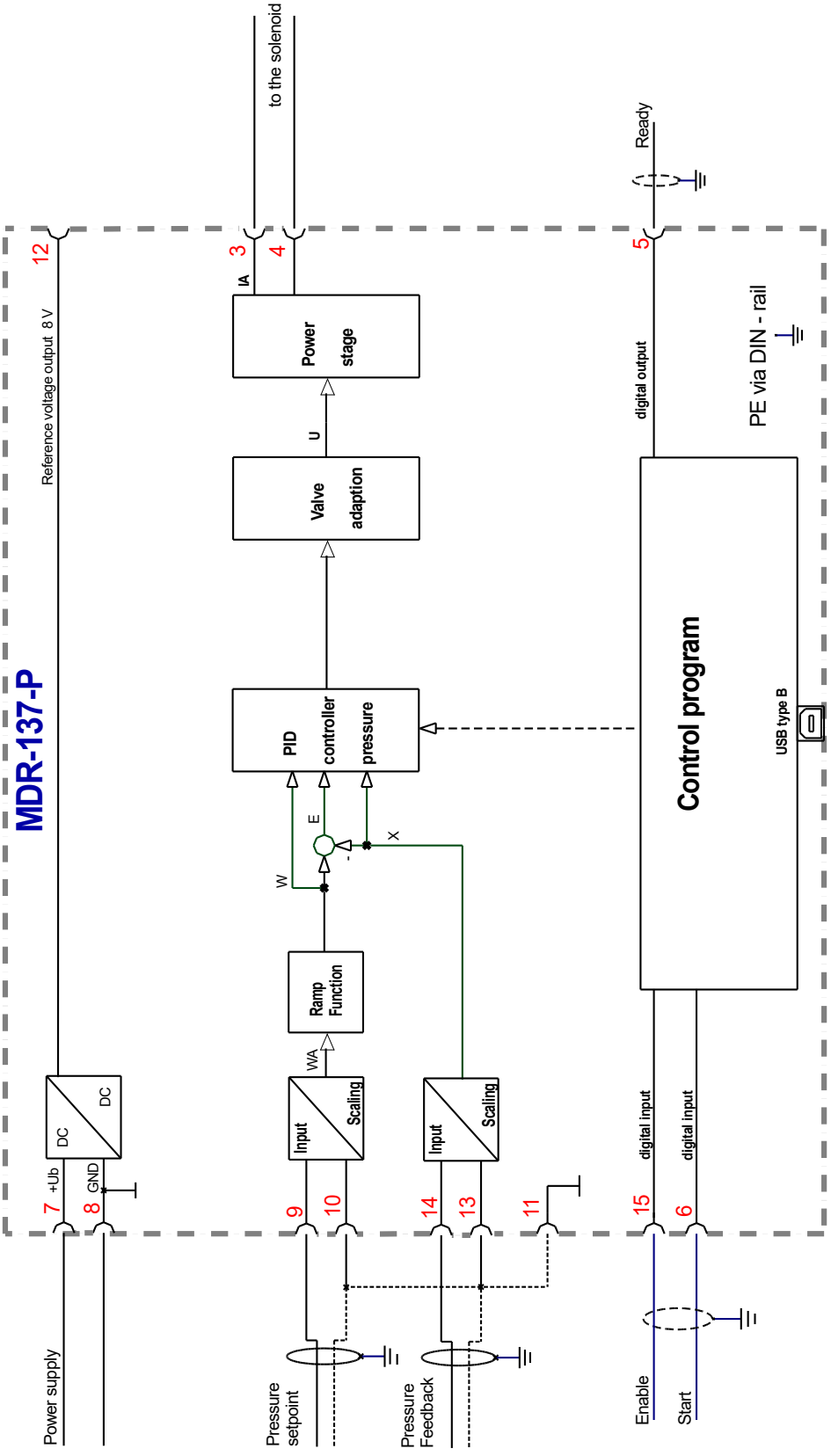
4.1 Input and output signals

Connection	Supply
PIN 7	Power supply (see technical data)
PIN 8	0 V (GND) connection.
Connection	**Analog signals**
PIN 9 / 10	Pressure command value (WA), signal range 0… 10 V or 4… 20 mA, scalable (SIGNAL W)
PIN 14 /13	Pressure feedback value (X), signal range 0… 10 V or 4… 20 mA, scalable (SIGNAL X)
PIN 11	0 V (GND) connection for analog signals
PIN 12	8V reference voltage output
PIN 3 / 4	PWM output to the solenoid
Connection	**Digital inputs and outputs**
PIN 15	**Enable input:** Generally enabling of the application.
PIN 6	**RUN (Start) Input**: **ON:** The controller is active. **OFF:** The controller is not active.
PIN 5	**READY output:** **ON:** The module is enabled; there are no discernable errors. **OFF:** ENABLE (PIN 15) is not active or an error has been detected.

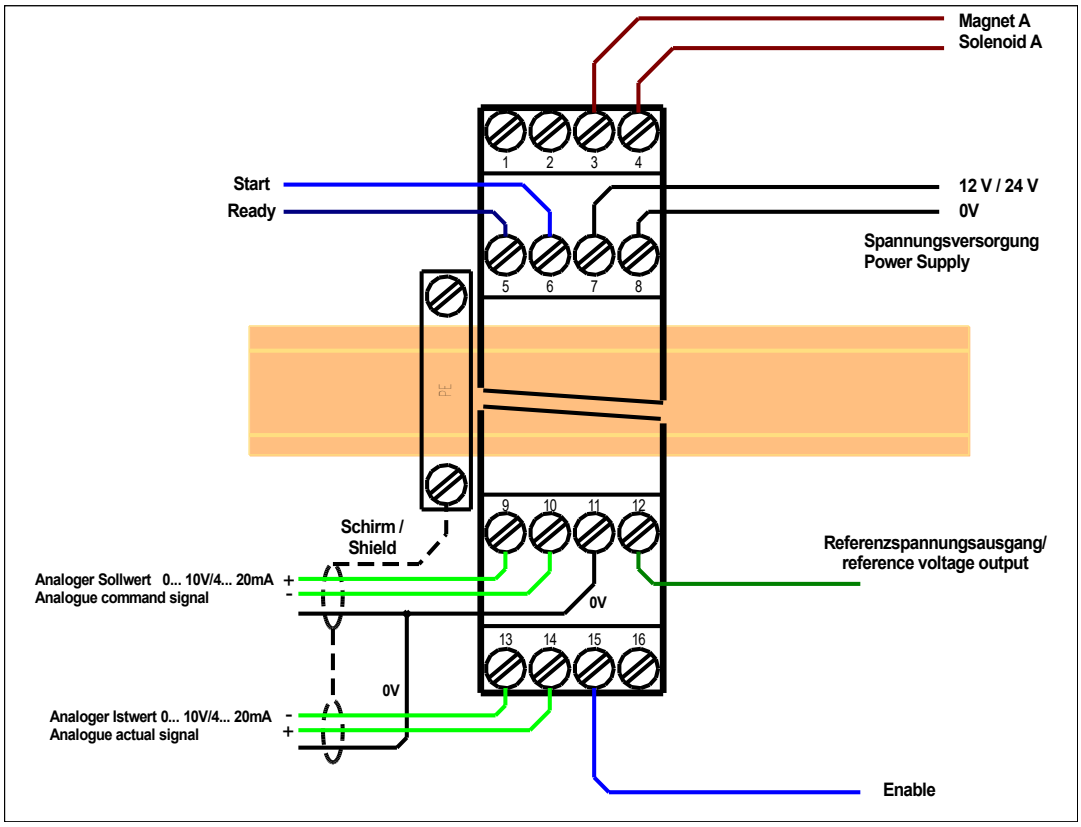
4.2 LED definitions

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 peration ***Flashing:*** Error discovered Only active when SENS = ON
YELLOW A	Intensity of the solenoid current
GREEN + YELLOW A	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 non-volatile stored parameters are inconsistent! To acknowledge the error, data has to be saved with the SAVE command or the corresponding button in the WPC.

4.3 Circuit diagram

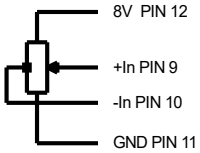


4.4 Typical wiring

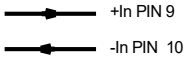


4.5 Connection examples

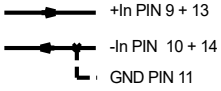
Joystick



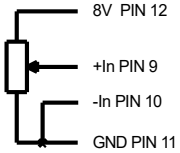
4... 20 mA input



SPS / PLC 0... 10 V / +/- 10 V



Potentiometer / Joystick



4.6 Technical data

Supply voltage (U_b) Current requirement External protection	**[VDC]** **[mA]** **[A]**	12… 30 (incl. ripple) 30 + solenoid current 3 medium time lag
Reference output Voltage Max. load	 **[V]** **[mA]**	 8 25
Digital inputs OFF ON Input resistance	 **[V]** **[V]** **[kOhm]**	 < 2 > 10 25
Digital outputs 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 / differential 0… 10 / -10… 10 min. 90 4… 20 390 0,03
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]**	0,13
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
Basic parameters				
	LG	EN	-	Changing language help texts
	MODE	STD	-	Parameter view
	SENS	ON	-	Malfunction monitor
	EOUT	0	0,01 %	Output signal if not ready
Input signal adaptation				
	SYS_RANGE	100	bar	System pressure
Sensor scaling				
	SIGNAL:X	U0-10	V	Type of input
	N_RANGE:X	100	bar	Sensor nominal pressure
	OFFSET:X	0	mbar	Sensor offset
Command signal scaling				
	SIGNAL:W	U0-10	mbar	Type of input
Ramp function				
	RA:UP **RA:DOWN**	100 100	ms ms	Command signal ramp times
Control parameters				
PID controller				
	C:P **C:I** **C:D** **C:D_T1** **C:FF**	50 4000 0 500 8000	0,01 0,1 ms 0,1 ms 0,1 ms 0,01 %	P gain I gain D gain D gain filter Feed forward
Integrator control				
	C:I_LIM **C:I_ACT**	2500 2500	0,01 % 0,01 %	Integrator limitation Integrator activation threshold
Output signal adaptation				
	MIN	0	0,01 %	Deadband compensation
	MAX	10000	0,01 %	Output scaling
	TRIGGER	200	0,01 %	Deadband compensation trigger point
	SIGNAL:U	+	-	Output polarity
Powerstage parameters				
	CURRENT	1000	mA	Rated solenoid current
	DFREQ	121	Hz	Dither frequency
	DAMPL	500	0,01 %	Dither amplitude
	PWM	2604	Hz	PWM frequency
	ACC	ON	-	Current loop auto adjustment
	PPWM **IPWM**	7 40	- -	Gain of the current loop

Group	Command	Default	Unit	Description
Special commands				
Scaling mode				
	AINMODE	EASY	-	Input scaling mode
	AIN:X **AIN:W**	A: 1000 B: 1000 C: 0 X: V	- - 0,01 % -	Free scaling of the analog inputs. Gets activated when AINMODE is switched over to MATH.

5.2 Basic parameters

5.2.1 LG (Changing the language)

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

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

CAUTION: After changing the language settings, the ID button in the menu bar (WPC-300) must be pressed (module identification).

5.2.2 MODE (Parameter view)

Command		Parameters	Unit	Group
MODE	x	x= STD|EXP	-	**STD**

This command changes the operating mode. Various commands (defined via STD/EXP) are blanked out in Standard Mode. The commands in Expert Mode have a more significant influence on system behavior and should accordingly be changed with care.

5.2.3 SENS (Malfunction monitor)

Command		Parameters	Unit	Group
SENS	x	x= ON|OFF|AUTO	-	**STD**

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 EOUT (Output signal if not ready)

Command	Parameters	Unit	Group
EOUT X	x= -10000… 10000	0,01 %	**EXP**

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 drive is to move to one of the two end positions (at the specified speed) in case 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 InSignal adaptation

5.3.1 SYS_RANGE (System pressure)

Command	Parameters	Unit	Group
SYS_RANGE X	x= 10… 1000	bar	**STD**

This command defines the pressure, which corresponds to 100 % of the input signal. If the demand is set incorrectly, this leads to incorrect system settings, and the dependent parameters cannot be calculated correctly.

5.3.2 SIGNAL (Type of input signal)

Command	Parameters	Unit	Group
SIGNAL:I X	i= W|X x= OFF|U0-10|I4-20	-	**EASY**

This command can be used to change the type of input signal (voltages or current) and to define the direction of the signal. This command is available for all analog inputs (W and X).
OFF= Deactivation of the input

5.3.3 N_RANGE:X (Sensor nominal pressure)

Command	Parameter	Unit	Group
N_RANGE:X X	x= 10… 10000	bar	**EASY**

N_RANGE (nominal range) is used to define the length of the sensor. This value should be always higher than SYS_RANGE. The control parameter cannot be calculated correctly in case of wrong values.

5.3.4 OFFSET:X (Sensor offset)

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

Adjustment of the zero point of the sensor.

5.3.5 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)

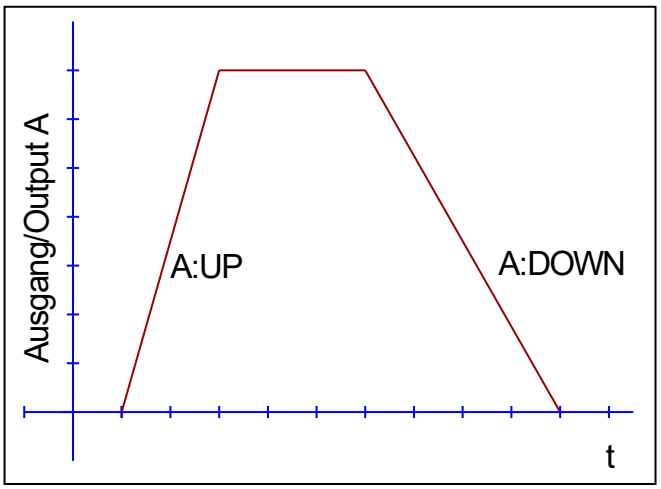
To scale this sensor correctly the following settings should be made:

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

5.3.6 RA (Command signal ramp time)

Command	Parameter	Unit	Group
RA:I X	i= UP|DOWN x= 1… 600000	ms	**STD**

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



5.4 Control parameters

5.4.1 PID controller

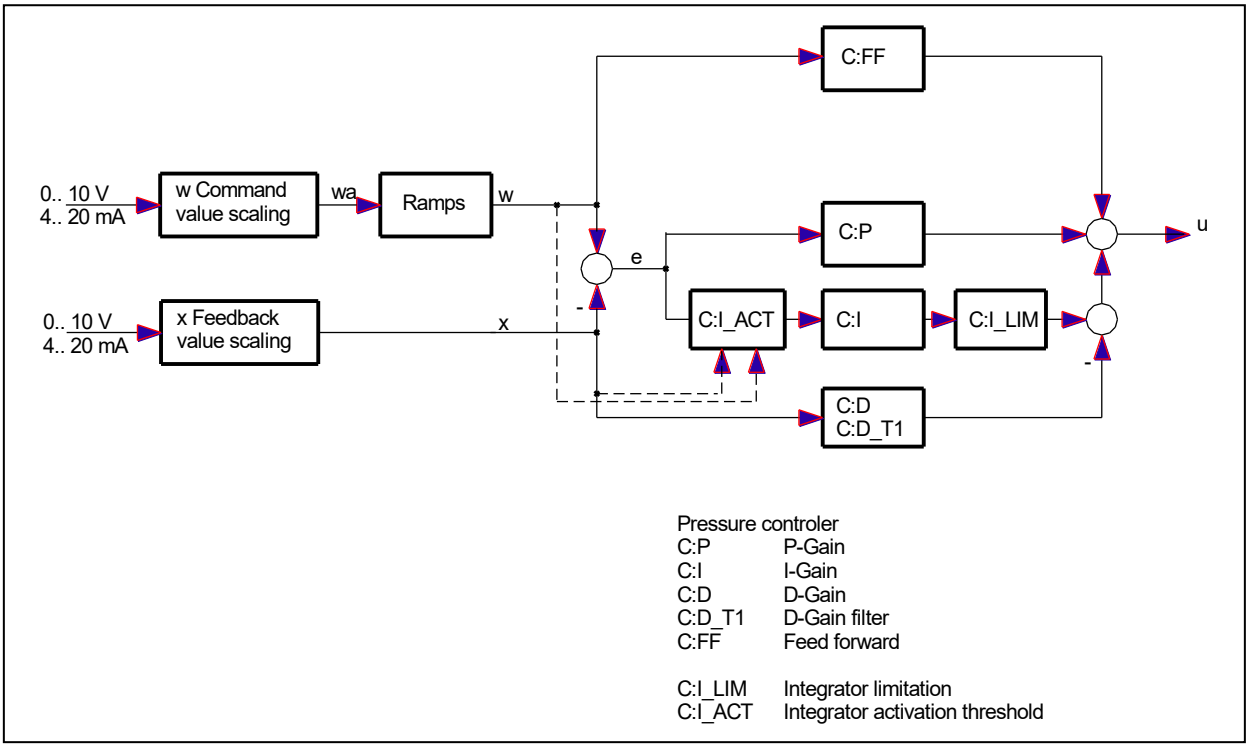
Command	Parameter	Unit	Group
C:I X	I= P|I|D|D_T1|FF		**STD**
	:P x= 0… 10000	0,01	
	:I x= 0… 30000	0,1 ms	
	:D x= 0… 1200	0,1 ms	
	:D_T1 x= 0… 1000	0,1 ms	
	:FF x= 0… 10000	0,01 %	

The control function will be parameterized via this command.

The P, I and D gain are similar to a standard PID controller. The T1 factor is used for the D-gain in order to suppress high-frequency noise.

The FF value is a forward control value to control the output by the input signal directly. The PID closed loop control function has only to adjust the difference (the error).

Value 0 deactivates the integrator.



5.4.2 Integrator control function

Command	Parameter	Unit	Group
C:I_LIM X	x= 0… 10000	0,01 %	**STD**
C:I_ACT X	x= 0… 10000	0,01 %	

The integrator function is controlled by this command.

C:I_LIM Limitation of the integrator range (faster control function by reduced pressure overshoots). By a high nonlinearity of the valve the LIM value must be sufficient to compensate it.

C:I_ACT Controls the integrator function. To reduce pressure overshoots, an activation point for the integrator can be programmed via the (I_ACT) value. The integrator is activated if the actual pressure is higher than the programmed threshold:

5.5 Output signal adaptation

5.5.1 MIN (Deadband compensation)

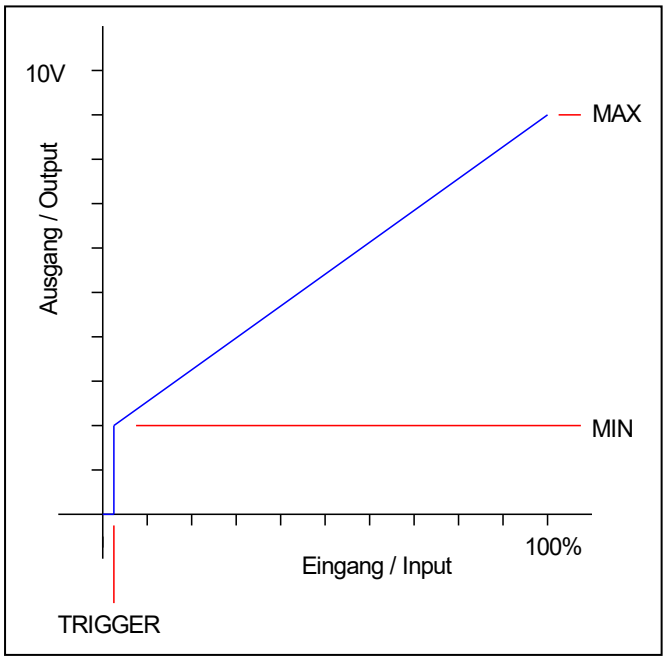
5.5.2 MAX (Output scaling)

5.5.3 TRIGGER (Response threshold for the MIN parameter)

Command	Parameters	Unit	Group
MIN:I X	x= 0… 6000	0,01 %	**STD**
MAX:I X	x= 3000… 10000	0,01 %	
TRIGGER X	x= 0… 3000	0,01 %	

With this command, the output signal is adjusted to the valve characteristics. With the MAX value the output signal (the maximum valve current) will be defined. With the MIN value the overlap (dead band of the valve) will be compensated. Via the TRIGGER the activation point of the MIN function is set and so a non-sensitive range around the zero-point[4] 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.



[4] 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).

5.5.4 SIGNAL:U (Output polarity)

Command	Parameter	Unit	Group
SIGNAL:U X	x= + | -	-	**EXP**

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

5.6 Output signal adaptation

5.6.1 CURRENT (Rated solenoid current)

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

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

5.6.2 DFREQ (Dither frequency)

5.6.3 DAMPL (Dither amplitude)

Command	Parameters	Unit	Group
DFREQ X	x= 60… 400	Hz	**STD**
DAMPL X	x= 0… 3000	0,01 %	

The dither[5] 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[6] (see: CURRENT command). The dither frequency is defined in Hz. Depending on the internal calculations, the frequency is adjustable in steps only[7].

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.*

[5] The dither is a ripple 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.

[6] The dither amplitude is a command signal. Derivations between the commanded amplitude and the real amplitude are possible, depending on the dynamic of the solenoid.

[7] The lower the dither frequency, the smaller the steps. Therefore no practical problems are expected.

5.6.4 PWM (PWM Frequency)

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

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 and 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.*

5.6.5 ACC (Current loop auto adjustment)

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

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.

5.6.6 PPWM (P gain of the current loop)

5.6.7 IPWM (I gain of the current loop)

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

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

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

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.

5.7 Special commands

5.7.1 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.

5.7.2 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 2500 1000 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 PROCESS DATA (Monitoring)

Command	Description	Unit
WA	Input signal	mm
W	Command value	mm
X	Feedback value	mm
E	Control error	mm
U	Output	%
IA	Solenoid current[8]	mA

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

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

6 Appendix

6.1 Failure monitoring

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

Source	Fault	Characteristic
Command signal PIN 9/10 4... 20 mA	Out of range or broken wire	The output will be switched off.
Feedback signal PIN 14 4… 20 mA	Out of range or broken wire	The output will be switched off.
Solenoids on PIN 3-4	Wrong cabling, broken wire	The power stage will be deactivated.
EEPROM (when switching on)	Data error	The output is deactivated. The module can only be activated by saving the parameters again!

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

7 Notes