WEST

Technical Documentation

MDR-337-P

Pressure control module with integrated power amplifier
and comissioning assistant

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CONTENTS

1 General Information 4
1.1 Order number 4
1.2 Scope of supply 4
1.3 Accessories 4
1.4 Symbols used 5
1.5 Legal notice 5
1.6 Safety instructions 6
2 Characteristics 7
2.1 Device description 8
2.2 Use and application 9
2.2.1 Installation instructions 9
2.2.2 Typical system structure 10
2.3 Method of operation 10
3 Commissioning 11
3.1 General Procedure 11
3.2 Comissioning assistant 12
3.2.1 Operating principle 12
3.2.2 Operation 12
3.2.3 Parameters 13
3.2.4 SR (Status Report) 13
3.2.5 Options for post-optimization by the user 15
4 Technical description 17
4.1 Input and output signals 17
4.2 LED definitions 17
4.3 Block diagram 18
4.4 Typical wiring 19
4.5 Connection examples 19
4.6 Technical data 20
5 Parameters 21
5.1 Parameter overview 21
5.2 Basic parameters 22
5.2.1 LG (Changing the language) 22
5.2.2 MODE (Parameter view) 22
5.2.3 SENS (Malfunction monitor) 23
5.2.4 EOUT (Output signal if not ready) 23
5.2.5 SYS_RANGE (System pressure) 23
5.3 Input Signal Definition 24
5.3.1 SIGNAL (Type of input signal) 24
5.3.2 N_RANGE:X (Sensor nominal pressure) 24
5.3.3 OFFSET:X (Sensor offset) 24
5.3.4 Using of the commands SYS_RANGE, N_RANGE:X and OFFSET:X 24
5.3.5 RA (Command signal ramp time) 25
5.4 Control parameters 26
5.4.1 CTRLTYPE (Type of the controller) 26
5.4.2 PID controller 26
5.4.3 MR – Pressure Controller (alternative) 28
5.4.4 PL:DYN (Lower limit for dynamics measurement) 28
5.5 Output signal adaptation 29
5.5.1 CCMODE (Activation of the characteristic curve linearization) 29
5.5.2 CCSET (Linearization curve) 29

5.5.3 MIN (Deadband compensation) 30
5.5.4 MAX (Output scaling) 30
5.5.5 TRIGGER (Response threshold for the MIN parameter) 30
5.5.6 SIGNAL:U (Output polarity) 31
5.6 Output signal adaptation 31
5.6.1 CURRENT (Rated solenoid current) 31
5.6.2 DFREQ (Dither frequency) 31
5.6.3 DAMPL (Dither amplitude) 31
5.6.4 PWM (PWM Frequency) 32
5.6.5 ACC (Current loop auto adjustment) 32
5.6.6 PPWM (P gain of the current loop) 32
5.6.7 IPWM (I gain of the current loop) 32
5.7 Special commands 33
5.7.1 AINMODE (Scaling mode) 33
5.7.2 DIAG (Query of the last switch-off causes) 33
5.7.3 AIN (Analog input scaling) 33
5.8 PROCESS DATA (Monitoring) 34
6 Appendix 35
6.1 Failure monitoring 35
7 Notes 36

1 General Information

1.1 Order number

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

Alternative products

MDR-137-P - pressure control module with integrated power output stage up to 2,6 A and analog interface **without** comissioning assistant

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 %)

1.2 Scope of supply

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

1.3 Accessories

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

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

1.4 Symbols used

General information

Safety-related information

1.5 Legal notice

W.E.St. Elektronik GmbH

Gewerbering 31
D-41372 Niederkrüchten

Tel.: +49 (0)2163 577355-0
Fax.: +49 (0)2163 577355-11

Home page: www.w-e-st.de
EMAIL: contact@w-e-st.de

Date: 03.01.2025

1.6 Safety instructions

Please read this document and the safety instructions carefully. This document will help to define the product area of application and to put it into operation. Additional documents (WPC-300 for the start-up software) and knowledge of the application should be taken into account or be available.
General regulations and laws (depending on the country: e. g. accident prevention and environmental protection) must be complied with.

These modules are designed for hydraulic applications in open or closed-loop control circuits. Uncontrolled movements can be caused by device defects (in the hydraulic module or the components), application errors and electrical faults. Work on the drive or the electronics must only be carried out whilst the equipment is switched off and not under pressure.

This handbook describes the functions and the electrical connections for this electronic assembly. All technical documents which pertain to the system must be complied with when commissioning.

This device may only be connected and put into operation by trained specialist staff. The instruction manual must be read with care. The installation instructions and the commissioning instructions must be followed. Guarantee and liability claims are invalid if the instructions are not complied with and/or in case of incorrect installation or inappropriate use.

CAUTION!
All electronic modules are manufactured to a high quality. Malfunctions due to the failure of components cannot, however, be excluded. Despite extensive testing the same also applies for the software. If these devices are deployed in safety-relevant applications, suitable external measures must be taken to guarantee the necessary safety. The same applies for faults which affect safety. No liability can be assumed for possible damage.

Further instructions

- The module may only be operated in compliance with the national EMC regulations. It is the user's responsibility to adhere to these regulations.
- The device is only intended for use in the commercial sector.
- When not in use the module must be protected from the effects of the weather, contamination and mechanical damage.
- The module may not be used in an explosive environment.
- To ensure adequate cooling the ventilation slots must not be covered.
- The device must be disposed of in accordance with national statutory provisions.

2 Characteristics

This module was developed for controlling the pressure in hydraulic systems. The controller structure is optimised for applications with typical pressure valves (proportional relief or pressure control valves and also for pressure-controlled pumps with pilot valve). An integrated power stage and highly dynamic control loops offer a simple and powerful solution.

The controller works with feedforward control, whereby the input signal is directly combined with the control output via a linearisation function. This means that the PID controller only has to adjust the hysteresis and the volume influence. The integrated commissioning assistant makes it much easier to set this important characteristic curve and, after activation, also carries out measurements to automatically set the PID parameters.

The output signal is available as an integrated PWM power signal from 0.5 to 2.6 A and is overcurrent and short-circuit proof.

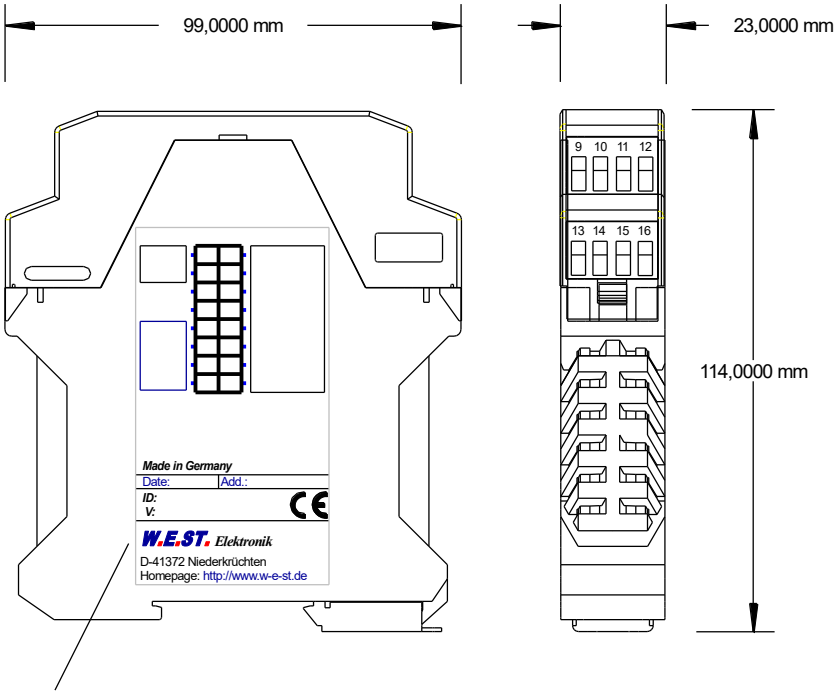
The simple handling ensures a very short training period.

Typical applications: Pressure control with pressure valves or variable displacement pumps with pressure pilot valve.

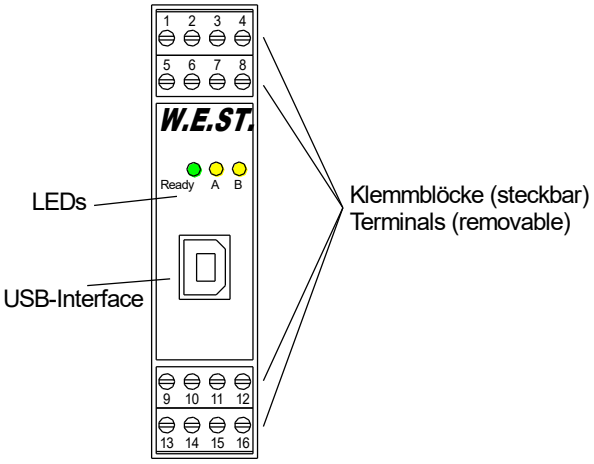
Features

- **Activation of pressure reducing valve and pressure control valve**
- **Compact housing**
- **Digital reproducible adjustments**
- **Universal PID actuator**
- **Alternative: MR - controller activatable, patented and particularly robust solution**
- **Commissioning assistant for determining an optimum feedforward characteristic and for dynamic controller adjustment**
- **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.

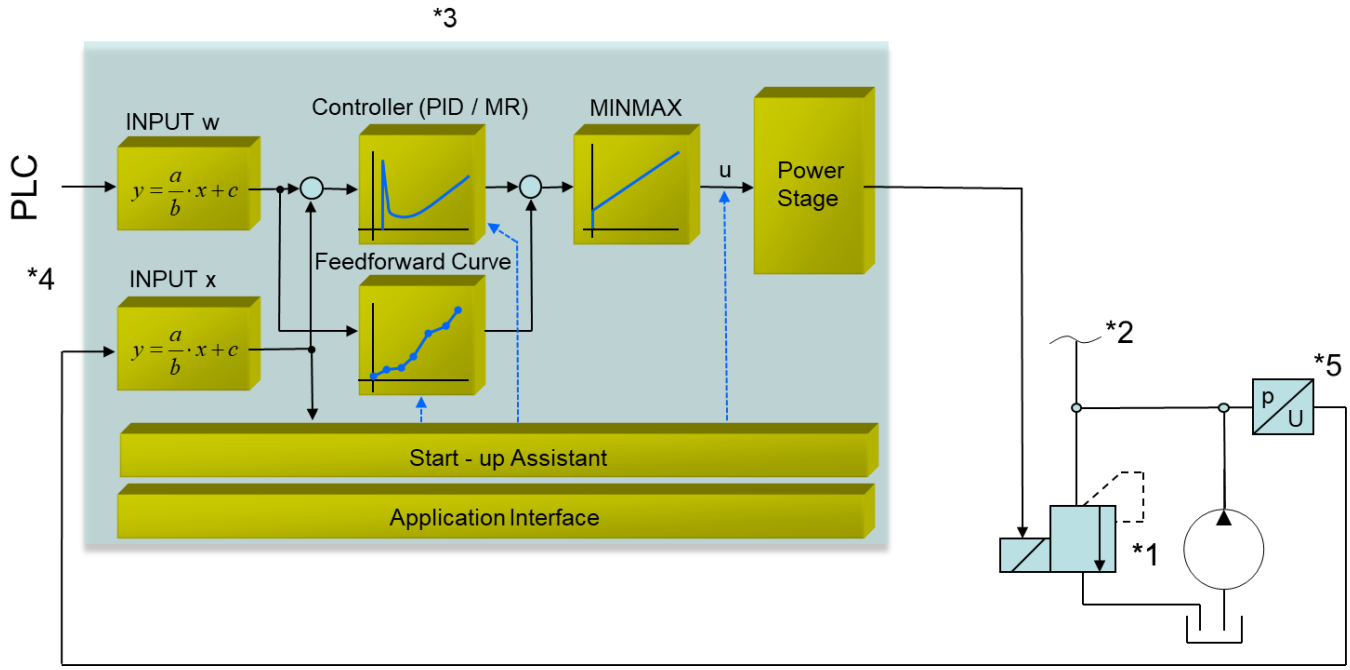
- The module should be installed and wired in accordance with the documentation bearing in mind EMC principles. If other consumers are operated with the same power supply, a star-shaped ground wiring scheme is recommended. The following points must be observed when wiring:
  - The signal cables must 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) Pressure line to the consumers
(*3) MDR-337-P pressure control module with integrated power amplifier
(*4) Interface to the 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

3.1 General 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 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.
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.
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.

3.2 Comissioning assistant

3.2.1 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 linearization 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.

3.2.2 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.
☐ 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 8 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 there are problems when 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 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". 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 (PIN 9/10). Please observe the safety notes.

3.2.3 **Parameters**

The following parameters are changed by the assistant:

Parameter	Beschreibung	Änderung:
C:P	P Gain	Is set according to the T - summation method.
C:I	I part, integration time	Is set according to the T - summation method.
C:D	D part, derivative time	Is deactivated (value „0“, pure PI – controller)
C:I_LIM	Integrator limitation	Is set depending on the valve hysteresis
C:I_ACT	Integrator activation threshold	Is set to "0" -> integrator always active
MR:T1	Time constant 1 of the MR - controller	Is determined using the system time constant
MR:T2	Time constant 2 of the MR - controller	Is determined using the system time constant
CCMODE	Characteristics linearization	Is switched on if previously inactive.
CCSET	Operational Curve	Is optimally adjusted based on the measured valve characteristics.

3.2.4 **SR (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 re-start	The assistant has not been called up since the module was last switched on.
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: PL:DYN < 0.6 * SYS_RANGE. If necessary, reduce PL:DYN. • 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 been done since the last time the device was switched on.
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" 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". • Incorrect parameterization of the sensor input (SIGNAL:X, N_RANGE: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" 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.

3.2.5 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:P)
   - ➔ Reduce the reset time (C:I)
   - ➔ Carefully activate the D - component (C:D and C:D_T1)

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

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

4.) Remaining control deviation
   - ➔ Increase the integrator limitation (C: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: (see on next page)

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

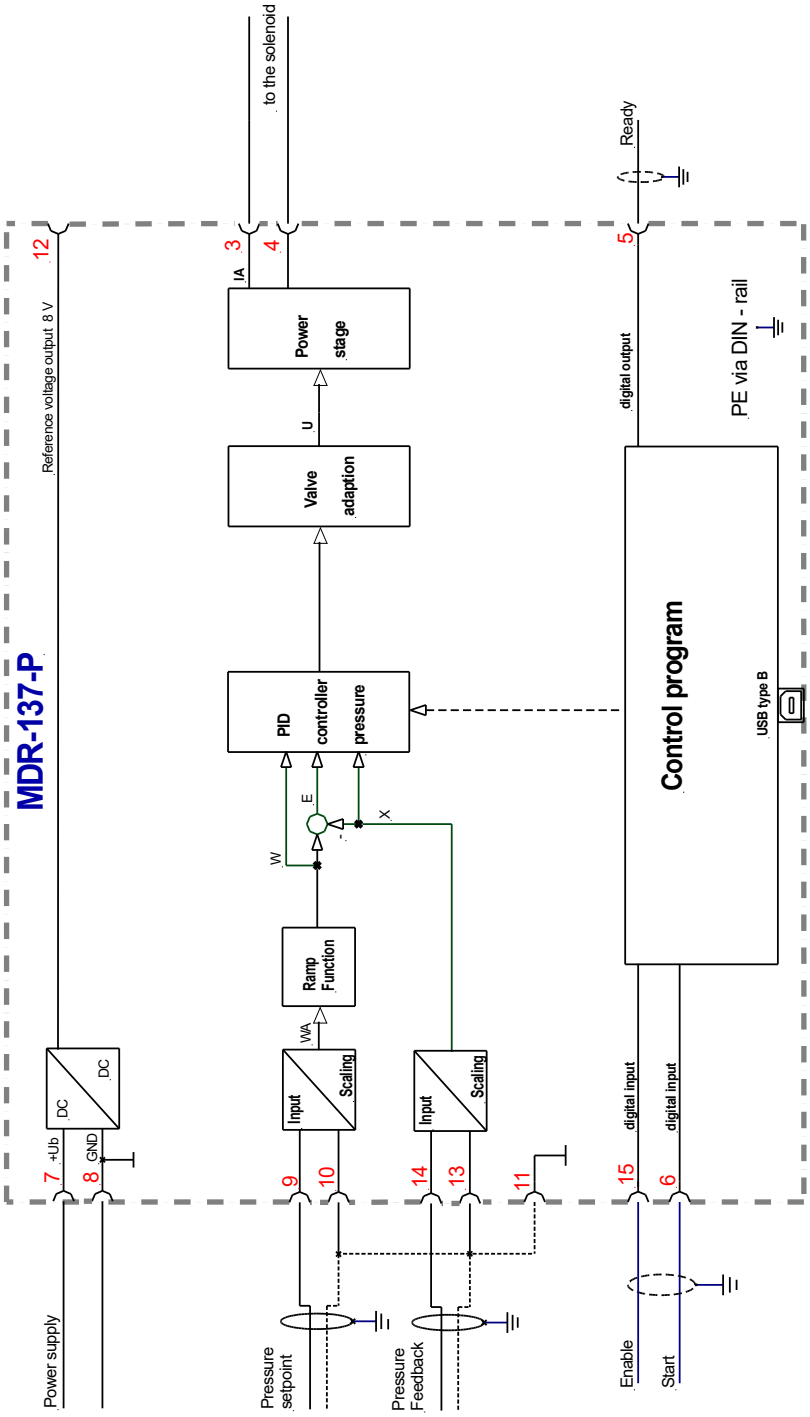
4.1 Input and output signals

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.

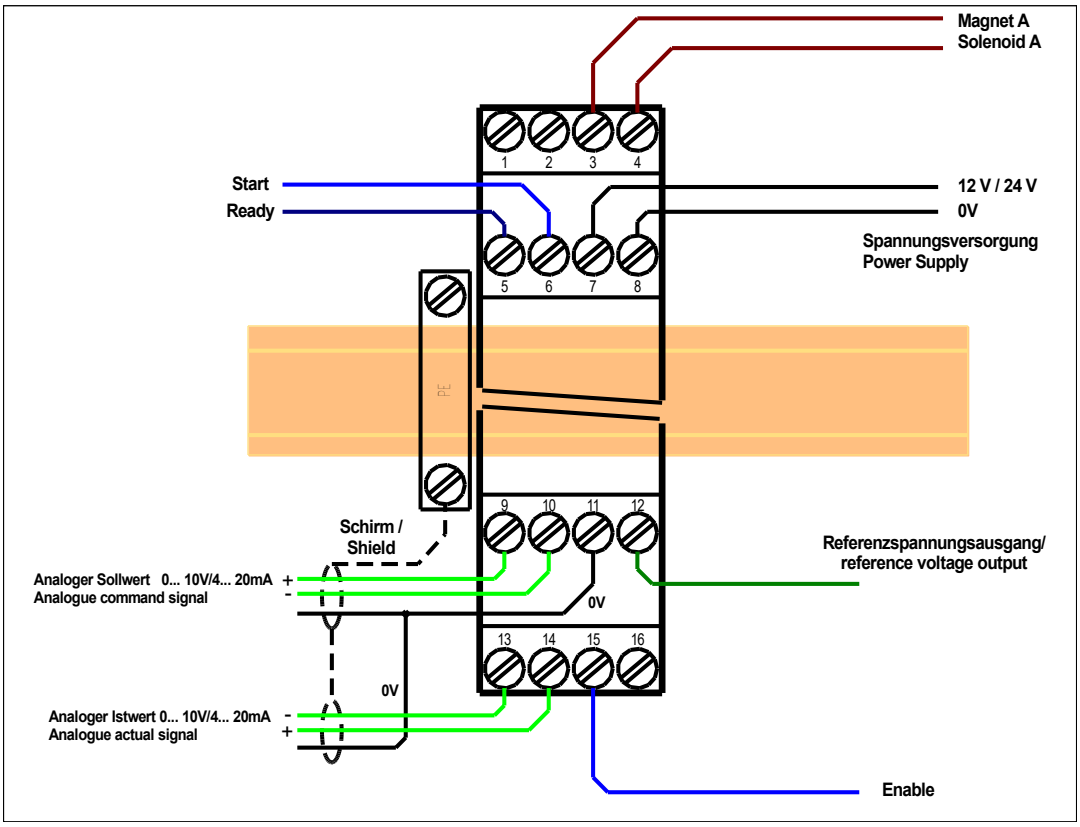
4.2 LED definitions

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 Block diagram

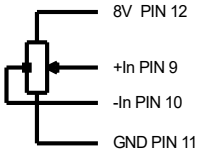


4.4 Typical wiring

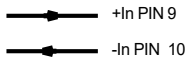


4.5 Connection examples

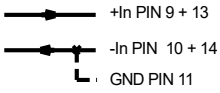
Joystick



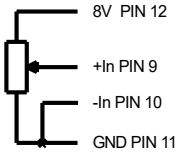
4... 20 mA input



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



Potentiometer / Joystick



4.6 Technical data

Supply voltage (U_b)	**[VDC]**	12… 30 (incl. ripple)
Current requirement	**[mA]**	30 + solenoid current
External protection	**[A]**	3 medium time lag
Reference output		
Voltage	**[V]**	8
Max. load	**[mA]**	25
Digital inputs		
OFF	**[V]**	< 2
ON	**[V]**	> 10
Input resistance	**[kOhm]**	25
Digital outputs		
OFF	**[V]**	< 2
ON	**[V]**	max. V_{cc}
Max. output current	**[mA]**	50
Analog inputs:		Unipolar / differential
Voltage	**[V]**	0… 10 / -10… 10
Input resistance	**[kOhm]**	min. 90
Current	**[mA]**	4… 20
Burden	**[Ohm]**	390
Signal resolution	**[%]**	0,03
PWM output		Wire break and short circuit monitored
Max. output current	**[A]**	2,6
Frequency	**[Hz]**	61… 2604 selectable in defined steps
Controller cycle times		
Solenoid current control	**[µs]**	125
Signal processing	**[ms]**	1
Serial interface	**-**	USB - virtual COM Port
Transmission rate	**[kBaud]**	9,6… 115,2
Housing		Snap-on module acc. EN 50022
Material		PA 6.6 polyamide
Flammability class		V0 (UL94)
Weight	**[kg]**	0,13
Protection class	**[IP]**	20
Temperature range	**[°C]**	-20… 60
Storage temperature	**[°C]**	-20… 70
Humidity	**[%]**	< 95 (non-condensing)
Vibration resistance	**-**	IEC 60068-2-6 (Category C)
Connections		
Communication	**-**	USB type B
Plug connectors		4 x 4-pole terminal blocks
PE		via the DIN mounting rail
EMC		EN 61000-6-2: 8/2005 EN 61000-6-4: 6/2007 + A1:2011

5 Parameters

5.1 Parameter overview

Group	Command	Default	Unit	Description
Basic parameters				
	LG	EN	-	Select language of the help texts
	MODE	STD	-	Parameter view
	SENS	ON	-	Malfunction monitor
	EOUT	0	0,01 %	Output signal if not ready
	SYS_RANGE	100	bar	System pressure
Input signals				
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				
	CTRLTYPE	PID	-	Select the controller type
PID controller				
	C:P **C:I** **C:I_LIM** **C:I_ACT** **C:D** **C:D_T1** **C:FF**	50 4000 2500 2500 0 500 8000	0,01 0,1 ms 0,01 % 0,01 % 0,1 ms 0,1 ms 0,01 %	P gain I gain Integrator limitation Integrator activation threshold D gain D gain filter Feed forward
MR Controller				
	MR:T1 **MR:T2**	150 300	0,1 ms 0,1 ms	Time constants of the MR controller
Commissioning assistant				
	PL:DYN	0	bar	Lower pressure for dynamic measurement
Valve linearization				
	CCMODE	ON	-	Activation of the characteristic curve linearization
	CCSET	X Y	-	Automatically determined feedforward control characteristic
	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

Group	Command	Default	Unit	Description
	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

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.

5.2.5 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.

For the commissioning assistant, the pressure entered here represents the upper limit of the range in which the characteristic curve is linearized. The recording ends when this value is reached.

Therefore, a pressure should be entered here which can actually be reached without triggering further safeguards (e.g. fixed pressure relief valve).

5.3 Input Signal Definition

5.3.1 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

5.3.2 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.

5.3.3 OFFSET:X (Sensor offset)

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

Adjustment of the zero point of the sensor.

5.3.4 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)

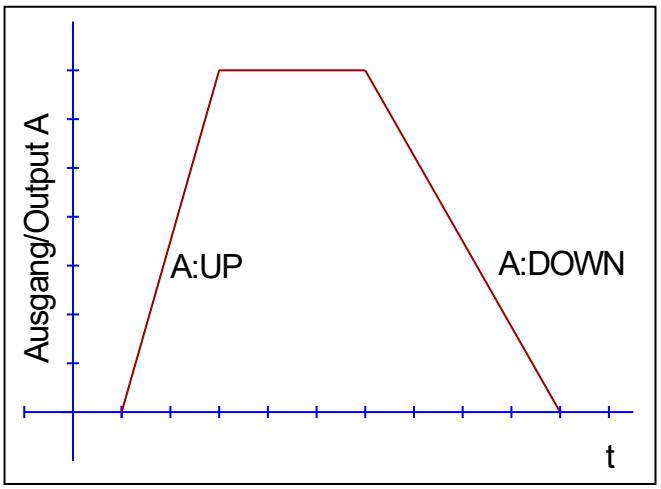
To scale this sensor correctly the following settings should be made:

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

5.3.5 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 CTRLTYPE (Type of the controller)

Command	Parameter	Unit	Group
CTRLTYPE x	x= PID|MR	-	**EXP**

This command is used to select the type of controller. It is possible to switch between a standard PID - controller and the MR - controller. The latter is characterized by its particularly stable operation and easy adjustment.

5.4.2 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	
	I_LIM x= 0… 10000	0,01 %	
	I_ACT x= 0… 10000	0,01 %	
	: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.

Value 0 deactivates the integrator.

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.

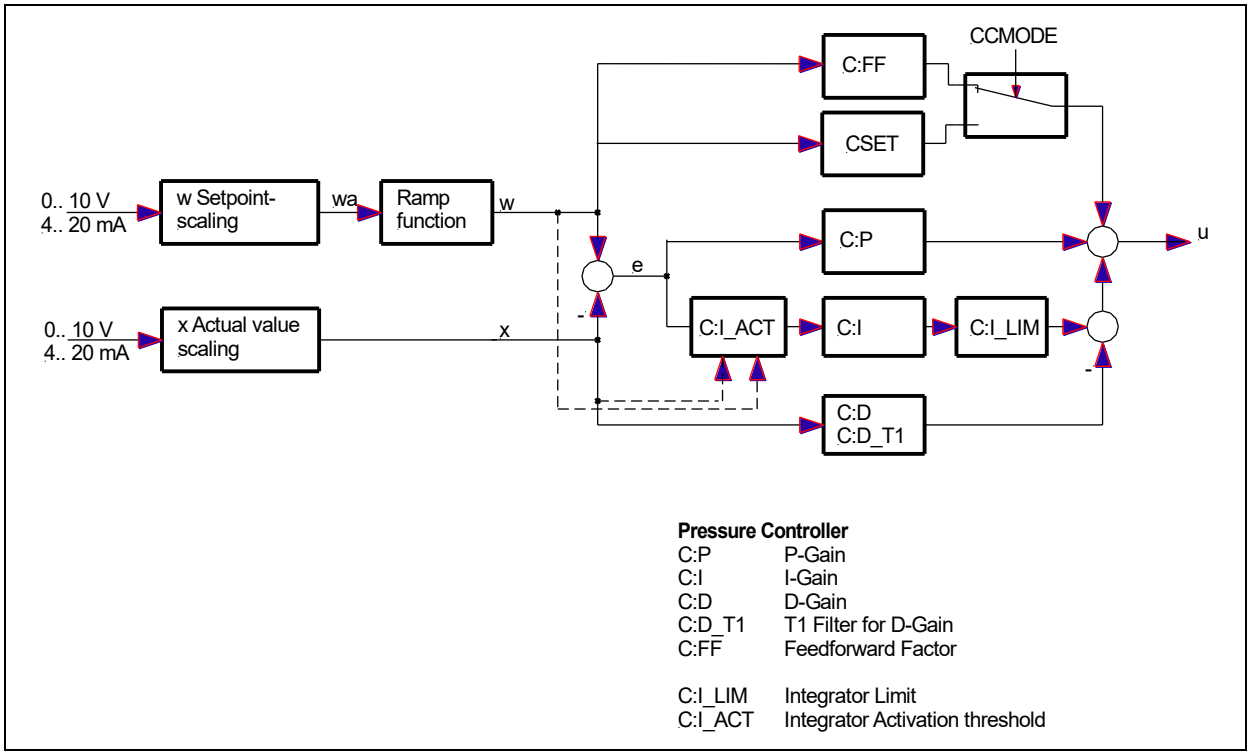
In this module an intelligent characteristic linearization is used, therefore the parameter C:FF listed here is normally not visible. CCMODE = ON switches to a characteristic curve by default, which can be displayed and, if necessary, adjusted via CCSET. The setting of this characteristic should normally be done with the help of the commissioning assistant.

Via the feed forward function by means of CCSET the set point is converted into an output signal which generates the correct pressure via the hydraulic control of the connected proportional valve or pump pressure control even without controller intervention.

In 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:



Pressure Controller

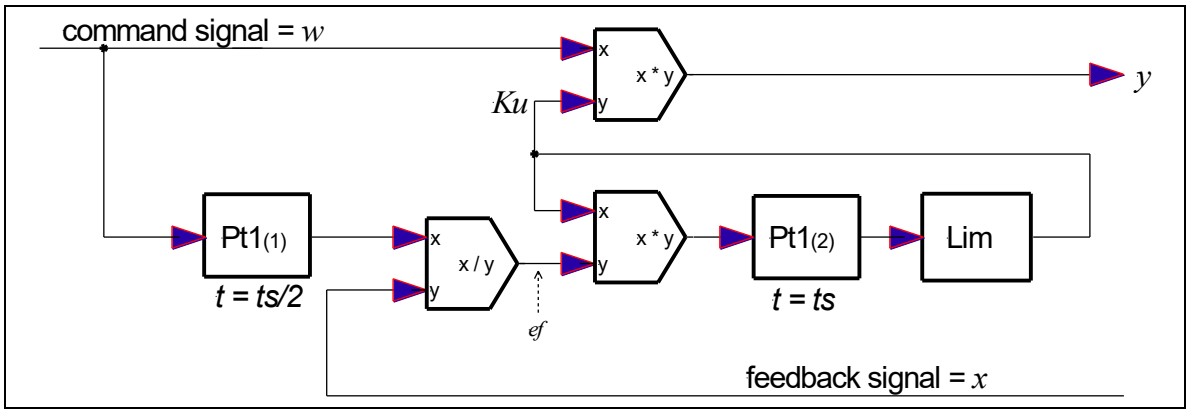
C:P	P-Gain
C:I	I-Gain
C:D	D-Gain
C:D_T1	T1 Filter for D-Gain
C:FF	Feedforward Factor
C:I_LIM	Integrator Limit
C:I_ACT	Integrator Activation threshold

5.4.3 MR – Pressure Controller (alternative)

Command	Parameter	Unit	Group
MR:T1	x= 0… 10000	0,1 ms	**STD**
MR:T2	x= 0… 10000	0,1 ms	

The MR regulator is an alternative possibility for pressure control. This controller is characterised by particularly simple parameterisation.

The time constant MR:T2 corresponds approximately to the system time constant and MR:T1 is around half the time of MR:T2.



5.4.4 PL:DYN (Lower limit for dynamics measurement)

Command	Parameter	Unit	Group
PL:DYN	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.

5.5 Output signal adaptation

5.5.1 CCMODE (Activation of the characteristic curve linearization)

Command	Parameter	Unit	Group
CCMODE X	x= ON|OFF	-	STD

This command is used to enable or disable the linearization function. Since the characteristic curve set by the commissioning assistant is a central function of the module, this parameter is set to the value "ON" by the assistant, which usually does not need to be changed.

5.5.2 CCSET (Linearization curve)

Command	Parameter	Unit	Group
CC:I X Y	i= -10… 10 x= -10000… 10000 y= -10000… 10000	- 0,01 % 0,01 %	CCMODE=ON

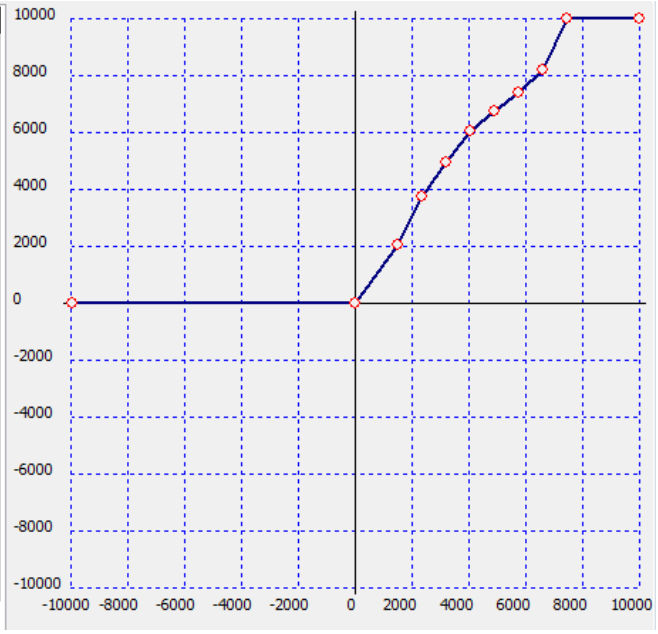
At this point the set characteristic curve can be displayed. The X-axis corresponds to the pressure, the Y-axis to the necessary control signal. This display is mirrored in comparison to a normal valve characteristic curve.

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



5.5.3 MIN (Deadband compensation)

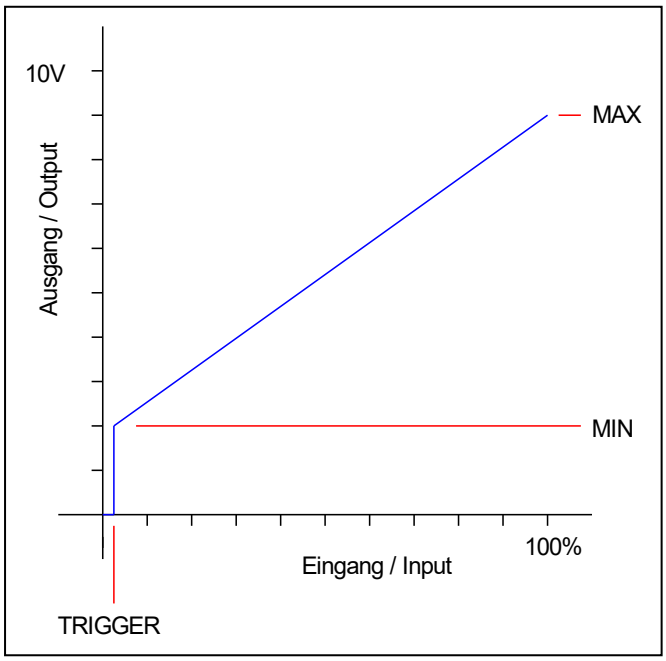
5.5.4 MAX (Output scaling)

5.5.5 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[1] 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!

[1] 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).

5.5.6 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[2] 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[3] (see: CURRENT command). The dither frequency is defined in Hz. Depending on the internal calculations, the frequency is adjustable in steps only[4].

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.*

[2] 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.

[3] 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.

[4] 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	**STD**

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 DIAG (Query of the last switch-off causes)

If this command is entered in the terminal window, the last 10 shutdowns (loss of Ready when Enable is present) 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:

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

5.7.3 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 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[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 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