W.E.S.T. Elektronik GmbH

Technical Documentation

SCU-138-P

Speed control unit with integrated power stage

CONTENTS

1 General Information

1.1 Order number

SCU-138-P - Speed control unit with integrated power stage and pulse transmitter input

1.2 Scope of supply

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

1.3 Accessories

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

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

1.4 Symbols used

General information

Safety-related information

1.5 Legal notice

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The data and characteristics described herein serve only to describe the product. The user is required to evaluate this data and to check suitability for the particular application. General suitability cannot be inferred from this document. We reserve the right to make technical modifications due to further development of the product described in this manual. The technical information and dimensions are non-binding. No claims may be made based on them.

1.6 Safety instructions

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

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

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

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

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

Further instructions

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

2 Characteristics

This module was developed for controlling a universal closed loop control system for speed and velocity control. A power amplifier for proportional valves is integrated. Various parameter settings allow an optimal adaptation to the corresponding valve. The controller runs with a loop time of 1 ms and the amplifier with 0,125 ms for the current control.

The command value is received by an analogue input signal (range 0… 10V or 4… 20mA). Alternatively the setpoint can be defined by an internal parameter (e.g. for generator speed control). Another possibility is the use of a PWM modulated signal for the transmittal of the command value.

Ramp function and PID controller can be used universally. The output current is closed loop controlled and therefore independent from the supply voltage and a varying solenoid resistance. The output stage is monitored (short circuit / broken wire) and switches off in case of detected error.

By the free parameterization of the power stage all typical proportional valves of the different manufactures can be optimal adapted.

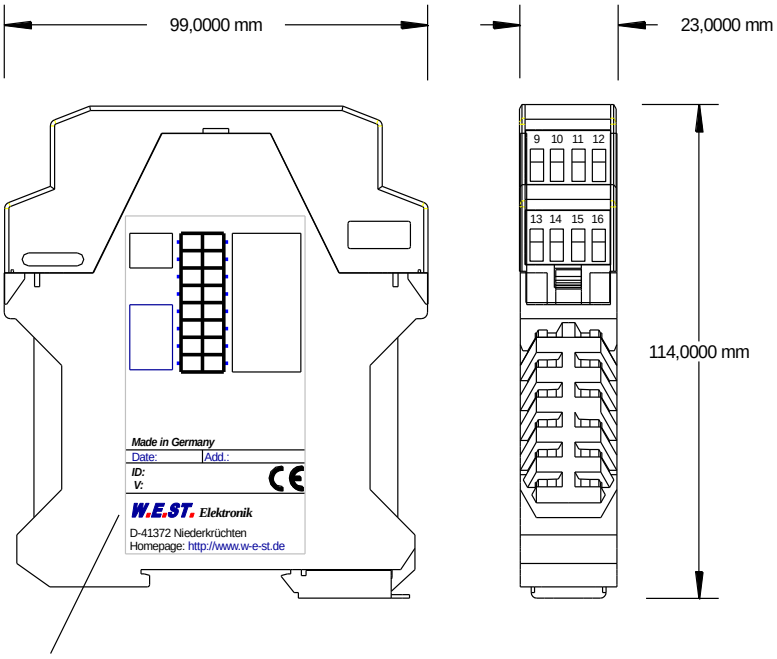
Because of the easy handling a very short training period is guaranteed.

Typical applications: Speed control using an impulse sensor.

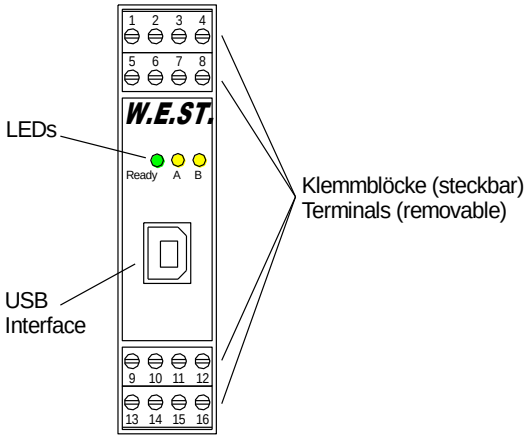
Features

- **Universal speed control unit**
- **Compact housing**
- **Digital reproducible adjustments**
- **Free scaling of the analogue command input**
- **Alternatively scalable PWM command input**
- **Universal PID controller**
- **Controlling of proportional valves with one or two solenoids**
- **Direct connection of pulse transmitter**
- **Free parameterization of ramps, MIN and MAX, DITHER (frequency and amplitude) and PWM frequency of the solenoid output**
- **Output current up to 2.6 A**
- **Adaptable to all standard proportional valves**
- **Application orientated parameter settings**
- **Fault diagnosis and extended function checking**
- **Parameterization via USB interface with WPC-300 software**

2.1 Device description



Typenschild und Anschlussbelegung
Type plate and terminal pin assignment



3 Use and application

3.1 Installation instructions

- This module is designed for installation in a shielded EMC housing (control cabinet). All cables which lead outside must be screened; complete screening is required. It is also necessary to avoid strong electro-magnetic interference sources being installed nearby when using our open and closed loop control modules.

- **Typical installation location:** 24 V control signal area (close to PLC)
  The devices must be arranged in the control cabinet so that the power section and the signal section are separate from each other.
  Experience shows that the installation place close to the PLC (24 V area) is most suitable. All digital and analogue inputs and outputs are fitted with filters and surge absorbers in the device.

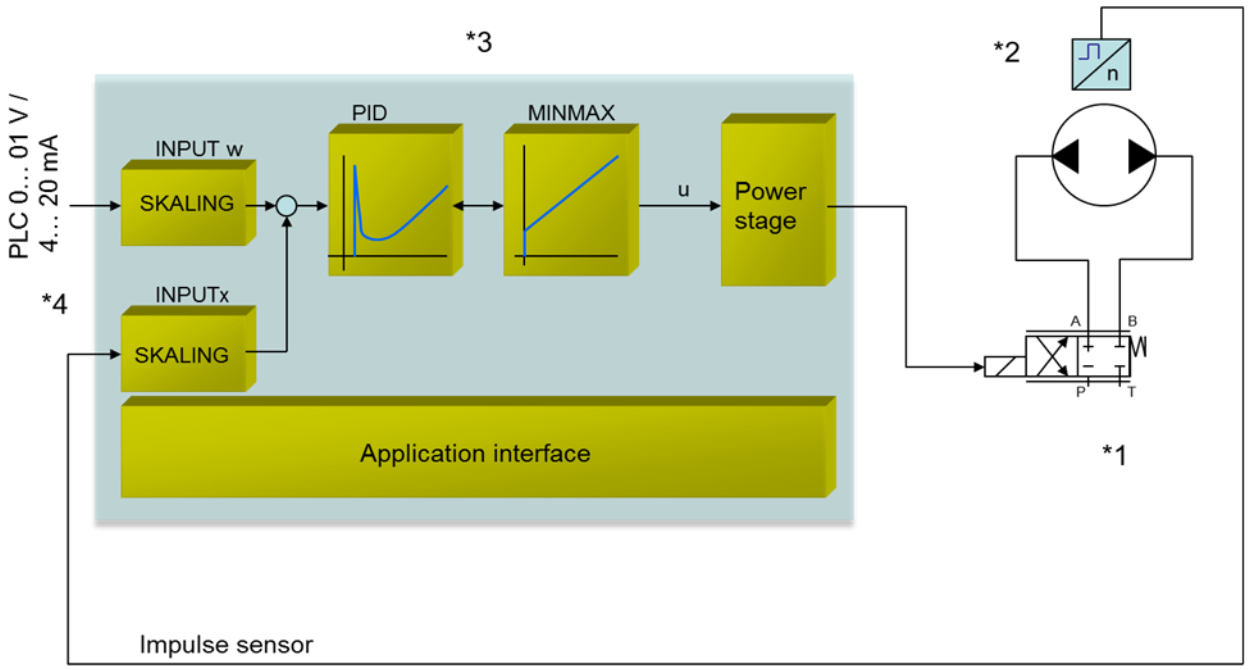
- The module should be installed and wired in accordance with the documentation bearing in mind EMC principles. If other consumers are operated with the same power supply, a star-shaped ground wiring scheme is recommended. The following points must be observed when wiring:
  - The signal cables must be laid separately from power cables.
  - Analogue signal cables **must be screened**.
  - All other cables must be screened if there are powerful interference sources (frequency converters, power contactors) and cable lengths > 3 m. Inexpensive SMD ferrites can be used with high-frequency radiation.
  - The screening should be connected to PE (PE terminal) as close to the module as possible. The local requirements for screening must be taken into account in all cases. The screening should be connected to at both ends. Equipotential bonding must be provided where there are differences between the connected electrical components.
  - If having longer lengths of cable (> 10 m), the diameters and screening measures should be checked by specialists (e. g. for possible interference, noise sources and voltage drop). Special care is required if using cables of over 40 m in length, and if necessary the manufacturer should be consulted if necessary.

- A low-resistance connection between PE and the mounting rail should be provided. Transient interference is transmitted from the module directly to the mounting rail and from there to the local earth.
- Power should be supplied by a regulated power supply unit (typically a PELV system complying with IEC364-4-4, secure low voltage). The low internal resistance of regulated power supplies gives better interference voltage dissipation, which improves the signal quality of high-resolution sensors in particular. Switched inductances (relays and valve coils) which are connected to the same power supply must always be provided with appropriate overvoltage protection directly at the coil.

3.2 Typical system structure

This minimal system consists of the following components:

(*1) Proportional valve
(*2) Pulse transmitter
(*3) Speed control unit SCU-138-P
(*4) Interface to PLC



3.3 Method of operation

This speed control module is controlled via an analogue command signal (from plc, joystick or potentiometer), a PWM Signal or a fix programmed command value. An ENABLE signal (24 V typical) activates the functions and if error-free operation this is reported via a READY output. Now the device is in power amplifier mode. The control loop is initiated by a digital START input. Therefore, the actual value is read by an encoder. If using two solenoids the closed loop controller gets activated directly with the ENABLE signal. The digital START input is used for switching the solenoids in this mode (DIR).

The integrated standard features are configured on the various parameters.

In case of a fault the power output stage will be deactivated and the fault will be indicated via deactivating the READY output and the flashing READY LED.

Three different modes can be used for the error management. SENS=ON: all faults have to be acknowledged by the ENABLE input. SENS=AUTO: automatic reset mode for all signal faults. SENS=OFF: fault detection is suppressed.

The output current is controlled whereby a high accuracy and a good dynamic will be obtained. All customary proportional valves (up to 2.6 A) could be controlled with this power amplifier.

3.4 Commissioning

Step	Task
Installation	Install the device in accordance with the circuit diagram. Ensure it is wired correctly and that the signals are well shielded. The device must be installed in a protective housing (control cabinet or similar).
Switching on for the first time	Ensure that no unwanted movement is possible in the drive (e. g. switch off the hydraulics). Connect an ammeter and check the current consumed by the device. If it is higher than specified, there is an error in the wiring. Switch the device off immediately and check the wiring.
Setting up communication	Once the power input is correct the PC (notebook) should be connected to the serial interface. Please see the WPC-300 program documentation for how to set up communication. Further commissioning and diagnosis are supported by the operating software.
Pre-parameterization	Parameterize now (with the help of the system redundancy and the connection diagram) the following parameters: The WORKING RANGE for the ANALOGUE INPUTS. See specifications of the system and the sensors. The output CURRENT and the typical valve parameters like DITHER and MIN/MAX. Pre-parameterization is necessary to minimize the risk of an unintentional movement / pressure.
Control signal	Check the control signal (output signal). The control signal (solenoid current) lies in the range of 0... 2.6 A. In the current state it should show around 0 A.
Switching on the hydraulics	The hydraulics can now be switched on. The module is not yet generating a signal. Drives should be at a standstill or drift slightly (leave its position at a slow speed).
Activating ENABLE	**CAUTION!** The power stage gets activated. The controller can now be driven by the analogue command value or preset fix rounds per minute.
Activating START	The actual value is read in now and the output signal is calculated depending on the control deviation and the controller settings.
Controller optimization	Now optimize the settings. The PID parameters have to be adapted depending on the application.

4 Technical description

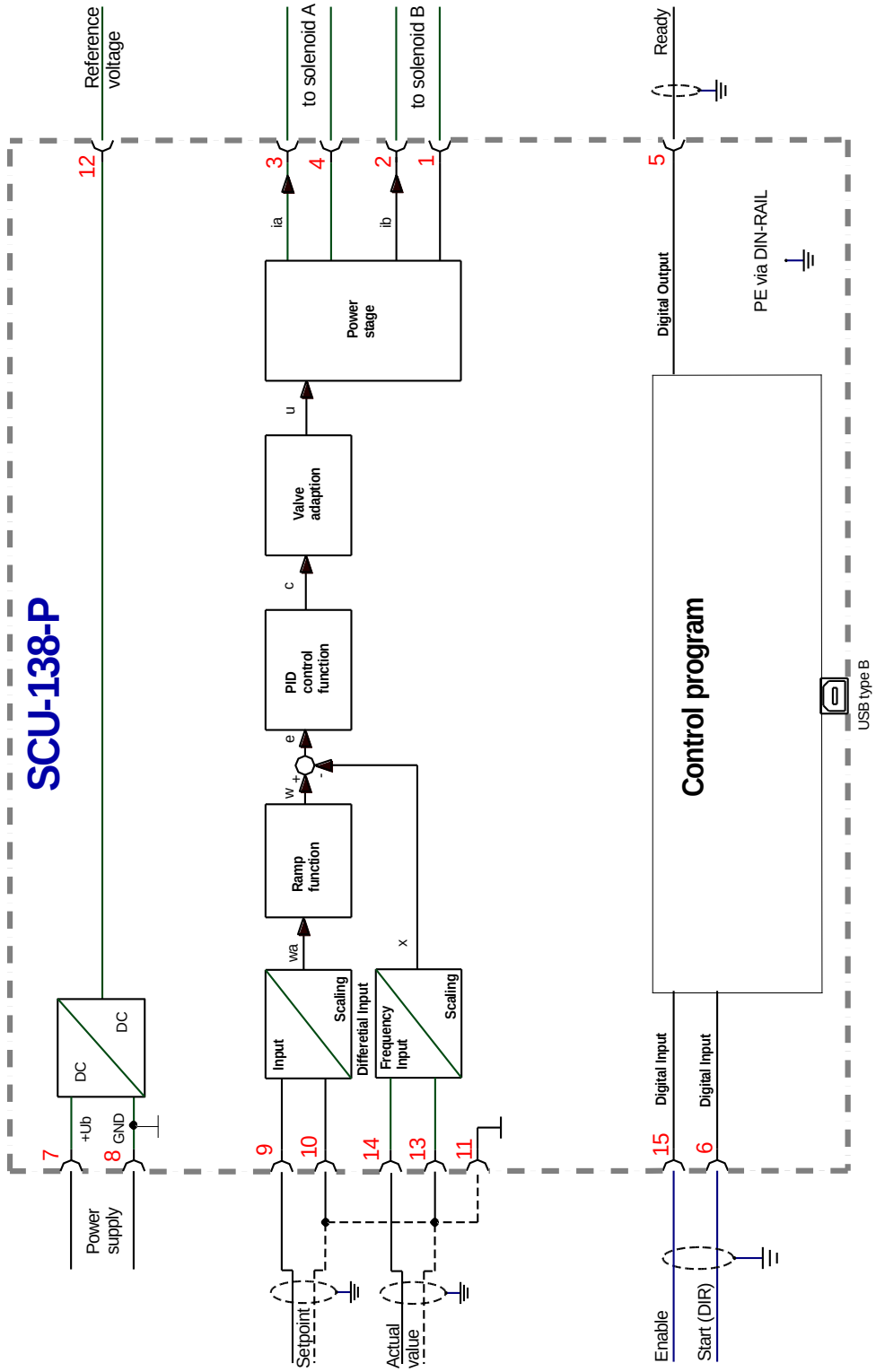
4.1 Input and output signals

Connection	Supply
PIN 7	Power supply (see technical data)
PIN 8	0 V (GND) connection.
Connection	**Analogue signals**
PIN 9 / 10	Command value (WA), signal range 0… 10 V or 4… 20 mA, scalable, alternatively PWM signal
PIN 13 /14	Feedback value (X), the actual speed is read in via a pulse transmitter (12 / 24 V)
PIN 11	0 V (GND) connection for analogue signals
PIN 12	8V reference voltage output
Connection	**Solenoids**
PIN 2 / 1	PWM output solenoid B
PIN 3 / 4	PWM output solenoid A
Connection	**Digital inputs and outputs**
PIN 15	**ENABLE input:** Generally enabling of the application. Erases error messages, activates the power stage and the READY signal.
PIN 6	**START (DIR) input**: **ON:** Closed loop control mode, the PID controller is activated **OFF:** Open loop amplifier mode, pure power amplifier
PIN 5	**READY output:** **ON:** The module is enabled; there are no discernable errors. **OFF:** ENABLE is not available, no supply or an error has been detected.

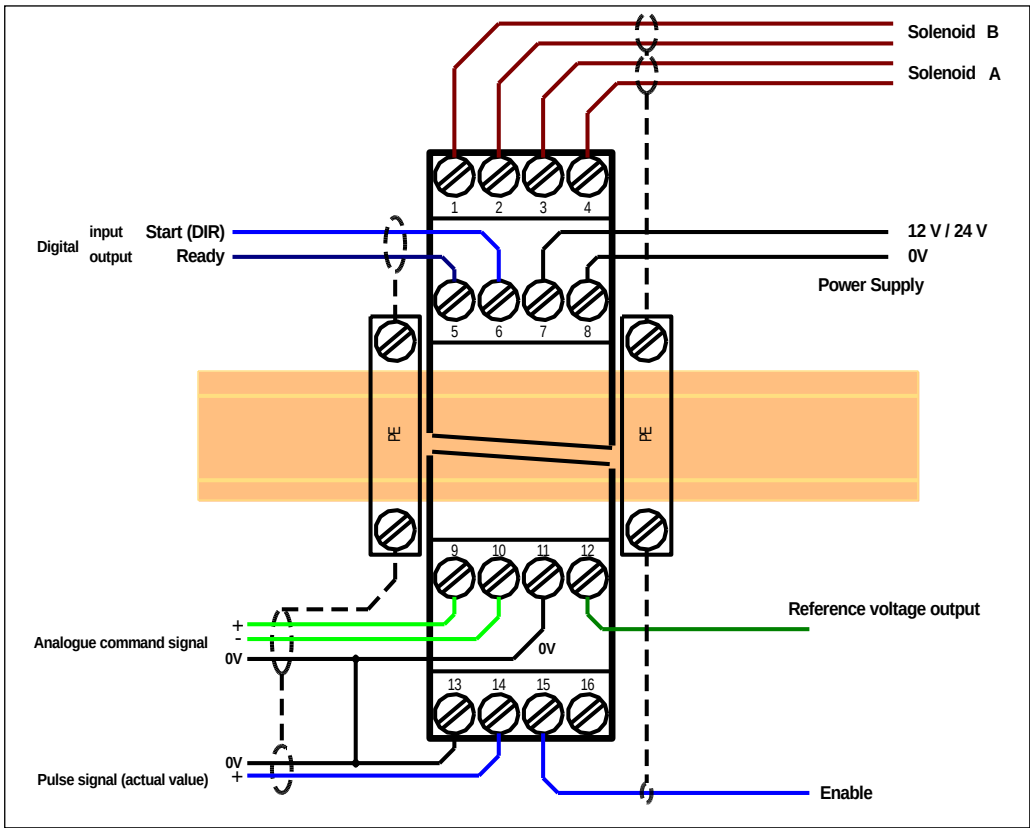
4.2 LED definitions

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 operation ***Flashing:*** Error discovered
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 nonvolatile stored parameters are inconsistent! To acknowledge the error, data has to be saved with the SAVE command or the corresponding button in the WPC.

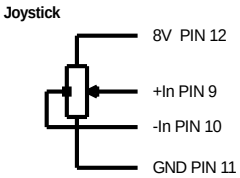
4.3 Circuit diagram

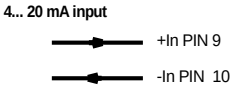


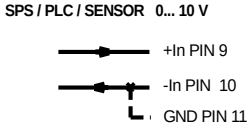
4.4 Typical wiring

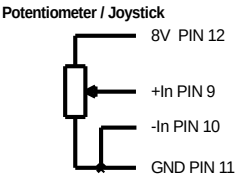


4.5 Connection examples

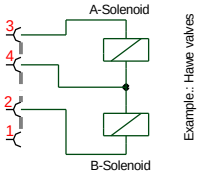








Alternative 3 – wire connection of two solenoids:



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]** **[%]**	 0… 10 min. 90 4… 20 390 0,03
PWM input (command value)	**[V]** **[Hz]**	Logic 0: < 2 V Logic 1: > 10 V, max. 1 mA 50… 1000
Pulse input (actual value)	**[V]** **[Hz]**	Logic 0: < 2 V Logic 1: > 10 V, max. 1 mA 35… 10000 (measurement value limited to 6 kHz)
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				
Command signal scaling				
	SELECT:W	ANA	-	Selection of the command value source
	SIGNAL:W	U0-10	-	Type of input
	SYS_RANGE	1000	Hz	Working range / reference value for 100% command value
	PWM:ZERO	0	0,01 %	PWM duty cycle yielding a setpoint of 0%
	PWM:FULL	10000	0,01 %	PWM duty cycle yielding a setpoint of 100%
	FIX_SPEED	0	0.01 %	Fix internal command value
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**	100 4000 0 500 0	0.01 0.1 ms 0.1 ms 0.1 ms 0.01 %	P gain I gain D gain D gain filter Feed forward gain
Integrator control				
	C:I_ACT **C:I_LIM** **C:I_PRE**	2500 2500 0	0.01 % 0.01 % 0.01 %	Integrator activation Integrator limitation Integrator pre-set value
Output signal adaptation				
	MIN:A **MIN:B**	0 0	0.01 % 0.01 %	Deadband compensation
	MAX:A **MAX:B**	10000 10000	0.01 % 0.01 %	Output scaling
	TRIGGER	200	0.01 %	Deadband compensation trigger point
	SIGNAL:U	1S+	-	Type and polarity of the output / controller

Group	Command	Default	Unit	Description
Parameters of the power stage				
	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	– –	P-Gain of the current loop I-Gain of the current loop
Special commands				
Scaling mode				
	AINMODE	EASY	–	Input scaling mode
	AIN:W	A: 1000 B: 1000 C: 0 X: V	– – 0.01 % –	Free scaling of the analogue input. 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= 0… 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, in case of an error of the setpoint signal the valve should be driven with a fixed current.

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

Inpenpendetly from the setting of the parameter SIGNAL:U the EOUT – Signal will always be applied to Solenoid A. No inversion or change to Solenoid B will occur. Solenoid B is always turned off in case of an error.

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 Input Signal adaptation

5.3.1 SELECT:W (command signal source selection)

Command	Parameters	Unit	Group
SELECT:W X	x= ANA|PWM|PRE	-	**STD**

By this command the source for the command value is set.

- ANA: The command value is read in via an analogue signal, which is defined by SIGNAL:W.
- PWM: The command value is read in via a pulse width modulated signal at the input.
- PRE: The command value is pre-set with parameter FIX_SPEED.

5.3.2 SIGNAL:W (Type of input signal)

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

This command can be used to set the type of the analogue input signal (voltages or current) and to define the direction of the signal.
OFF= Deactivation of the input

5.3.3 SYS_RANGE (Working range)

Command	Parameter	Unit	Group
SYS_RANGE X	x= 200… 8000	Hz	**STD**

This command defines the nominal working range, which corresponds to 100% of the input signal. This value is in relation to the sensor working stroke (FMAX). Wrong parameterization causes wrong system settings. The control parameters cannot be calculated correctly in case of wrong values.

It has to be considered that instead of a rotational speed in [rpm] the module measures the frequency of the input signal. If multiple pulses are triggered per revolution, here a value has to be entered which is accordingly higher.

Example: Desired Speed at 100% is 1500 rpm.

Per revolution 30 pulses are produced. f_{Setp} = 1500 rpm * (min. / 60 s) * 30 = 750 Hz.

This value has to be entered in SYS_RANGE.

5.3.4 PWM:ZERO (scaling of the PWM input)

5.3.5 PWM:FULL

Command	Parameter	Unit	Group
PWM:ZERO	x= 0… 10000	0,01 %	**PWM**
PWM:FULL	x= 2000… 15000	0,01 %	**PWM**

These values are used to calculate the speed / frequency setpoint on the basis of the read in duty cycle of the PWM input.

These parameters are only visible and operational if the setpoint source “PWM” is selected via the parameter SELECT:W.

The factory setting 0 / 10000 yields a proportional behaviour and 100% setpoint if the duty cycle is 100% that means a permanent signal. This is only a theoretical value because a permanent signal means the absence of pulses and therefore the pulse width cannot be evaluated.

The calculation of the command value is accomplished according to this formula:

WA = (DC – PWM:ZERO) / (PWM:FULL - PWM:ZERO) * 100%

The range (PWM:FULL - PWM:ZERO) must not be defined too small because otherwise the resolution of the signal will be bad. Therefore an internal limitation of PWM:FULL is active which will set this parameter to at least PWM:ZERO + 2000 (+ 20%). This means lower values cannot be entered.

5.3.6 FIX_SPEED (Internal demand value)

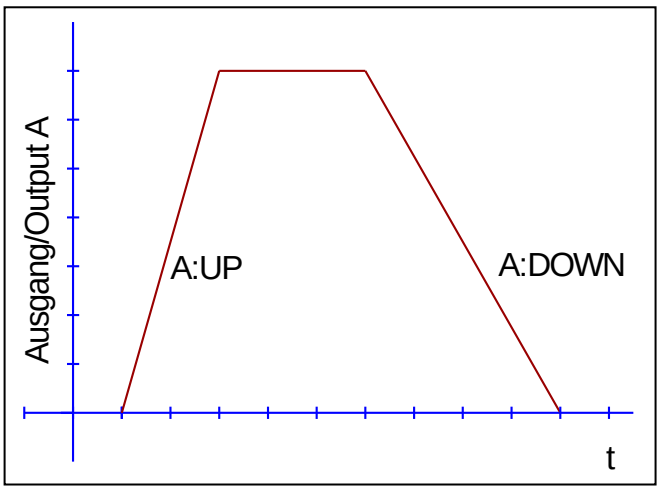
Command	Parameter	Unit	Group
FIX_SPEED X	x= 0… 10000	0.01 %	**STD**

The internal setpoint is activated if the parameter SELECT:W is set to “PRE” (preset). In this case, the command input is disabled and the value specified here is used as demand value. This function can be used, whenever the driven equipment should be operated at a constant speed.

5.3.7 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

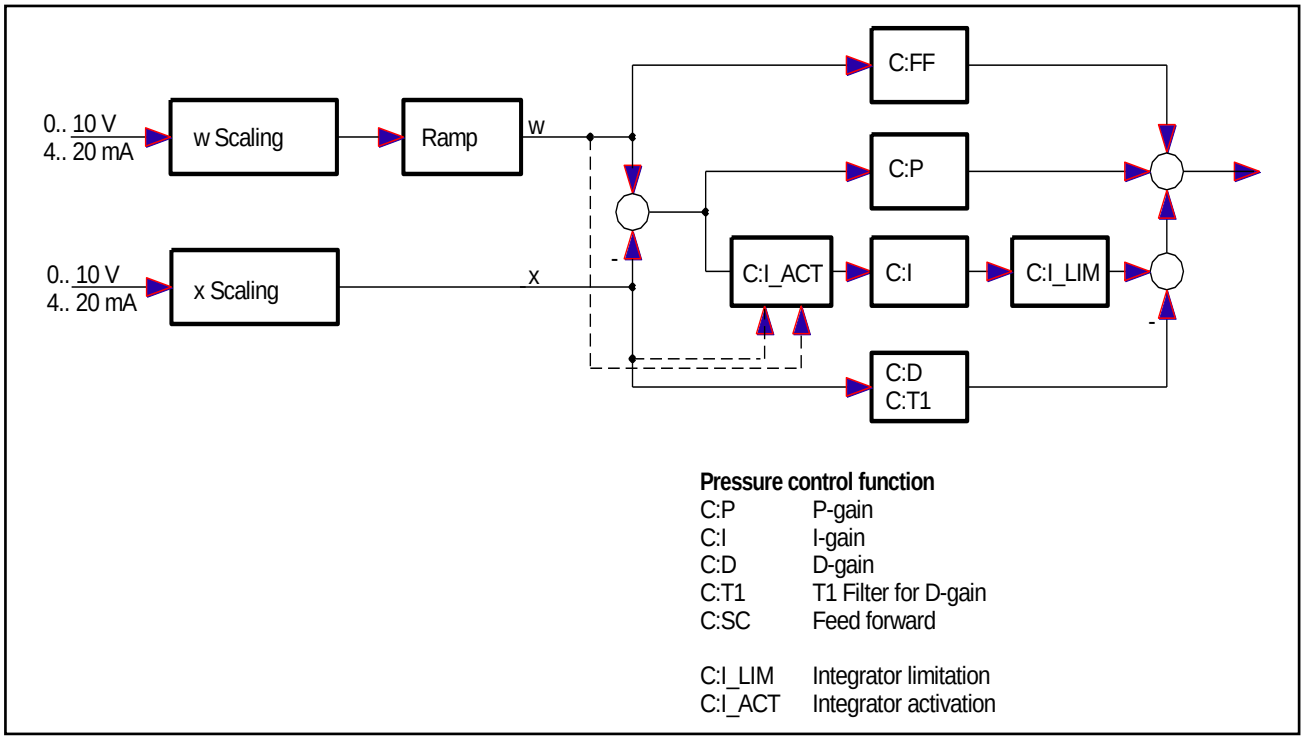
Command	Parameter	Unit	Group
C:I X	I= P|I|D|D_T1|FF P x= 0… 10000 I x= 0… 30000 D x= 0… 1200 D_T1 x= 10… 1000 FF x= 0… 10000	 0.01 0.1 ms 0.1 ms 0.1 ms 0.01 %	**STD**

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.

Entering a value of “0” in “I” deactivates the integrator.

Via the feed forward (FF) value the output is controlled directly. The PID closed loop control function has only to adjust the difference (the error). This leads to a stable control behavior and also to a dynamic drive. The value depends on the command value.



Pressure control function

C:P	P-gain
C:I	I-gain
C:D	D-gain
C:T1	T1 Filter for D-gain
C:SC	Feed forward
C:I_LIM	Integrator limitation
C:I_ACT	Integrator activation

5.4.2 Integrator control function

Command	Parameter	Unit	Group
C:I_ACT X	x= 0… 10000	0.01 %	**STD**
C:I_LIM X	x= 0… 10000	0.01 %	
C:I_LIM X	x= 0… 10000	0.01 %	

C:I_ACT controls the integrator function. To reduce speed overshoots, an activation point for the integrator can be programmed via the I_ACT value. The integrator is activated if the feedback signal is higher than the programmed threshold depending on the command value.

C:I_LIM limits the working range of the integrator, so that the controller can quickly react to the process without any major overshoots. If the value is too small, it may have the effect that the non-linearity of the system cannot be fully compensated.

C:I_PRE defines a pre-set value for starting the integrator function with when the closed loop controller gets activated. Meaningful values have to be <= than C:I_LIM therefore C:I_PRE is additionally limited to this value.

5.5 Output signal adaptation

5.5.1 MIN (Deadband compensation)

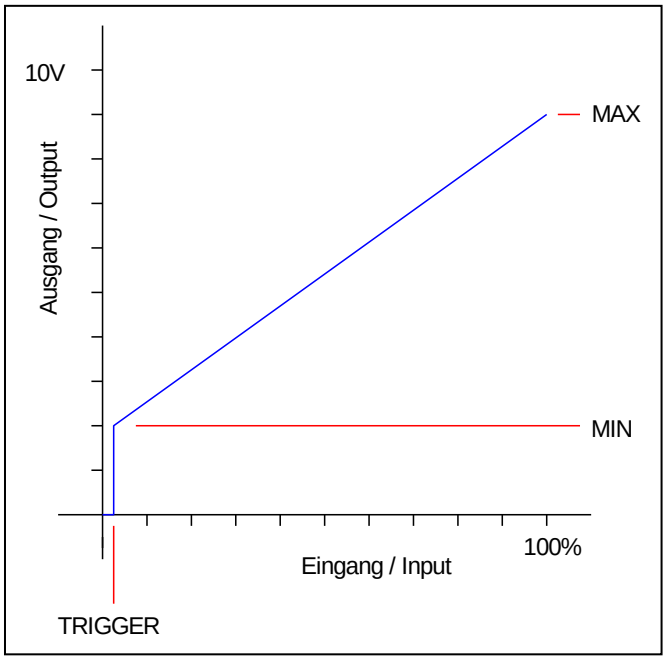
5.5.2 MAX (Output scaling)

5.5.3 TRIGGER (Response threshold for the MIN parameter)

Command	Parameters	Unit	Group
	I= A|B		**STD**
MIN:I X	x= 0… 6000	0.01 %	
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 minimum speed, which cannot be adjusted any longer. In extreme cases this could cause an oscillation at small input values.



[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).

5.5.4 SIGNAL:U (Output polarity)

Command	Parameter	Unit	Group
SIGNAL:U X	x= 1S+|1S-|2S+|2S-	-	**EXP**

This command is used to define the type of the controller and accordingly the output signal and its polarity.

Selectable are one solenoid or two solenoid control. Furthermore the direction of the output signal can be switched. Using applications with one solenoid it means an inverted characteristic curve. If two solenoids are used it effects the switching of the solenoids.

- 1S+: One solenoid standard
  - U = 0… 100% -> IA = 0… 100%
- 1S-: One solenoid inverted
  - U = 0… 100% -> IA = 100… 0%
- 2S+: Two solenoids standard
  - PIN 6 not set -> Controlling IA, 0… 100%
  - PIN 6 set -> Controlling IB, 0… 100%
- 2S-: Two solenoids switched
  - PIN 6 not set -> Controlling IA, 100… 0%
  - PIN 6 set -> Controlling IB, 100… 0%

CAUTION: Controlling the second solenoid is realized via the digital input at PIN 6. If a two solenoid controlling is chosen here, the START signal for the controller is not longer available. With setting ENABLE the controller is imeadiatelly activated.

5.6 Power stage

5.6.1 CURRENT (Rated solenoid current)

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

The nominal current (for 100% opening) of the solenoid is set here. Dither and also MIN/MAX always refer to this current value.

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

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.

5.6.4 PWM (PWM Frequency)

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

The frequency of the output stage 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 analogue 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 (Analogue input scaling)

Command	Parameters	Unit	Group
AIN:W			**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:W 1000 1000 0 V	0… 10 V	Range: 0… 100 %
AIN:W 10 8 1000 V OR **AIN:W 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:W 10 4 500 V OR **AIN:W 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:W 20 16 2000 C OR **AIN:W 2000 1600 2000 C** OR **AIN:W 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 (read in)	%
W	Command value after ramp function	%
WR	Command value	Hz
X	Feedback value	%
XR	Feedback value	Hz
E	Control error	%
C	Controler output	%
U	Output to valve	%
IA	Solenoid current[3] A	mA
IB	Solenoid current B	mA

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

[3] 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 power stage and the READY output will be deactivated.
Solenoid A on PIN 3-4	Wrong cabling, broken wire	The power stage and the READY output will be deactivated.
Solenoid B on PIN 2-1	Wrong cabling, broken wire	The power stage and the READY output will be deactivated.
EEPROM (when switching on)	Data error	The power stage and the READY output will be deactivated. Module can be activated by saving the parameters.

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

6.2 Troubleshooting

It is assumed that the device is in an operable state and there is communication between the module and the WPC-300. Furthermore, the valve control parameterization has been set with the assistance of the valve data sheets.
The RC in monitor mode can be used to analyze faults.

CAUTION: All safety aspects must be thoroughly checked when working with the RC (Remote Control) mode. In this mode the module is controlled directly and the machine control cannot influence the module.

FAULT	CAUSE / SOLUTION
ENABLE is active, the module does not respond, and the READY LED is off.	There is presumably no power supply or the ENABLE signal is not present. Other errors are displayed via the READY LED. If there is no power supply, there is also no communication via our operating program. If a connection has been made, then a power supply is also available. In this case in monitor window the ENABLE input can be checked.
ENABLE is active, the READY LED is flashing.	The flashing READY LED signals that a fault has been detected by the module. The fault could be: • A broken cable or no signal at the input (PIN 13 or PIN 14), if 4… 20 mA signals are parameterized. • A broken cable or incorrect cabling to the solenoids. • Internal data error: press the command/SAVE button to delete the data error. The system reloads the DEFAULT data. With the operating program the fault can be localized directly via the monitor.

6.3 Description of the command structure

The command structure:

[nnnn:i x] or
[nnnn x]

Meaning:

nnnn - used for an arbitrary command name
nnnn: - used for an arbitrary command name, expandable by an index.
Indexed commands are indicated by the sign ":"
i oder **I** - is a dummy for the index. E. g. an index can be „A" or „B", depending on the direction.
x - parameter value, in case of special commands more than one parameter are possible.

Examples:

MIN:A 2000 nnnn = "MIN", i = "A" and x = "2000"

OFFSET 50 nnnn = „OFFSET" and x = „50"

C:IC 2000 nnnn = "C", i = "IC" and x = "2000"

7 Notes