WEST

Technical Documentation

CSC-152-U
CSC-152-P

Universal synchronization control module for analog signals, alternatively with power stage

Electronics
Hydraulics meets
meets Hydraulics
Electronics

CONTENTS

1 General Information

1.1 Order number

CSC-152-U - with programmable output (±10 V differential output or 4… 20 mA) and analogue sensor interface

CSC-152-P - with integrated power output stage up to 2,6 A (*see additional information*)

Extended, alternative versions

POS-124-U-PDP - two axes positioning module with SSI or analogue sensor interface, ProfibusDP interface, synchronious control and universal analogue control output.

POS-124-U-PFN - two axes positioning module with SSI or analogue sensor interface, Profinet interface,synchronious control and universal analogue control output.

POS-124-U-ETC - two axes positioning module with SSI or analogue sensor interface, EtherCat interface,synchronious control and universal analogue control output.

CSC-156-U-SSIC - up to four axes with extended position and pressure control, SSI or analogue sensor interface, ProfibusDP interface (via coupler) and universal analogue control output.

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 Using this documentation

Structure of the documentation:

The standard product is descibed up to chapter 6. Extensions concerning the POWER STAGE are described in the chapter ADDITIONAL INFORMATION.

1.6 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

Datum: 07.01.2025

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.

1.7 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 electronic module has been developed for controlling hydraulic positioning / synchronization drives. Proportional valves with integrated or external electronics can be controlled with the differential output.

Alternatively, the device is available as -P version with an integrated power output stage (see chapter POWER OUTPUT STAGE). The advantage of the integrated power output stage lies in the integrated control behavior without additional dead times. This allows higher dynamics and higher stability for proportional valves.

The internal profile generation is optimized for stroke-dependent deceleration or NC control. The controller and the controller setting are adapted to the typical requirements and thus permit rapid and uncritical optimization of the control behavior. The time-optimized control function offers a high degree of precision together with high stability for hydraulic drives. The movement cycle is controlled via the external position and speed inputs.

Alternatively the system can be controlled via joystick. In this mode the command position is set internally to a predefined target position depending on the polarity of the speed demand.

All values are read in as analog signals with high resolution which ensures good positioning behavior.

The synchronization control works as a second overriding velocity / position controller. Failure between the axes will be compensated by adjusting the speed of the slave axis. The speed can be limited with the external analogue speed input.

Setting up this module is simple and easy to handle with our WPC-300 start-up software.

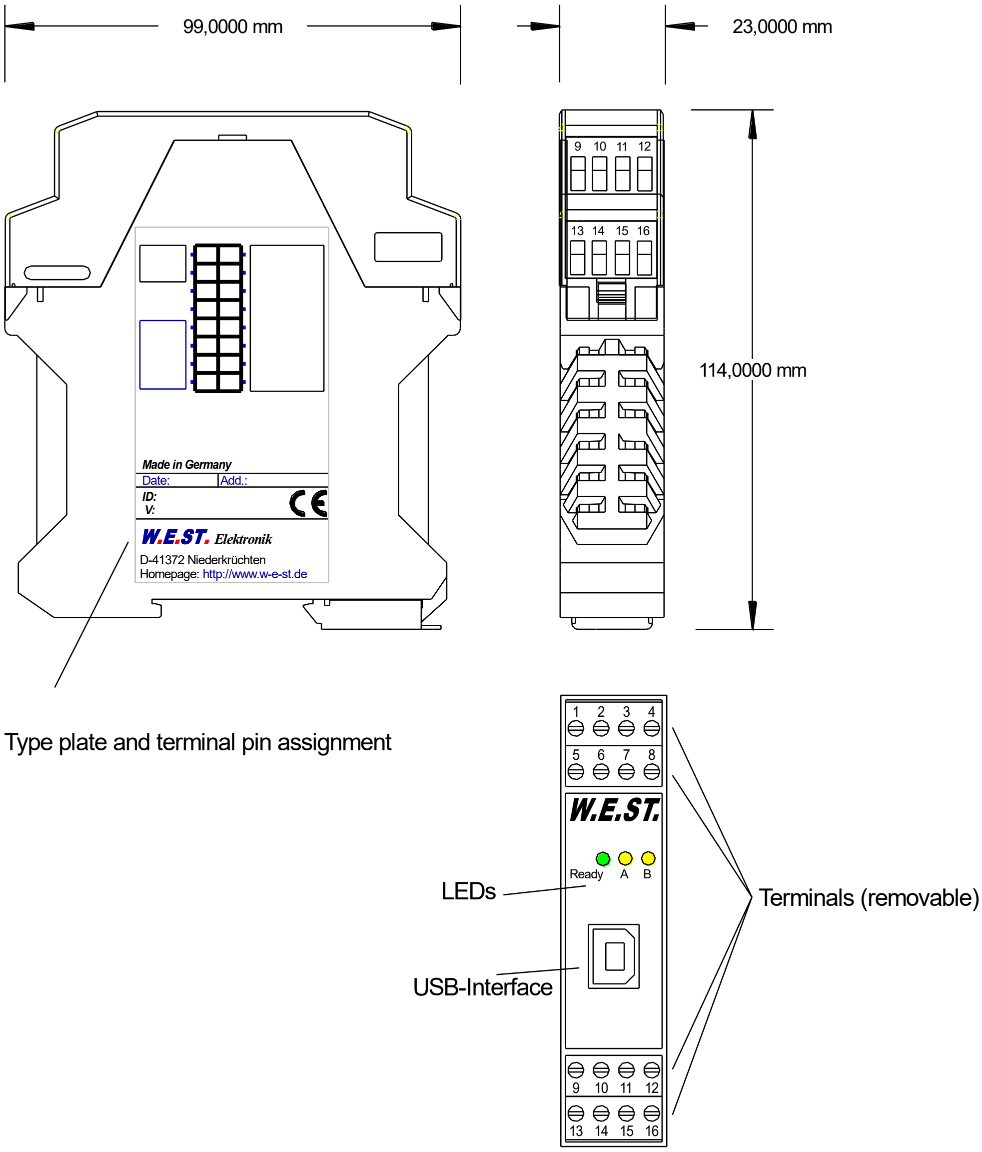
Typical applications: Synchronization and positioning of two axes (up to 4 axes in master slave mode).

Features

- **Analogue position and speed inputs**
- **Analogue feedback sensors**
- **Simple and intuitive scaling of the sensor**
- **Motion command values in mm resp. mm/s**
- **Internal profile definition by acceleration, velocity and deceleration**
- **Principle of stroke-dependent deceleration for fast and robust positioning**
- **NC profile generator for constant speed**
- **Superimposed synchronization controller**
- **Usable with overlapped proportional valves and with zero lapped control valves**
- **Fault diagnosis and extended function checking**
- **Simplified parameterization with WPC-300 software**
- **Optionally:**
    - **Integrated power output stage (P version)**

2.1 Device description

Standard module – for the P-Version look at chapter 7.2



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.

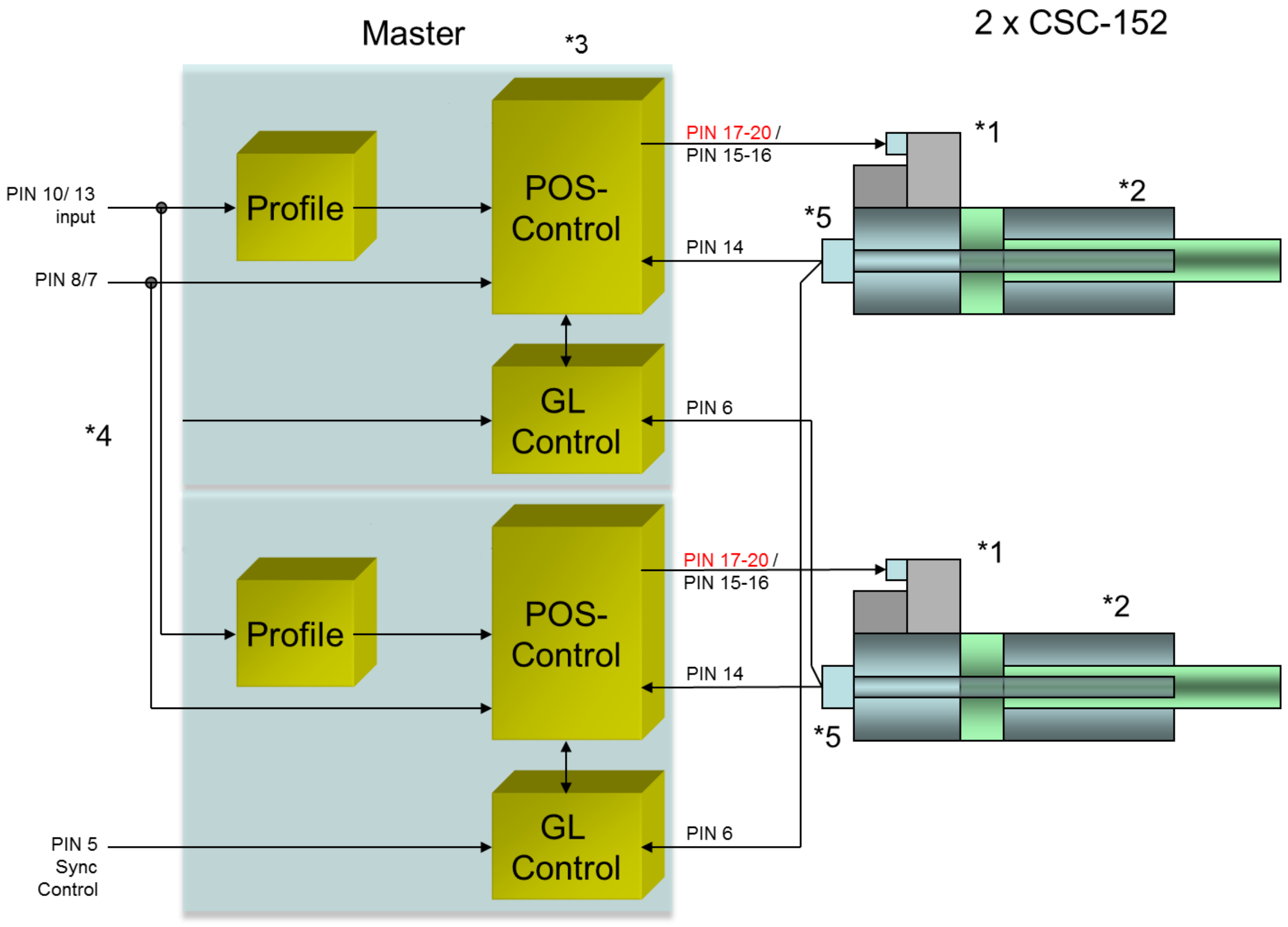
- The module should be installed and wired in accordance with the documentation bearing in mind EMC principles. If other consumers are operated with the same power supply, a star-shaped ground wiring scheme is recommended. The following points must be observed when wiring:
  - The signal cables must 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 <u>always</u> 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 valves with or without integrated electronic
(*2) Cylinder drive
(*3) CSC-152-P control modules
(*4) Interface to PLC with analogue and digital signals
(*5) Position sensors



3.3 Method of operation

The structure of the synchronization controller is derived from our positioning controllers. The inputs 13 (target position for the axis) and 14 (feedback position of the axis) is used to control the movement. The input 6 (feed-back position of the master axis) in addition to feedback position PIN 14 is used to supply the slave axis with the position of the reference axis for the synchronization controller.

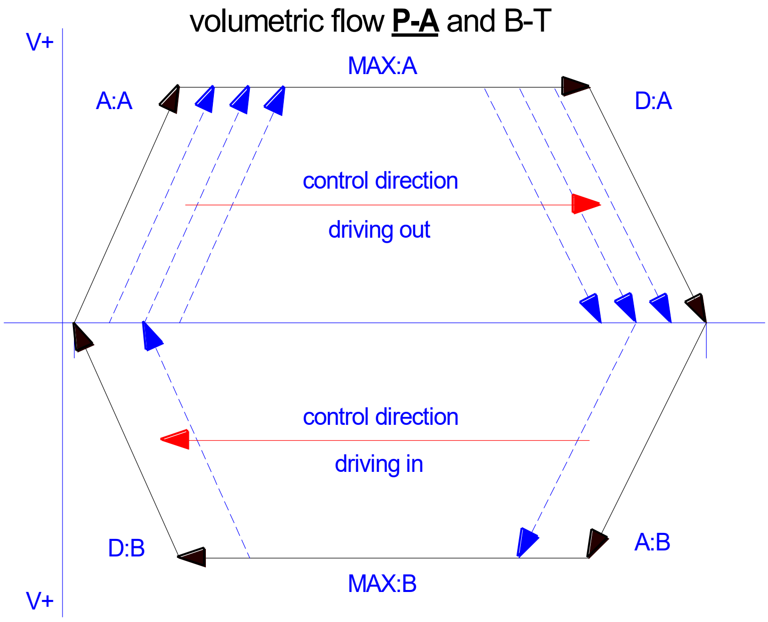
Through the activation of the **GL-active** input the synchronization controller is activated. This is done at each slave axis whereby they are synchronized to the master axis.

If there are two axes in synchronism, the actual position of the other axis can be linked crosswise. In this case a master / master synchronization control (average control) is possible. Both inputs GL-active (master and slave) have to be activated.

The function of the status output is switched automatically. If the input GL-active is deactivated the status signal is generated by the InPos messages (error between the input position (13) and feedback position (14)). If the input GL-active is activated, the synchronization error (feedback position (14) and master's feedback position (6)) is monitored. In master-master mode the status message can be defined by AXISFUNC. Master 1 is used for target position monitoring and Master 2 is used for synchronous operation monitoring.

The synchronization works reliable if the master axis or the speed is limited at 70….80% of the maximum speed. To be able to compare faults the slave axes must be able to drive faster than the master axis.

For a stable behavior of the synchronous controller the maximum speed should be reduced to approximately 70… 80% of the possible drive speed. For compensating errors the slave axes have to be able to drive faster than the master axis. This reserve is necessary and should be considered when planning the system.



Influences on positioning accuracy:

The positioning accuracy is determined by the hydraulic and mechanical conditions. The right choice of valve is therefore a decisive factor. In addition, two mutually contradictory requirements (short position time and high accuracy) must be taken into account when designing the system.
The electronic limitations lie mainly in the resolution of the analogue signals, although a resolution of < 0,01 % only needs to be considered for our modules with long strokes. In addition, the linearity of the individual signal points (PLC, sensor and control module) must be taken into account too.

It is generally recomended to calculate the static and dynamic behavior of the hydraulic axis. For supporting this, following technical basic data are required:

- minimum natural frequency of the cylinder,
- maximum theoretical speed for extending and retracting,
- valve characteristics (natural frequency, overlapped or zero lapped, hysteresis and the flow gain (flow and pressure drop),
- system pressure, maximum pump flow,
- and a description of the general system requirements.

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	Now set up the following parameters (with reference to the system design and circuit diagrams): The SYS_RANGE, SENSOR SETTING, OUTPUT SIGNAL, ACCELERATION and DECELERATION. Pre-parameterization is necessary to minimize the risk of uncontrolled movements. Parameterize specific settings for the control element (MIN for deadzone compensation and MAX for maximum velocity). Reduce the speed limitation (VELO command) to a value which is uncritical for the application.
Control signal	Check the control signal with a voltmeter. The control signal (PIN 15 to PIN16) lies in the range of ± 10 V. In the current state it should be 0 V. Alternatively, if current signals are used, approx. 0 mA should flow.
Switching on the hydraulics	The hydraulics can now be switched on. Since the module is not yet generating a signal, the drive should be at a standstill or drift slightly (leave its position at a slow speed).
Activating ENABLE	**CAUTION!** The drive can now leave its position and move to an end position at full speed. Take safety measures to prevent personal injury and damage. The drive stays in the current position (with ENABLE the actual position is accepted as the required position). If the drive moves to an end position, the polarity is probably wrong.
Speed demand	The speed can be limited by means of the VELO parameter or the external speed demand (SIGNAL:V).
Activating START	With the start signal the demand value of the analogue demand value input is accepted and the axis moves to the predefined target position. If START is disabled, the axis stops in the preset deceleration distance D:S.
GL-ACTIVE	This input hase to be activated depending on the start-up procedure. If each axis can be started-up indiviually this input has to be activated after the optimisation of the axes. Now the system can be driven in synchronous control.
Optimize controller	Now optimize the control parameters according to your application and your requirements.

4 Technical description

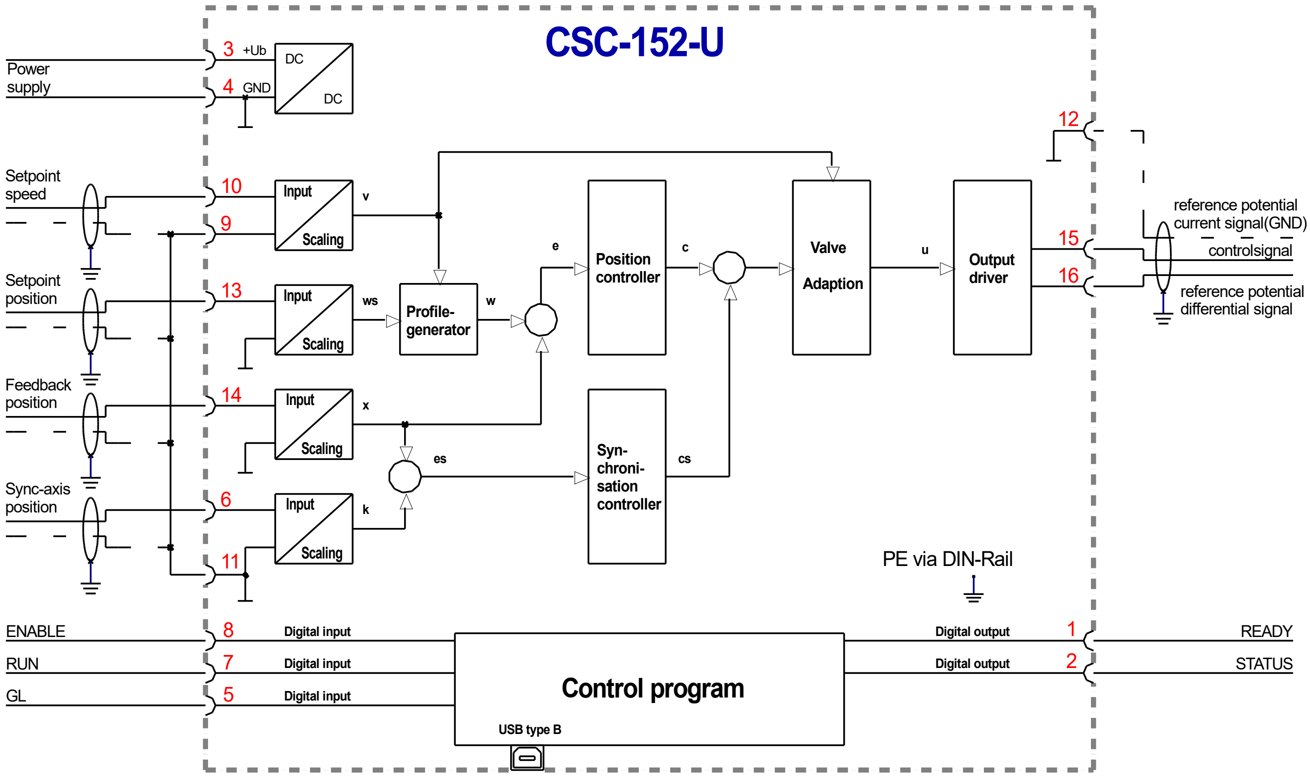
4.1 Input and output signals

Connection	Supply
PIN 3	Power supply (see technical data)
PIN 4	0 V (GND) connection.
Connection	**Analogue signals**
PIN 9 / 10	External speed demand (V), range 0… 10 V or 4… 20 mA (scalable)
PIN 6	Feedback value of the master axes (k), range 0… 10 V or 4… 20 mA (scalable)
PIN 13	Position demand value (W), range 0… 10 V or 4… 20 mA (scalable)
PIN 14	Analogue position actual value (X), range 0… 10 V or 4… 20 mA (scalable)
PIN 11 / PIN 12	0 V (GND) connection for analogue signals
PIN 15 / 16 PIN 15 / 12	Valve control signal. Type of signal and polarity can be selected by the parameter SIGNAL:U.
Connection	**Digital inputs and outputs**
PIN 8	**Enable input:** This digital input signal initializes the application and error messages are deleted. The controller and the READY signal are activated. The output signal to the control element is enabled. The actual position is accepted as the command position and the drive remains stationary under control at this position. If the input is disabled, the output (control signal) is switched off(disabled). Take care of the EOUT-command!
PIN 7	**START (RUN) input:** The position controller is active and the external analogue demand position is accepted as the demand value. If the input is disabled during the movement, the system is stopped within the set emergency stopping distance (D:S).
PIN 5	**GL-ACTIVE input:** **ON:** The synchronization controller is active. **OFF:** The synchronization controller is inactive.
PIN 1	**READY output:** **ON:** The module is enabled; there are no discernable errors. **OFF:** Enable (PIN 8) is disabled or an error (sensor or internal error) has been detected.
PIN 2	**STATUS output:** **INPOS message** Depending on the configuration (for target position or synchronous run). **ON:** **INPOS message.** The axis is within the INPOS window. **OFF:** **INPOS message.** The axis is outside the INPOS window.

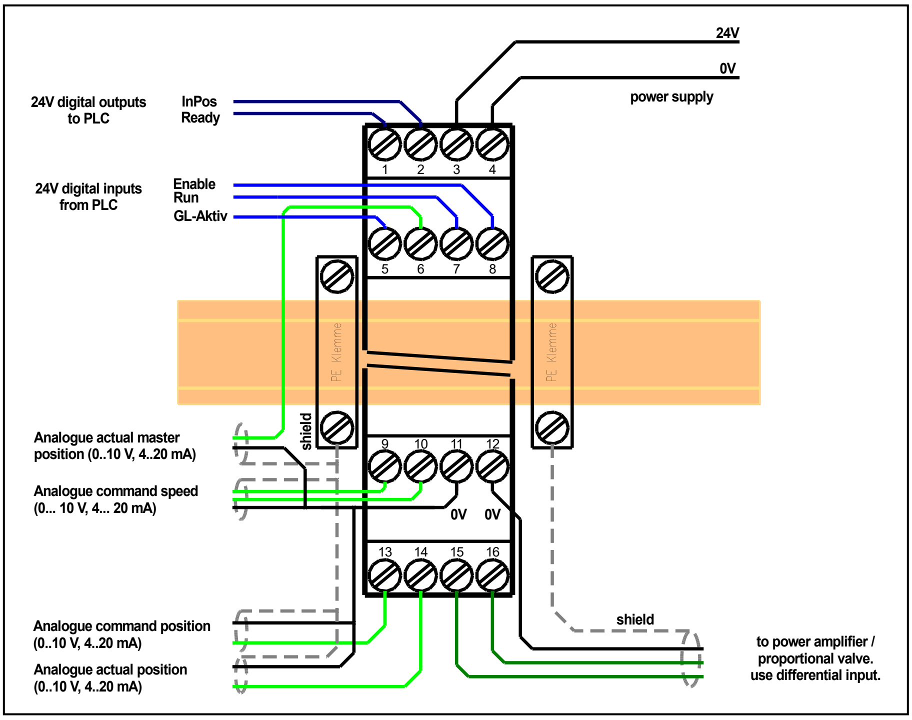
4.2 LED definitions

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	Identical to the STATUS output. **OFF:** The axis is outside the INPOS window. **ON:** The axis is within the INPOS window.
GREEN + YELLOW A+B	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 in-consistent! To acknowledge the error, the data have to be saved with the SAVE command or the corresponding button in the WPC. If the function of the module has changed via the FUNCTION parameter, all parameters are deleted purposely and set to default values. In this case the LEDs indicate no error, but a desired state. To acknowledge please save.

4.3 Circuit diagram

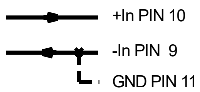


4.4 Typical wiring

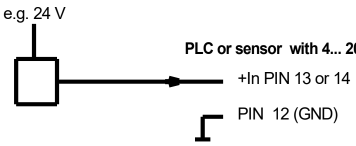


4.5 Connection examples

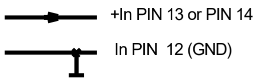
PLC 0... 10 V speed input signal



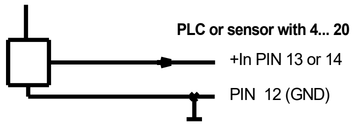
PLC or sensor with 4... 20 mA (two wire connection)



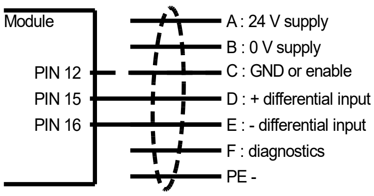
PLC 0... 10 V command and feedback signal



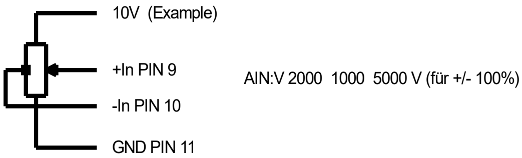
PLC or sensor with 4... 20 mA (three wire connection)



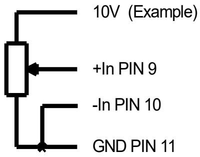
Valve (6 + PE plug) with OBE electronics



Joystick



Potentiometer / Joystick



4.6 Technical data

Supply voltage (U_b) Power consumption External protection	[VDC] [W] [A]	12…30 (incl. ripple) max. 1.2 1 medium time lag
Digital inputs OFF ON Input resistance	 [V] [V] [kOhm]	 < 2 > 10 25
Digital outputs OFF ON Maximum current	 [V] [V] [mA]	 < 2 max. U_b 50
Analogue inputs Voltage Input resistance Signal resolution Current Burden Signal resolution	 [V] [kOhm] [%] [mA] [Ohm] [%]	Unipolar 0… 10 min. 25 0.003 incl. Oversampling 4… 20 240 Ohm 0.006 incl. Oversampling
Analogue outputs Voltage Maximum load Current Maximum load Signal resolution	 [V] [mA] [mA] [Ohm] [%]	 0… 10, +/- 10 differential 10 4… 20 390 0.007
Controller cycle times Signal processing	 [ms]	 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]	0.15
Protection class Temperature range Storage temperature Humidity	[IP] [°C] [°C] [%]	20 -20… 60 -20… 70 < 95 (non-condensing)
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
	AXES	2	-	Number of axes
	SENS	ON	-	Malfunction monitor
	EOUT	0	0.01 %	Output signal if no ready
	INPOS	200	µm	Range of the in position monitoring
Input signal adaptation				
	AXIS_FUNC	AUTO	-	Function of the axis in the system
	SYS_RANGE	100	mm	Active working stroke
Sensor scaling				
	SIGNAL:X	U0-10		Type of input
	N_RANGE:X	100	mm	Nominal range
	OFFSET:X	0	µm	Sensor offset
Command signal				
	SOURCE:W	SEPARATE	-	Providing command signal when using current signals
	SIGNAL:W	U0-10	-	Type of input
Master position				
	SIGNAL:K	U0-10	-	Type of input
	OFFSET:K	0	µm	Sensor offset master axis
Speed input				
	SIGNAL:V	OFF	-	Type of input
	VELO	10000	0.01 %	Internal speed value (SIGNAL:V = OFF)
	VRAMP	200	ms	External speed ramp time
Profile generator				
	VMODE	SDD	-	Method of positioning
	ACCEL	250	mm/s²	Acceleration in NC mode
	VMAX	50	mm/s	Maximum speed in NC mode
Closed loop control parameters				
	A:A **A:B**	100 100	ms ms	Acceleration (ramp times) in SDD mode
	D:A **D:B** **D:S**	25 25 10	mm mm mm	Deceleration stroke in SDD mode
	V0:A **V0:B** **V0:RES**	10 10 1	1/s 1/s -	Closed loop gain in NC mode
	PT1	1	ms	PT1 time constant (damping)
	CTRL	SQRT1	-	Control characteristics

Group	Command	Default	Unit	Description
Synchronisation loop control parameters				
	GL:P	25	mm	Deceleration stroke in SDD mode
	GL:V0	10	1/s	Closed loop gain in NC mode
	GL:T1	30	ms	Time constant
Output signal adaptation				
	MIN:A **MIN:B**	0 0	0.01 % 0.01 %	Deadband compensation or flow characteristic lineariza-tion
	MAX:A **MAX:B**	10000 10000	0.01 % 0.01 %	Output scaling
	TRIGGER	200	0.01 %	Deadband compensation trigger point
	OFFSET	0	0.01 %	Output offset value
	SIGNAL:U	U+-10	-	Type of output signal and polarity
Special commands				
AINMODE				
	AINMODE	EASY	-	Input scaling mode
	AIN:I	**I= W|X|V|K** A: 1000 B: 1000 C: 0 X: V	 - - 0.01 % -	Free scaling of the analogue inputs (AINMODE = MATH).
Joystick control				
	JSCMODE	OFF	-	Activation joystick control mode
	JSC:POS1 **JSC:POS2** **JSC:DEADBAND**	95 5 100	Mm Mm 0.01 %	Target position for positive speed demand Target position for negative speed demand Deadband for the joystick center position

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 (SPEED BUTTON) in the menu bar (WPC-300) must be pressed (module identification).

5.2.2 MODE (STD or EXP parameters)

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 AXES (Number of axes)

Command	Parameters	Unit	Group
AXES **x**	x= 1… 6	-	**STD**

This command defines the number of driven axes. It is used to calculate a correction factor for parallel wired inputs when current signals are used. It compensates the deviations relating to the several parallel measuring circuits. Chosing "1" means no corrective calculation (compatible to former generation of the controller). The inputs to be adapted depend on the configuration of the system which is defined by AXIS_FUNC and SOURCE:W.

5.2.4 SENS (monitoring of the modul functions)

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.

5.2.5 EOUT (Output signal: READY = OFF)

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! If the output signal is 4… 20 mA, the output is switched off when **|EOUT| = 0**. If a null value = 12 mA is to be output in the event of an error, EOUT must be set to 1[1].

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.

Do not use the manual mode in conjunction with the EOUT command. After the deactivation of the HAND input the output is set to the EOUT value.

[1] This is necessary if using valves without error detection for signals lower than 4 mA. If the valve has an error detection, it moves into a defined position after switching off the output.

5.2.6 INPOS (In position range)

Command	Parameters	Unit	Group
INPOS x	x= 2… 200000	µm	**STD**

This parameter is entered in µm.
The INPOS command defines a range for which the INPOS message is generated. This function monitors the failure between the command and actual position. If the failure is less than the programmed value a INPOS message is displayed at the status output and the STATUS LED. The positioning process is not influenced by this message.

When the synchronous controller is active, this window is used for displaying the synchronous error.

PIN 7 (START) muss be acivated to generate the INPOS messages.

5.2.7 AXIS:FUNC (Function of the axis in synchronous system)

Command	Parameters	Unit	Group
AXIS_FUNC x	x= AUTO|MASTER|SLAVE|MASTER_2	-	**EXP**

This command defines the function of the device in the synchronous system.

Only if using **4… 20 mA current signals** parallel on several inputs a deviation of the signal is caused by the parallel measuring circuits. This deviation will be corrected automatically with the information about the device's function.

AUTO: Compatibility mode to further revisions. Configuration is done via external activation of PIN 5.

Manual settings for each axis:

MASTER: Defines the axis as master axis.

SLAVE: Defines the axis as slave axis.

*Setting **only** for the second axis in a master-master system:*

MASTER_2: Defines the axis as second master axis in a master-master system.

AUTO is the default choice because it is the compatibility mode to the former devices of this version. With activation of the synchronous controller at PIN 5 the axis is defined as slave and the according to this input corrections factors are determined for the analogue current inputs.

If the synchronous activation on PIN 5 does not exist continuously, e.g. for driving a single axis separately, the correction temporarily is not done respectively at the wrong input.

To avoid additional manual corrections or temporary deviations, with this parameter the definition of the role of the module in the system can be permanentelly defined.

In general a manual definition is recommended for new applications.

In case of manual settings all axes should be defined. One axis has to be set as master axis. The other existing axes are configured according to the description above.

EXAMPLES: see "helping information" in chapter 8, section 3.

Attention: These settings also serve selecting the status message (InPos) in master-master mode of two axes with target position (master) and synchronous run (master 2).

5.3 Input signal adaptation

5.3.1 SYS_RANGE (Active working stroke)

Command	Parameters	Unit	Group
`SYS_RANGE x`	`x= 10… 10000`	mm	**STD**

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

5.3.2 SOURCE:W (Providing command position)

Command	Parameters	Unit	Group
`SOURCE:W x`	`x= SEPARATE|COMMON`	-	**EXP**

This command defines the kind of providing the command position. If using a **4… 20 mA current signal** for parallel connected modules, only one shunt has to be active. For that this information is necessary.
If using voltage signals this parameter has no influence.

SEPARATE: Each control module gets a separate 4… 20 mA signal at PIN 13.
COMMON: One 4… 20 mA signal is connected parallel to several control modules.

Caution: In COMMON mode AXIS_FUNC settings may be essential.

5.3.3 SIGNAL (Type of input)

Command	Parameter	Unit	Group

`SIGNAL:i x`	`i= W|X|V|K`
	`x= OFF`
	`U0-10`
	`U10-0`
	`I4-20`
	`I20-4`
		-	**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 analogue inputs (W, X, and V).
OFF= Deactivation of the input[2].

[2] The deactivation can be used to deactivate the velocity (speed) input PIN_9/10 (the VELO value is active).

5.3.4 N_RANGE:X (Nominal range of the sensor)

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

N_RANGE (nominal range or nominal stroke) is used to define the length of the sensor. This value should be always higher than SYS_RANGE. The addicted control parameters like speed and gain cannot be calculated correctly in case of wrong values.

5.3.5 OFFSET:X (Sensor offset)

5.3.6 OFFSET:K (Sensor offset master axis input)

Command	Parameter	Unit	Group
OFFSET:X x	x= -100000… 100000	µm	EASY
OFFSET:K x	x= -100000… 100000	µm	EASY

Adjustment of the zero point of the sensor.

OFFSET:X is limited to SYS_RANGE internally.

The value for the OFFSET:K normally can be taken from the OFFSET:X of the master axis.

5.3.7 Using of the commands SYS_RANGE, N_RANGE:X and OFFSET:X

The application scaling will be done by these three commands. In this example the system is defined by a length of 120 mm of the sensor, a working stroke of 100 mm of the cylinder and an offset of 5 mm. These parameters have to be typed in and the axis is driving between 5 mm and 105 mm of the sensor stroke and between 0 mm and 100 mm of the cylinder stroke.

Correct scaling:
SYS_RANGE = 100 (mm)
N_RANGE:X = 120 (mm)
OFFSET:X = -5000 (µm)

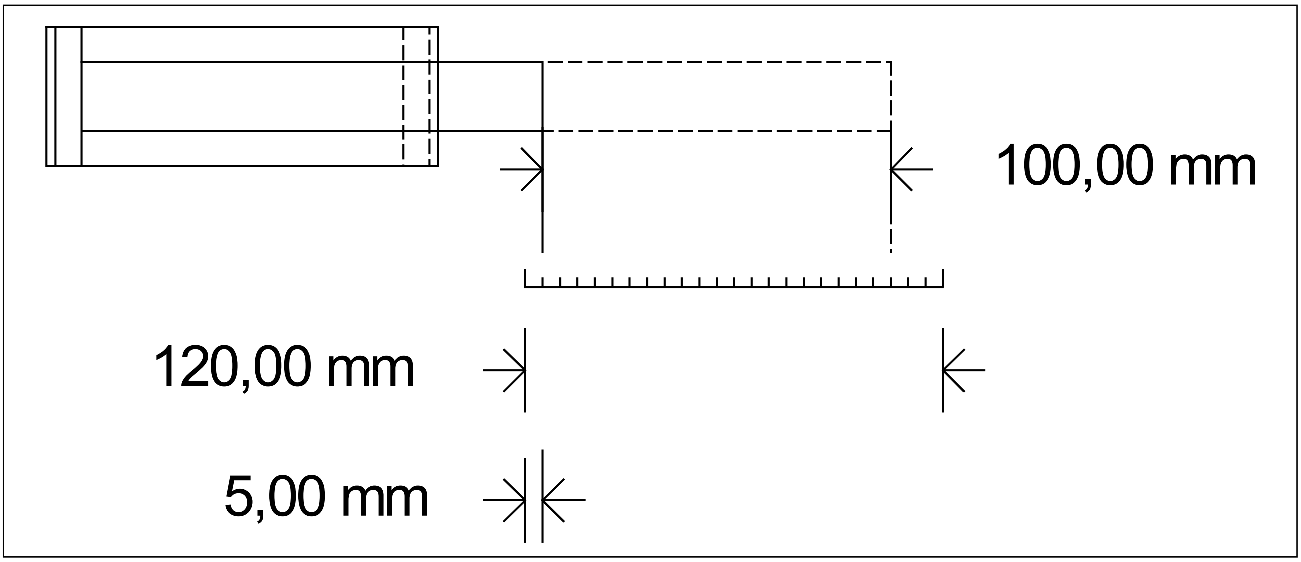


Figure 1 (Input scaling of the sensor)

5.3.8 Speed demand

The SIGNAL:V command is used to switch over between external or internal speed limitation.
SIGNAL:V = OFF   Internal speed limitation is active (VELO command)
Otherwise SIGNAL:V defines the type of external signal for what VRAMP provides a ramp generator function[3].

[3] The output signal is directly limited in SDD mode (default mode). In NC mode the speed profile of the generator is limited. The lowest adjustable speed is 0,01 mm/s (VMAX = 1 mm/s and VELO = 1 %).

5.3.9 VELO (Internal speed demand value)

Command	Parameters	Unit	Group
VELO x	x= 1… 10000	0,01 %	**SIGNAL:V = OFF or JSCMODE**

Setting of the internal speed limit in SDD mode, the setpoint speed in NC mode or the maximum control for holding the position in JSCMODE / SDD operation.

5.3.10 VRAMP (Ramp time for external speed demand)

Command	Parameters	Unit	Group
VRAMP x	x= 10… 5000	ms	**STD**

The rate of change of the external speed demand can be limited by this ramp time. The command is only active if external speed demand has been parameterized.

5.4 *Profile generator*

5.4.1 VMODE (Methode of positioning)

Command	Parameters	Unit	Group
VMODE x	x= SDD|NC	-	**EXP**

The fundamental control structure can be changed with this parameter.

SDD: **S**troke-**D**ependent **D**eceleration. In this mode, stroke-dependent deceleration is activated. This mode is the default mode and is suitable for most applications. With stroke-dependent deceleration the drive comes to a controlled stop at the target position. From the deceleration setpoint the drive then switches to closed loop control mode and moves accurately to the desired position. This control structure is very robust and reacts insensitively to external influences such as fluctuating pressures. One disadvantage is that the speed varies with the fluctuating pressure as the system runs under open-loop control.

NC: **N**umerically **C**ontrolled. In this mode a position profile is generated internally. The system always works under control and uses the following error to follow the position profile. The magnitude of the following error is determined by the dynamics and the closed loop gain. The advantage is that the speed is constant (regardless of external influences) due to the profile demand. Because of continuous control, it is necessary not to run at 100 % speed, as otherwise the errors cannot be corrected. 70… 80 % of the maximum speed is typical although especially the system behavior and the load pressure should be taken into account when specifying the speed.

5.4.1 ACCEL (Acceleration in NC mode)

Command	Parameters	Unit	Group
ACCEL x	x= 1… 20000	mm/s²	**VMODE=NC**

This command is used to define the acceleration in NC mode. The command is only active if the VMODE has been parameterized to NC.

5.4.2 VMAX (Maximum speed in NC mode)

Command	Parameters	Unit	Group
VMAX x	x= 1… 2000	mm/s	**VMODE=NC**

Specification of the maximum speed in NC mode. This value is defined by the drive system and should be specified as precisely as possible (not too high under any circumstances). The speed is scaled by means of the VELO value or via the external speed demand. The command is only active if the VMODE has been parameterized to NC.

5.5 Positioning controller

5.5.1 A (Acceleration (ramp) time)

Command	Parameters	Unit	Group
`A:i x`	i= A|B x= 1… 5000	ms	**VMODE=SDD**

Ramp function for the 1st and 3rd quadrants.

The acceleration time for positioning is dependent on the direction. “A” corresponds to connection 15 and “B” corresponds to connection 16 (if POL = +).
Normally A = flow P-A, B-T and B = flow P-B, A-T.

For quadrants 2 and 4, parameters D:A and D:B are used as the deceleration distance demand.

5.5.2 D (Deceleration stroke / braking distance)

Command	Parameters	Unit	Group
`D:i x`	i= A|B|S x= 1… 10000	mm	**VMODE = SDD**

This parameter is specified in mm[4].
The deceleration stroke is set for each direction of movement (A or B). The control gain is calculated internally depending on the deceleration distance. The shorter the deceleration distance, the higher the gain. A longer deceleration distance should be specified in the event of instability.

Parameter D:S is used as the stopping ramp when disabling the START signal. After disabling, a new target position (current position plus D:S) is calculated in relation to the speed and is specified as a command value.

$$G_{Intern} = \frac{N\_RANGE:X}{D_i}$$ Calculation of control gain

CAUTION: If the maximum stroke (SYS_RANGE command) is changed, the deceleration distance must also be adjusted. Otherwise this can result in instability and uncontrolled movements.

[4] **CAUTION!** In older modules this parameter was specified in % of the maximum stroke. Since data specification for this module has now been converted to mm, the relationship between the stroke (SYS_RANGE command) and these parameters must be taken into account.

5.5.3 V_0 (Loop gain setting)

Command	Parameters	Unit	Group
V0:i x	i= A|B x= 1… 400	s^{-1}	**VMODE = NC**

This parameter is specified in s^{-1} (1/s).
In NC Mode normally the loop gain is specified rather than the deceleration stroke[5].
The internal gain is calculated from this gain value together with the parameters VMAX and SYS_RANGE.

$$D_i = \frac{v_{max}}{V_0}$$

$$G_{Intern} = \frac{N\_RANGE:X}{D_i}$$

Calculation of the internal control gain

In NC Mode the following error at maximum speed is calculated by means of the loop gain. This following error corresponds to the deceleration stroke with stroke-dependent deceleration. The conversion and therefore also the correct data demands related to the closed loop control system are relatively simple if the relationship described here is taken into account.

5.5.4 V0:RES (Scaling of the loop gain)

Command	Parameters	Unit	Group
V0:RES x	x= 1|100	-	**VMODE = NC**

V0:RES = 1 loop gain in s^{-1} (1/s) units.
V0:RES = 100 loop gain in 0,01 s^{-1} units[6].

The increased resolution should be used in case of $V_0 < 4$.

[5] The loop gain is alternatively defined as a KV factor with the unit (m/min)/mm or as V_0 in 1/s. The conversion is KV = V_0/16,67.

[6] In case of very low loop gains (1 s^{-1} to 3 s^{-1}) the better resolution of the adjustment should be selected.

5.5.5 **PT1 (Timing of the controller)**

Command	Parameter	Unit	Group
PT1 x	x= 0… 300	ms	**EXP**

This parameter can be used to change the internal timing of the control function.
Hydraulic drives are often critically to control especially in case of high speeds and very fast valves. The PT1 filter can be used to improve the damping rate and allows therefore higher loop gains.

Requirements for the use are: The natural frequency of the valve should be equal or higher than the natural frequency of the drive.

5.5.6 **CTRL (Deceleration characteristics)**

Command	Parameters	Unit	Group
CTRL x	x= LIN|SQRT1|SQRT2	-	**STD**

The deceleration characteristic is set with this parameter. In case of positively overlapped proportional valves the SQRT function should be used. The non-linear flow function of these valves is linearized by the SQRT[7] function.

In case of zero lapped valves (control valves and servo valves) the LIN or SQRT1 function should be used regardless of the application. The progressive characteristic of the SQRT1 function has better positioning accuracy but can also lead to longer positioning times in individual cases.

LIN: Linear deceleration characteristic (gain is increased by a factor of 1).

SQRT1: Root function for braking curve calculation. The gain is increased by a factor of 3 (in the target position). This is the default setting.

SQRT2: Root function for braking curve calculation. The gain is increased by a factor of 5 (in the target position). This setting should only be used with a significantly progressive flow through the valve.

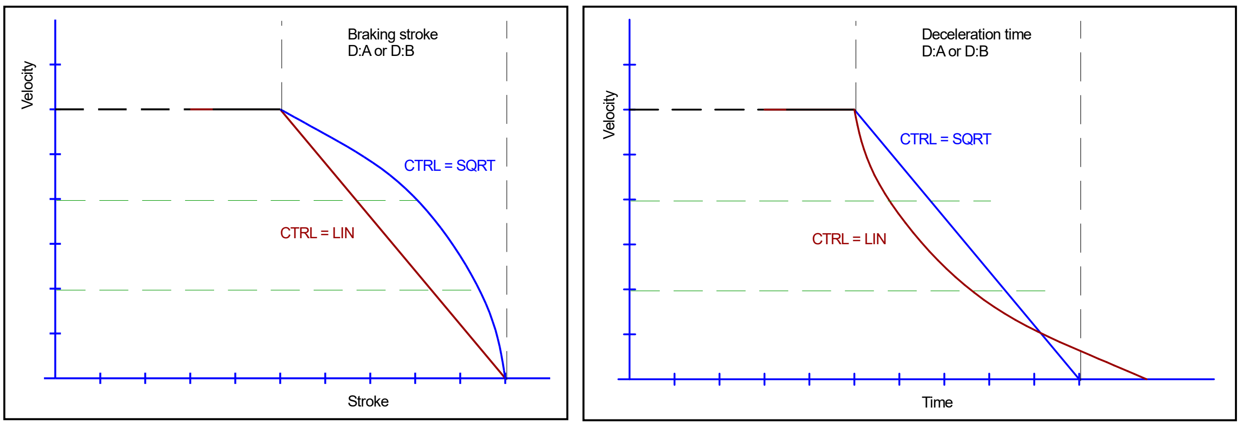


Figure 2 (Braking function with respect to stroke and time)

[7] The SQRT function generates constant deceleration and thus reaches the target position faster. This is achieved by increasing the gain during the deceleration process.

5.6 *Synchronization controller*

5.6.1 **GL:P (Proportional control gain)**

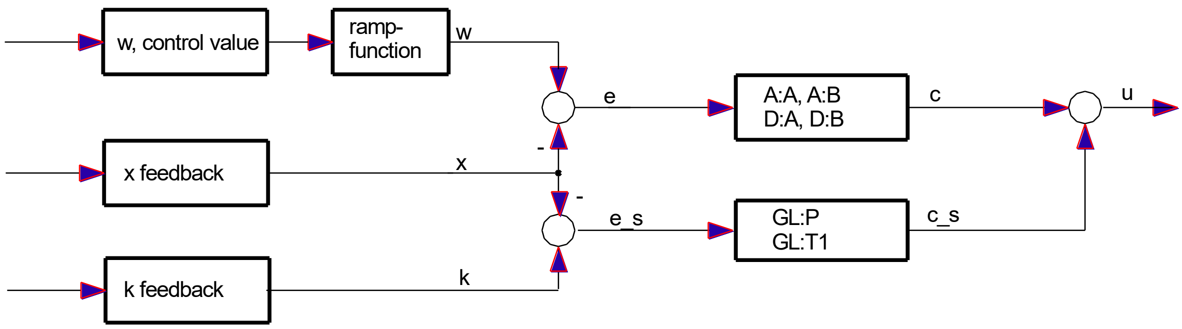
5.6.2 **GL:V0 (Proportional control gain in NC mode)**

5.6.3 **GL:T1 (damping of the synchronization control function)**

Commands	Parameter	Units	Group
GL:P x	x= 1… 10000	mm	**VMODE = SDD**
GL:V0 x	x= 1… 400	s^{-1}	**VMODE = NC**
GL:T1 x	x= 1… 300	ms	**STD**

These parameters are used to optimize the synchronization controller The SYNC-controller works as a PT1 or PI compensator for optimized controlling of hydraulic drives. The parameter T1 effects a delayed action of the SYNC Controller. The stability of the compensator could be increased in critical cases with the up streamed T1 Filter.

In **SDD-mode** is specified with GL:P, the braking distance in mm. The gain will depend on the stopping distance is calculated internally. The shorter the braking distance is set, the higher is the controller's gain. In case of instability a longer stopping distance should be adjusted.
In the **NC-mode** parameters of the GL: V0 is in s-1 (1 / s) specified.
In this mode, the loop gain is entered.
The parameter GL: T1 causes a delayed action of the synchronized controller. The stability of the controller can be increased by the upstream T1-filter in critical cases.



5.7 *Output signal adaptation*

5.7.1 MIN (Deadband compensation)

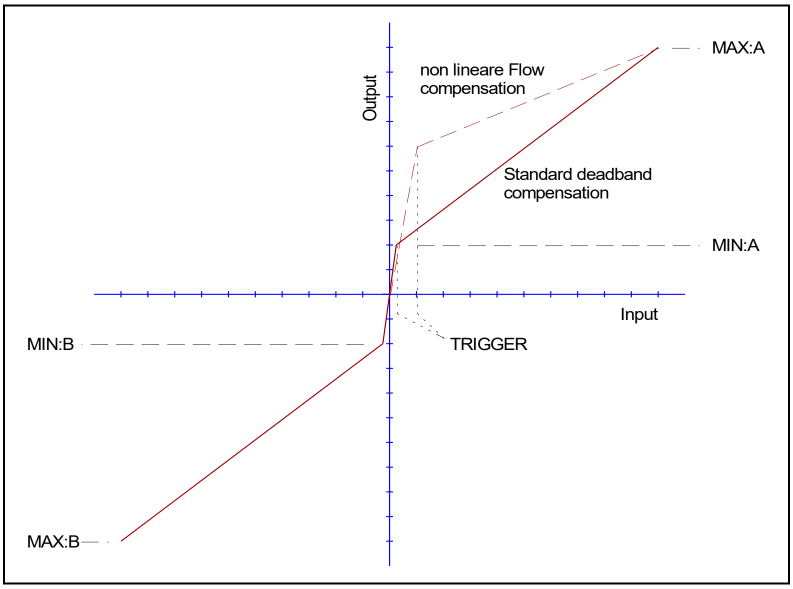
5.7.2 MAX (Output scaling)

5.7.3 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… 4000	0,01 %	

The output signal to the valve is adjusted by means of these commands. A kinked volume flow characteristic is used instead of the typical overlap step for the position controls. The advantage is better and more stable positioning behavior. At the same time, kinked volume flow characteristics can also be adjusted with this compensation[8].

CAUTION: If there should also be adjustment options for deadband compensation on the valve or valve amplifier, it must be ensured that the adjustment is performed either at the power amplifier or in the module.
If the MIN value is set too high, this has an effect on the minimum speed, which can then no longer be adjusted. In extreme cases this leads to oscillation around the controlled position.



[8] Various manufacturers have valves with a defined nonlinear curve: e.g. a kink at 40 or 60 % (corresponding to 10 % input signal) of the nominal volume flow. In this case the TRIGGER value should be set to 1000 and the MIN value to 4000 (6000).

If zero lapped or slightly underlapped valves are used, the volume flow gain in the zero range (within the underlap) is twice as high as in the normal working range. This can lead to vibrations and jittery behavior. To compensate this, the TRIGGER value should be set to approximately 200 and the MIN value to 100. The gain in the zero point is thus halved and an over-all higher gain can often be set.

5.7.4 OFFSET (Zero correction)

Command	Parameters	Unit	Group
OFFSET x	x= -4000… 4000	0,01 %	**STD**

This parameter is entered in 0,0 1% units.
The offset value is added to the output value. Valve zero offsets can be compensated with this parameter.

5.7.5 SIGNAL:U (Type and polarity of the output signal)

Command	Parameter	Unit	Group
SIGNAL:U x	x= U+-10 I4-12-20 U-+10 I20-12-4	-	**EXP**

This command is used to define the output signal (voltage or current) and to change the polarity[9].

Differential output ± 100 % corresponds with ± 10 V (0… 10 V at PIN 15 and PIN 16).
Current output ± 100 % corresponds with 4… 20 mA (PIN 15 to PIN 12). 12 mA (0 %) = center point of the valve.

An output current of << 4 mA indicates an error and the module is disabled. The current input of the proportional valves should be monitored by the valve. The valve have to be deactivated in case of < 4 mA input signal. Otherwise the EOUT command can be used to get a defined output signal.

[9] The older POL command is removed.

5.8 Special commands

5.8.1 AINMODE (Input scaling mode)

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

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.

5.8.2 AIN (Free analogue input scaling)

Command	Parameters	Unit	Group
AIN:i	i= W|X|V|K		**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. It is available for the inputs W (command signal), X (feed-back signal), K (Master position) and V (Speed limit). 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 (not at master position input K because it is connected parallel to master's feedback).

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

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 1000 800 1000 V	1… 9 V	Range: 0… 100 %; 1 V = 1000 used for the offset and gained by 10 / 8 (10 V divided by 8 V (9 V -1 V))
AIN:X 10 4 500 V OR AIN:X 1000 400 500 V	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 %.
AIN:V 2000 1000 5000 V	0… 5… 10 V	-100%... 0%... 100% speed (e.g. for joystick control)

5.8.3 JSCMODE (Joystick mode)

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

The JSCMODE activates the joystick control mode. Via the speed input the joystick signal is read in, the scaling has to be adapted to it (look above). The command position input is omitted then and the command position is taken internally depending on the polarity of the speed demand and the preset target positions. The target positions are parameterized with the following JSC:POS commands.

Note: Resetting all parameters to factory settings (DEFAULT) will also deactivate JSCMODE. It is therefore advisable not to use this command during commissioning and to use a saved parameter file instead.

5.8.4 JSC (Joystick control)

Command	Parameter	Unit	Group
JSC:POS1 x JSC:POS2 x JSC:DEADBAND x	x= 1… 10000 x= 1… 10000 x= 0… 5000	mm mm 0.01 %	**JSC**

Via this parameters the joystick control gets parameterized. The positions POS1 and POS2 are the position demands, which are taken internally as target position depending on the polarity of the speed demand. Positive speed leads to target POS1 and negative speed leads to target POS2. The DEADBAND defines a range around the center position of the joystick in order to avoid not wanted movements. The % value of this parameter refers to the measuring range of the input variable.

In the middle position of the joystick, the speed setpoint is equal to the value of the "VELO" parameter. This means that the axes and the synchronisation are also controlled in this state. For this purpose, when the movement is stopped, the current axis position is taken over as the setpoint, and when synchronisation is activated (PIN5), the average value of the axis position and feedback K is taken over.

If VMODE = NC is selected, the profile generator is initialised to this setpoint in the middle position. For a bumpless function, the parameter "ACCEL" must be set to its maximum value and the acceleration must be set with the parameter VRAMP.

5.9 PROCESS DATA (Monitoring)

Command	Description	Unit
WA	Demand value (input signal)	mm
W	Demand value (according to the profile generator)	mm
V	Speed input	%
X	Actual value	mm
E	Position error	mm
C	Output of the positioning controller	%
K	Master position	mm
E_S	Synchronisation error	mm
C_S	Output of the synchronous controller	%
U	Output signal of the module	%
IA	Solenoid current A	mA (P Version only)
IB	Solenoid current B	mA (P Version only)

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

6 Appendix

6.1 Failure monitoring

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

Source	Fault	Characteristic
Master feedback signal PIN 6 4… 20 mA	Out of range or broken wire	The output will be switched off.
Command speed PIN 10 4... 20 mA	Out of range or broken wire	The output will be switched off.
Command signal PIN 13 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.
P-VERSION Solenoids on PIN 17-20	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.

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 (PIN 8) is not present. If there is no power supply, there is also no communication via our operating program. If a connection has been made to the WPC-300, then a power supply is also available. If the power supply exists, an attempt should be made to see whether the system can be moved by means of the HAND+ and HAND- inputs (measuring the output signal to the valve helps).
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 one of the inputs if 4… 20 mA signals are parameterized. • A broken cable or incorrect cabling to the solenoids (in the P version only). • Internal data error: press the command/SAVE button to delete the data error. The system reloads the DEFAULT data. With the WPC-300 operating program the fault can be localized directly via the monitor.
ENABLE is active; the READY LED is on, the system moves to an end position.	The control circuit polarity is incorrect. The polarity can be changed with the POL command or by reversing the connections to PIN 15 and PIN 16.
ENABLE is active, the READY LED is on, the STATUS LED is not on, the system moves to the target position but doesn't reach it (positioning error).	Serious positioning errors can result from incorrect parameterization or incorrect system design. • Is the cylinder position specified correctly? • Are the deceleration strokes correct (to start the system the deceleration distances should be set to approx. 20… 25 % of the cylinder position[10])? • Is the valve a zero lapped control valve or a standard proportional valve? In the case of a proportional valve, the valve overlap which may be present should be compensated for with the MIN parameters. Typical values are to be found in the valve data sheet.
ENABLE is active, the READY LED is on, and the system oscillates on the target.	The system is working and also actuating the valve. Various potential problems could be: • The parameterization is not yet adjusted to the system (gain too high). • There is severe interference on the power supply. • Very long sensor cables (> 40 m) and sensor signal interference. • The MIN setting to compensate the valve overlap is too high. As a basic principle, the parameterization of the sensor data and the controller settings must be carried out first (before switching on). An incorrect demand is equivalent to incorrect system design which then leads to incorrect operation. If the system oscillates, the gain should first be reduced (longer deceleration distances for D:A and D:B) and in the case of overlapped valves the MIN parameter should also be reduced.

Speed too low	The drive may be able to move to position but the speed is too low.
	• Check the control signal to the valve.
	    • Via the integrated oscilloscope (U variable).
	    • Measure the signal to the valve with an external oscilloscope / voltmeter.
	• If the control is within the range of ± 100 % (± 10 V), the fault must be sought in the hydraulics.
	• If the control signal is relatively low, the following points should be checked:
	    • Is the internal/external speed signal limiting the speed?
	    • Which setting has been specified for the deceleration distance in relation to the POSITION?

[10] The stability criterion of the hydraulic axes must be taken into account.

FAULT	CAUSE / SOLUTION
Speed too high	The drive should move to position. The drive moves in and out too fast leading to uncontrolled behavior. Reducing the speed (MAX or VELO parameter) has very little or no effect. • The hydraulic system is over-sized. The entire parameterization of the movement cycle cannot be reproduced (overlap and deceleration distance settings)
Positioning is OK, the synchronization error is too high.	There may be several reasons. The synchronization accuracy is determined by the parameter GL:P. The higher the value, the smaller the synchronization error (within physical limits). Reasons: 1. The parameter setting is different between the two axes. 2. The hydraulic system pressure is not sufficient. The supply pressure is not constant.[11] 3. The slave axis can't follow the master axis at high speeds. This means that the natural velocity of the master axis is higher than that of the slave axis[12]. In this case, the maximum speed of the master axis should be limited (MAX parameter). 4. The sensor scaling or the position of sensor includes an offset error. This error is typically constant. Solution: Move the sensor mechanically or compensate for the fault over the AIN command.

[11] High demands to the synchronization have to be regarded with high demands to the pressure supply. Pressure errors lead always to synchronization faults, which the control has to compensate for.

[12] In principle, the master axis should be limited in the master/slave configuration in the speed.
The slave axis must have the possibility of driving faster than the master axis. Otherwise control errors cannot be compensated for.

7 DDITIONAL INFORMATION: Power output stage

7.1 General function

The power output stages have been developed for controlling proportional valves without spool position feedback. The output stage is controlled by the microcontroller on the basic module by means of pulse width modulated signals, and the current is continuously controlled. The cycle time for the controller is 0,125 ms.

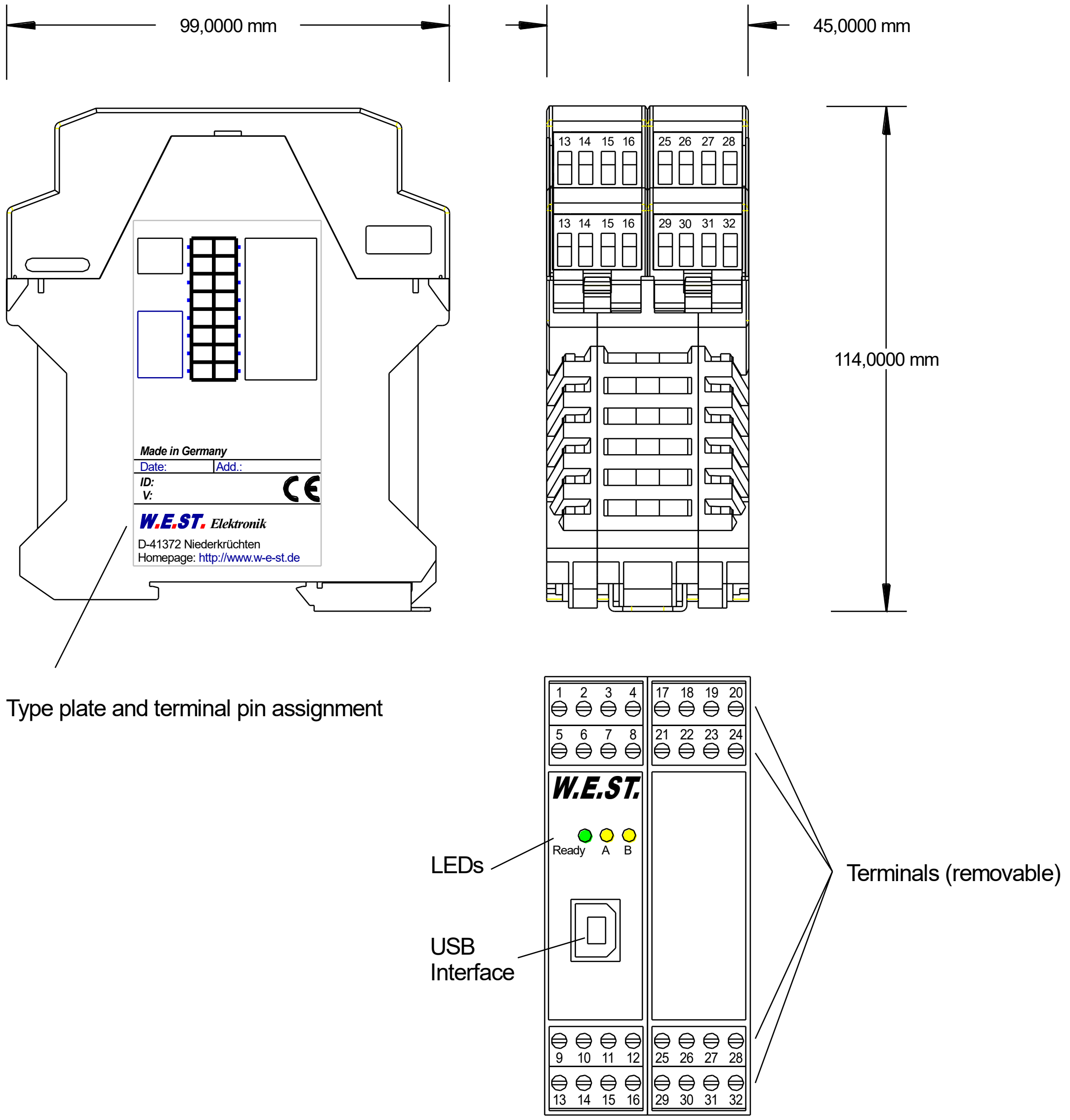
The output stage can be ideally adjusted to dynamic requirements via internal parameters.

Valve technology: Proportional valves manufactured by REXROTH, BOSCH, DENISON, EATON, PARKER, FLUID TEAM, ATOS and others.

Features

- **Two power output stages with maximum output range of 0.5 A to 2,6 A**
- **Hardware short-circuit protection with 3 µs response time**
- **Adjustable PWM frequency, dither frequency and dither amplitude**
- **High current signal resolution**
- **No additional delay times between the control function and the power stage**
- **Separate power supply for safety-relevant applications**
- **Integrated into the standard controller, no additional wiring necessary**
- **Optimum price/performance ratio**

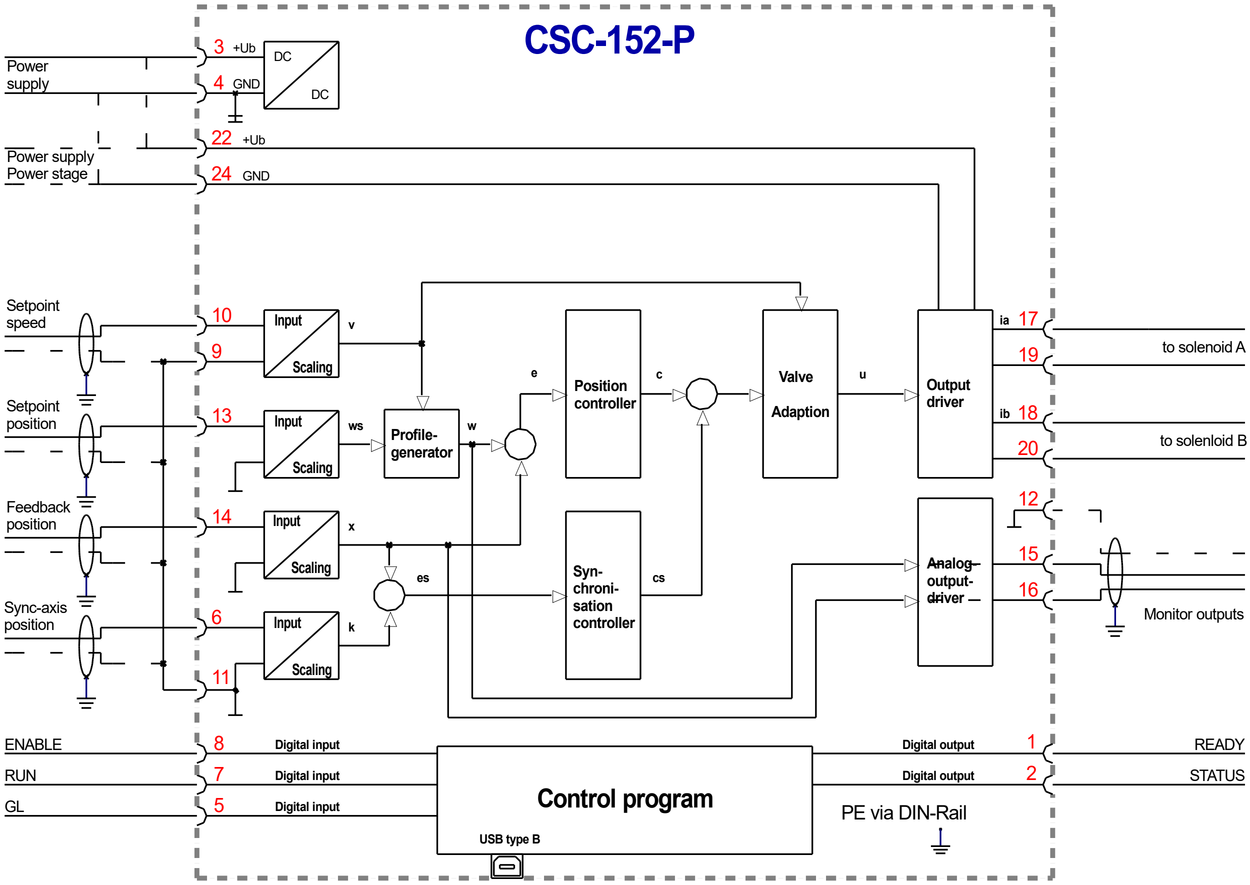
7.2 Device description



7.3 Inputs and outputs

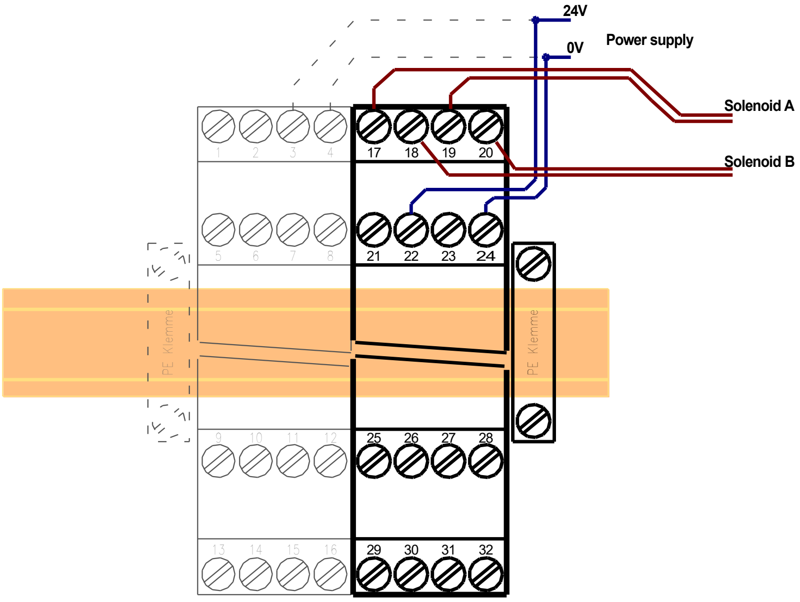
Connection	Signal description
PIN 22 + PIN 24 -	**Power supply: 10… 30 VDC:** For safety-related applications, the output stage can be deactivated thanks to the separate power supply inputs.
PIN 17 + 19	Solenoid current output A
PIN 18 + 20	Solenoid current output B
Connection	**Signals modified from the standard (A and I version)**
PIN 15	0… 10 V / 4… 20 mA output with the scaled position demand value
PIN 16	0… 10 V / 4… 20 mA output with the scaled feedback position value

7.4 Circuit diagram



7.5 Typical wiring

CAUTION: The solenoid cables should be screened due to electro-magnetic emissions.



CAUTION: plugs with free-wheeling diodes and LED indicators cannot be used with current-controlled power outputs. They interfere with the current control and can destroy the output stage.

7.6 Technical data

Supply voltage Power consumption max. Fuse protection	**[VDC]** **[W]** **[A]**	12... 30 (incl. ripple) max. 1.2 + Power of the connected coils 3 (medium time lag)
PWM output Max. output current Frequency	 **[A]** **[Hz]**	Wire break and short circuit monitored 2.6 61… 2604 selectable in defined steps
Sample time solenoid current control	**[µs]**	125
Weight	**[kg]**	0.28 (incl. standard module)
Connections Plug connectors		 6 x 4-pole terminal blocks (incl. the base modul)

7.7 Parameter overview

Command	Default	Unit	Description
SIGNAL:M	V	-	Type of the monitor output signal
CURRENT	1000	mA	Output current range
DFREQ	121	Hz	Dither frequency
DAMPL	500	0,01 %	Dither amplitude
PWM	2604	Hz	PWM frequency
ACC	ON	-	Automatical calculation of the PPWM and IPWM parameter
PPWM **IPWM**	7 40	- -	Current control loop PI control dynamics
SIGNAL:U	+	-	Output polarity

The standard parameterization has been used with a large number of proportional vales from various manufacturers. This parameterization has proved to be good as long as no special demands concerning the application have to be fulfilled.

7.8 Parameter description of the power stage

7.8.1 SIGNAL:M (Type of the monitor output signal)

Command	Parameter	Unit	Group
SIGNAL:M x	x= U0-10|I4-20	-	**EXP**

This command is used to define the output signal.

U0-10 - Voltage signal 0… 10V for 0… 100%.

I4-20 - Current signal 4… 20mA for 0… 100%.

7.8.2 CURRENT (Rated output 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.

7.8.3 DFREQ (Dither frequency)

7.8.4 DAMPL (Dither amplitude)

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

The dither[13] 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[14] (see: CURRENT command).

The dither frequency is defined in Hz. Depending on the internal calculations, the frequency is adjustable in steps only[15].

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.*

7.8.5 PWM (PWM Frequenz)

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

The frequency can be changed in defined steps (61 Hz, 72 Hz, 85 Hz, 100 Hz, 120 Hz, 150 Hz, 200 Hz, 269 Hz, 372 Hz, 488 Hz, 624 Hz, 781 Hz, 976 Hz, 1201 Hz, 1420 Hz, 1562 Hz, 1736 Hz, 1953 Hz, 2232 Hz and 2604 Hz). The optimum frequency depends on the valve.

Attention: *The PPWM and IPWM parameters should be adapted when using low PWM frequencies because of the longer dead times which forces a reduced stability of the closed loop control.*

---

[13] 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.

[14] 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.

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

7.8.6 ACC (Current loop ato 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.

7.8.7 PPWM (Solenoid current controller P element)

7.8.8 IPWM (Solenoid current controller I element)

Command	Parameters	Unit	Group
PPWM x	x= 0… 30	-	**EXP**
IPWM x	x= 4… 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.

7.9 Changed parameter from U-version

7.9.1 SIGNAL:U (Polarity of the output signal)

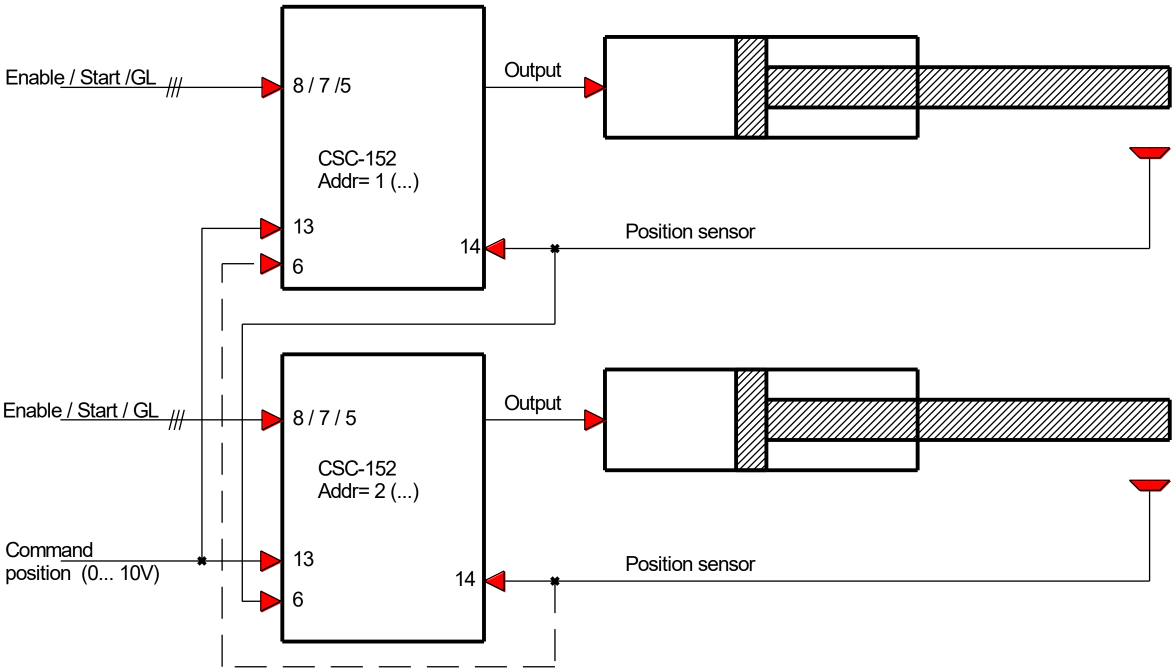
Command	Parameters	Unit	Group
SIGNAL:U x	x= +|-	-	**STD**

In P-version this command provides defined switching the polarity of the output signal.

8 HELPING INFORMATION: Schematic diagrams

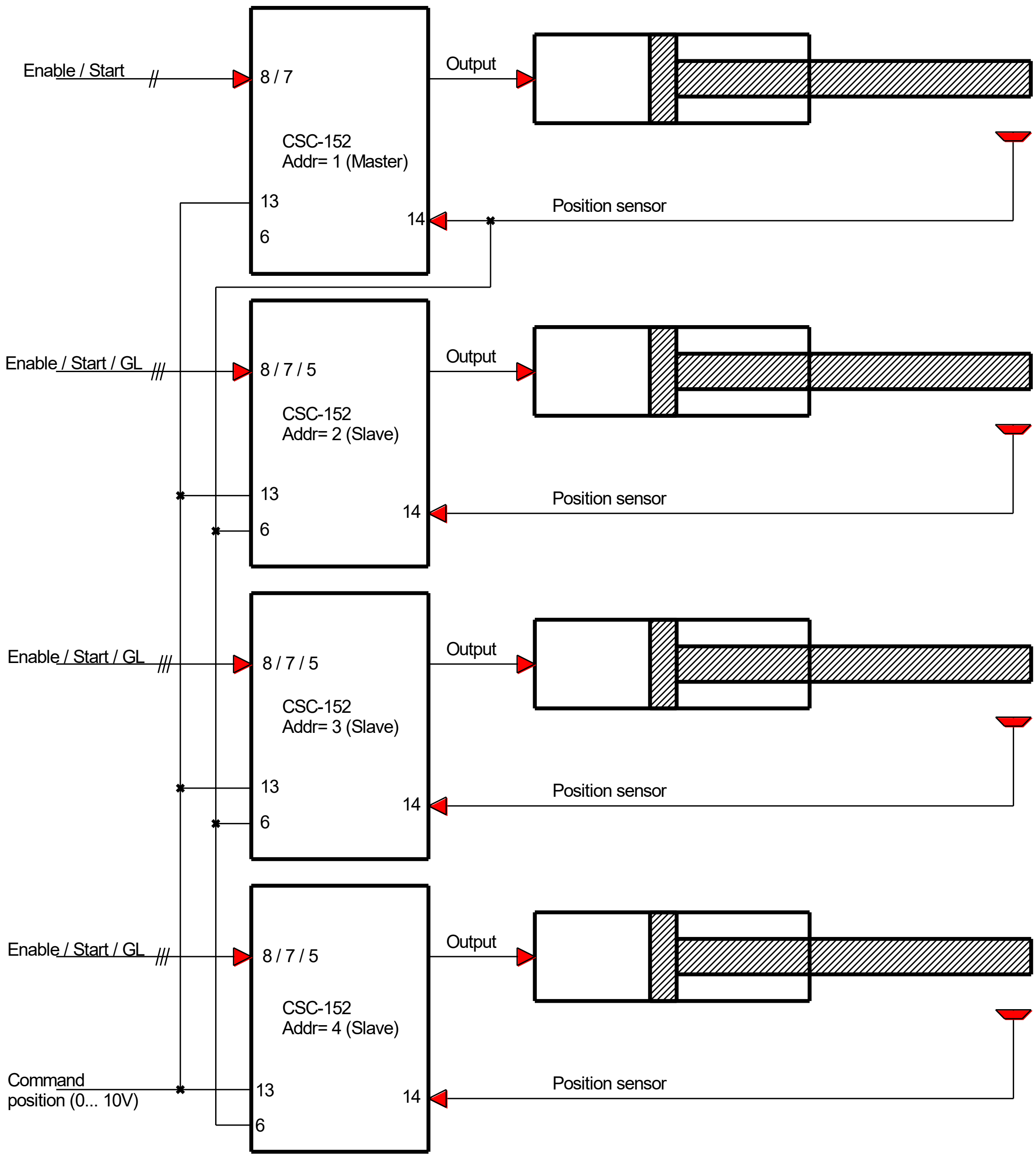
8.1 2 axes system

The slave can be defined with the digital input PIN 5 (GL-active) if only two axes are synchronized. Activating the synchronous controller in both axes results in a master/master system with average value controlling.



8.2 4 axes system

In four axes, the master-/ slave-structure is predetermined. Other control structures are only possible using the system CSC-156-SSIC with CAN bus networking.



8.3 Using current signals parallel connected

8.3.1 Background

When using 4… 20 mA current signals an internal measuring resistor is connected to the analogue inputs. This is accomplished by the program logic automatically. If a current signal is used in parallel at several inputs, only one of these resistors must be active. At input PIN 6 the resistor will never be activated because this input is always parallel to PIN 14 of another device.

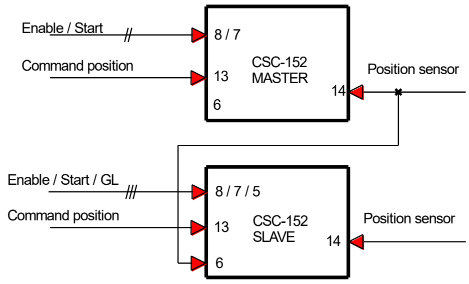
Besides the measuring resistor there is always an internal resistance of the input circuit which cannot be switched off. If a current signal is connected to several units in parallel, this will cause a small but noticeable influence on the signal. The deviation will be compensated automatically at the relating input. For example, for PIN 14 at a master axis it has to be considered that the internal resistances of the slave modules are connected in parallel. The controller differs between master and slave by the input PIN 5, if the parameter AXIS_FUNC is switched to „AUTO“ (compatibility mode) or by manual choice of the axis type by this parameter (recommended).

If the command position should also be provided with one common current signal, the device needs information in order to decide if the measurement resistor should be activated and for compensating deviations. For that the command SOURCE:W is available. At the slave axes the resistor stays inactive, the master will activate it.

If the master-master principle should be applied and at the same time a common set-point by one current signal is used, it is necessary to use the parameter AXIS_FUNC and to define one module as “MASTER” and the other as “MASTER_2”. The latter will not activate its measurement resistor at PIN 13.

8.3.2 Examples

2 axes Master-Slave prinziple
-- 2 separate command signals --



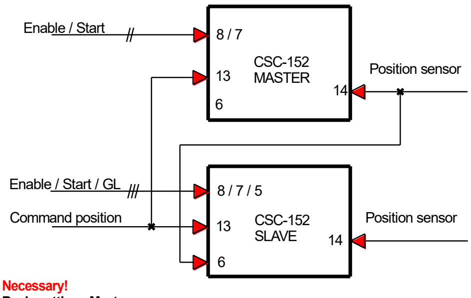
Default settings:
SOURCE:W = SEPARATE
AXIS_FUNC = AUTO

Manual settings Master:
AXIS_FUNC = MASTER
Manual settings Slave:
AXIS_FUNC = SLAVE

Case 1: PIN:5 constantly available:
No parameter changes necessary.
Manual settings have the same effect.

Case 2: PIN 5 gets temporarily deactivated:
Manual settings recommended.

2 axes Master-Slave prinziple
-- one common command signal --



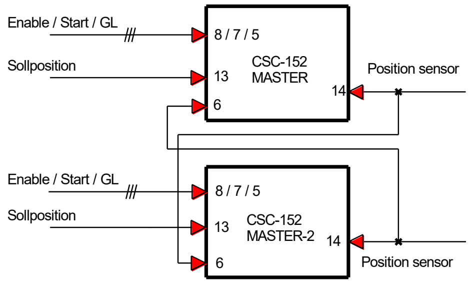
Necessary!
Basic settings Master:
SOURCE:W = COMMON
Basic settings Slave:
SOURCE:W = COMMON

Manual settings Master:
AXIS_FUNC = MASTER
Manual settings Slave:
AXIS_FUNC = SLAVE

Fall 1: PIN:5 is constantly available:
No further changes necessary.

Fall 2: PIN 5 gets temporarily deactivated:
Manual settings are recommended.

2 axes Master-Master prinziple
-- 2 separate command signals --



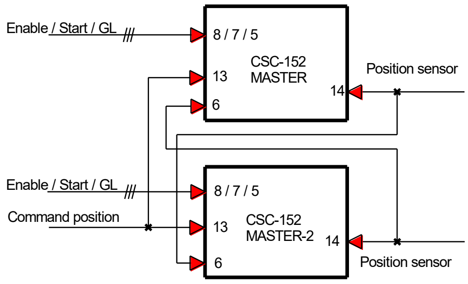
Default settings:
SOURCE:W = SEPARATE
AXIS_FUNC = AUTO

Manual settings Master:
AXIS_FUNC = MASTER
Manual settings Master-2:
AXIS_FUNC = MASTER_2

Case 1: PIN:5 is constantly available:
Both axes have no correction at PIN 14.
- When exchanging devices and taking over existing scalings: No changings of the settings.
- At new applications: manual settings are recommended.

Fall 2: PIN 5 gets temporarily deactivated:
Manual settings are recommended.

2 axes Master-Master prinziple
-- one common command signal --



Necessary!
Basic settings Master:
SOURCE:W = COMMON
AXIS_FUNC = MASTER
Basic settings Master-2:
SOURCE:W = COMMON
AXIS_FUNC = MASTER_2

No alternative settings:
If using a common command position current signal this settings are mandatory!

9 Notes