Manual for

DAC-4x(A)-14-PpQ

DIGITAL AMPLIFIER AND CONTROLLER CARD FOR ALL KIND OF PROPORTIONAL VALVES

	Model Code	SW Version	Remarks
Applicable for SW Versions	DAC-4x(A)-x-PpQ with power limitation parameters	V 53.xx	xx = 01 or higher * = a, b, …. x = additional options All SW versions are working in the control mode 14
	DAC-42A)-x-PBDP-PpQ with power limitation parameters and PROFIBUS interface [1)]	V 54.xx	
	DAC-42(A)-x-PN-PpQ with power limitation parameters and PROFINET interface [1)]	V 55.xx	
	DAC-42(A)-x-PN-pQ only pQ application with PROFINET interface [1)]	V 56.xx	
	DAC-4x(A)-x-PpQ with power or torque limitation parameters	V 63.xx	
	DAC-42(A)-x-PBDP-PpQ with power or torque limitation parameters and PROFIBUS interface [1)]	V 64.xx	
	DAC-42(A)-x-EIP-PpQ with power or torque limitation parameters and EtherNet-IP interface [1)]	V 65.xx	
	DAC-42(A)-x-PN-PpQ with power or torque limitation parameters and PROFINET interface [1)]	V 66.xx	

[1)] For the Bus Version, please refer also the related BUS documentation

*) picture versions with PROFINET and without bus interface

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Revision History

Revision	Date	Author	Description
1.0	18.10.2023	Bm	First edition
1.0	21.02.2024	Bm	Correction
1.0	24.04.2024	Bm	EIP interface description
1.0	06.05.2024	Bm	New block diagram, Correction
1.1	16.05.2024	Deu	Textual corrections
1.1	11.07.2024	Bm	Functional diagram included
1.1	02.09.2024	Bm	Typo on page 48 corrected.
1.1	05.09.2024	Bm	Document renamed to DAC-4x(A)-14…, ID address for C2.27, C2.28 corrected
1.3	29.07.2026	Bm	New parameters d2.10b, C2.36, C2.37, C2.38 added (SW V63.03). New software block diagram R03 (29.06.2026) inserted.

Table of contents

1 Abbreviations

Abbreviation	Description
DAC	**D**igital **A**mplifier and **C**ontroller
EMC	**E**lectro **M**agnetic **C**ompatibility; properties of the unit in order to comply with the EMC directive
USB	**U**niversal **S**erial **B**us; interface for communication between a PC and the DAC-4x(A)
PC	**P**ersonal **C**omputer
µC	**M**icro **C**ontroller; CPU used inside the unit to control all functions
mamsl	**me**ters **a**bove **m**edian **s**ea **l**evel
IP65	Protection Class; solid particle protection and protection level against water ingress
LED	**L**ight **E**mitting **D**iode
PWM	**P**ulse **W**idth **M**odulation; method to control the output current at low power losses
Ub	Supply voltage
FS	**F**ull **S**cale
PpQ	The unit controls displacement or flow (Q), pressure(p) and power or torque(P)
pQ	The unit controls only displacement or flow (Q) and pressure (p)

Table 1: Abbreviations

2 Terms and Definitions

Term	Description
Amplifier Card	Amplifier for 19” rack system in Eurocard format
HCSTool	Software tool provided by HCS in order to adjust and parametrize DAC-4x(A) units
CANopen	Bus interface for digital communication, defined by CIA
PROFIBUS	Process Field Bus interface for digital communication, defined by BMBF (German department of education and research) and used by Siemens
PROFINET	Process Field Net interface for digital communication, the standard is maintained and supported by PROFIBUS & PROFINET International
EtherNet/IP	(IP = Industrial Protocol) is an industrial network protocol that adapts the Common Industrial Protocol to standard Ethernet
USB-C connector	Connector type used on the USB interface

Table 2: Terms and definitions

3 General information

3.1 Abstract

This document describes the function of the HCS digital amplifier and controller card “DAC-4x(A)-x-PpQ”.

This manual was prepared with great care and the contents reflect the author’s best knowledge. However, the possibility of error remains and improvements are possible. Please feel free to submit any comments regarding errors or possibly incomplete information to HCS GmbH.

DANGER

Read this manual carefully before working with the digital amplifier cards!

The general and especially the safety instructions of this manual must be observed in any case!

Electronic equipment of all kinds can have component failures or software may lead to unpredictable reactions. Secondary safety measures must be taken to ensure safety under all circumstances. This is especially the case for safety critical applications.

Furthermore, it is the responsibility of the user to always comply with applicable safety standards (e.g. EN 13849) and to implement a system architecture capable to cover all safety requirements. The unit itself does not comply with any performance level given in EN 13849 or any SIL level as per EN 61508.

Applicable laws and safety standards must be observed at any time. Before commissioning or using the equipment, the necessary risk analysis must be conducted and suitable protection measures must be taken.

HCS GmbH refuses any liability in case of omission to comply with these requirements.

3.2 Scope

With the help of this document a professional, competent and trained user should be able to install, wire, connect, commission, set parameters, perform fault analysis and fix issues. Also, the document will provide the user any technical and operational details necessary to safely operate the product. It remains the user responsibility to set-up a safe working environment while operating the product.

The information contained in this manual is valid at the time of this version's release. See footer for version number and release date of this manual.

3.2.1 Copyright

3.2.2 Documents place of storage

This manual and all other associated documentation for hardware and software must always be kept in a location where they will be readily accessible and close to the digital amplifier and controller card DAC-4x(A) or the equipment in which it is installed.

3.2.3 Warning signs, symbols and notes

DANGER
Identifies safety instructions that are intended to warn of an immediate and impending danger to life and limb. Failure to observe these safety instructions will – with a very high probability - lead to death, serious personal injury (disablement)!

WARNING
Identifies safety instructions that are intended to warn of potential danger to life and limb. Failure to observe these safety instructions might lead to death, serious personal injury (disablement)!

CAUTION
Identifies safety instructions that are intended to warn of slight personal injury. Failure to observe these safety instructions might lead to slight personal injury.

NOTICE
Failure to observe this safety notice can result in property damage!

Identifiers important information

Other identifiers (when applicable):

Identifier	Description
●/ -	Listings
□	References to another chapter, page, table or figure in this manual
blue text	Hyperlink within the document
1., 2., …	Steps in a procedure that should be performed in consecutive order
'STATE'	States of a state machine
«ES»	LEDs of the amplifier (for example, «ES»)
< >	parameter name
"…"	Used for references

Table 3: Identifiers

3.2.4 Safety and liability

NOTICE

**The information in this document is subject to change without further notice.
HCS assumes no responsibility for any faults that may appear in this manual.**

This operating manual represents the knowledge of HCS and during the drafting of this operating manual the greatest possible care was taken. Nevertheless, HCS disclaims any responsibility and liability claims for individual applications of the user. This is particularly true in cases of non-compliance, omissions, faults, misinterpretations and misunderstandings.

Applicable laws and safety standards must be observed at any time. Before commissioning or using the equipment, the necessary risk analysis must be conducted and suitable protection measures must be taken.

This manual only describes the functionality and influence of the parameters. The described software functionality can be used in various amplifier models which can be implemented in a vast range of applications. Hence it is not possible to assume liability for the influence of the parameters.

HCS GmbH refuses any liability in case of omission to comply with these requirements.

⚠ WARNING

In the case of applications with critical safety requirements or where accident prevention regulations must be observed, it may be necessary to isolate the components from the solenoids with relays in e-stop circuits.

To switch off the enable signal (0 V at terminal 8d) is insufficient. In these cases, hydraulic and/or mechanical safety measures to stop the drive must be provided (e.g. through switching valves with position monitoring).

⚠ WARNING

All types of proportional directional valves, which may be used in all kinds of different environments and applications, can eventually fail and hence are able to cause damage.

It is the customers obligation to analyze all safety related aspects of the application. It is within the full responsibility of the machine builder and/or system integrator to make the final selection of products and reassure and confirm that all requirements regarding safety and performance are met.

The procedure of selecting the proper control system and related safety levels is covered by the machine directive EN 13849.

NOTICE

Liability for any content of this document is rejected!

Any claims against HCS GmbH – based on whatever legal reason – resulting from the use of the information, programs, engineering and performance data etc., described in this document shall be excluded. Exclusion in such cases shall not apply for mandatory liability, e.g. under the "Product Liability Act", in case of intent, gross negligence, or injury of life, body or health, guarantee for the quality of a product, fraudulent concealment of a deficiency or breach of a condition. Damages for breach of a substantial contractual obligation are, however, limited to the foreseeable damage, typical for the type of contract, except in the event of intent or gross negligence or injury to life, body or health. The above provisions do not imply a change of the burden of proof to your detriment.

We reserve the right to make changes to this document at any time without prior notice.

3.2.5 General information

⚠ WARNING

ESD (electrostatic discharge) may damage components on the card. To prevent any damage please always follow the recommendations below!

Discharge static voltage from your body by using best practice.
Work in safe environment and do not use any devices in the working surrounding which could generate or hold static charge. Avoid using the product in areas where floors or surfaces are composed of materials that could generate static charges.

Handle all equipment very carefully and do not touch exposed pins or components.

Store and transport the units only in its original packaging.

⚠ WARNING

During commissioning, particular attention must be paid to the correct design and realization of the wiring. This must be checked before applying the supply voltage.

To avoid collisions, the safety devices and limit switches must be activated. All safety regulations are to be observed.

Monitoring the fault signal (terminal 14d) is recommended.

Malfunctions can occur with the following:

- Changes to the settings made by the supplier.
- Neglecting of operating parameters (e.g. supply voltage, application of inadmissible signals on inputs or outputs, ambient conditions, wiring, unsafe loads such as motors, contactors, relays, ohm loads, etc.)
- Faults in series-connected controls components and set points or actual values
- Faults in the subsequent hydraulic components
- Removing of solenoids connections.

3.3 Terms and conditions

Please pay attention to our general terms and conditions (available on request).

3.4 Delivery state (default setting)

The product is shipped in a ready-to-use state (default settings). After correct installation and setting of all parameters relevant for the application, the amplifier card is ready for use.

3.5 Correct product use

The digital amplifier and controller cards "DAC-4x(A)-x-PpQ" are used for the following applications:

- Controlling of proportional valves (namely directional control valves); with or without feedback (depending on operation mode).
- Controls the delivery volume of a pump with a proportional or servo valve in terms of pressure and performance, without the need for hydraulic-mechanical control parts.
- For industrial applications only.

The operation of other inductive or resistive loads is not recommended (motors, heaters, etc.). If you are considering any applications like this please contact HCS GmbH.

If used correctly, the safety of the user as well as the safe and proper function of the amplifier DAC-4x(A) is given.

3.6 Non-intended product use

The digital amplifier and controller cards "DAC-4x(A)-x-PpQ" should not be used in the following cases:

- if noticeably damaged
- when the electrical connections are damaged
- if they do not function correctly
- after incorrect handling or storage
- in non-appropriate applications or environments.

In these cases, the digital amplifier and controller card must be disabled and secured against accidental restarting.

In the case of applications with critical safety requirements or where accident prevention regulations must be observed, it may be necessary to isolate the components from the solenoids with relays in e-stop circuits. In these cases, hydraulic and/or mechanical safety measures to stop the drive must be provided (e.g. through switching valves with position monitoring).

During commissioning, particular attention must be paid to the correct design and realization of the wiring. This must be checked before applying the supply voltage.

To avoid collisions, the safety devices and limit switches must be activated. All safety regulations are to be observed.

Malfunctions can occur when:

- Changes to the settings made by the supplier.
- Neglecting of operating parameters (e.g. supply voltage, application of inadmissible signals on inputs or outputs, ambient conditions, wiring, unsafe loads such as motors, contactors, relays, ohm loads, etc.)
- Faults in series-connected controls components and set points or actual values
- Faults in the subsequent hydraulic components
- Removing of valve connection.

3.7 Selection and qualification of personnel

Only qualified users may work with the amplifier. Qualified users are properly trained experts with the required knowledge and experience. In particular, these experts must have the authorization to bring into operation systems and power circuits in accordance with safety engineering standards. They must be familiar with safety concepts common in automation.

3.7.1 Inquiries and ordering

To order the product, the complete order code is requested.

See □ Chapter "3.7.1 Inquiries and ordering", page 10

Please pay attention to our general terms and conditions (available on request) and forward orders and enquiries to the companies as listed on our web page:

Sales Partners (h-c-s-gmbh.de)

https://www.h-c-s-gmbh.de/en/sales-partners

They are our official distributors/partners. We reserve the right to forward any direct inquiries or orders to our distributors/partners. Nevertheless, we will be available for any necessary technical support.

Germany and other countries without distributor/partner:

Neuffener Strasse 29
D-72636 Frickenhausen
Tel: (+49) 7025 - 911 007
Fax: (+49) 7025 - 911 008
Email: info@h-c-s-gmbh.de
www.h-c-s-gmbh.de

3.7.2 Service and repair

WARNING
Do not attempt - under any circumstances - to repair the product yourself

After repair, certain adjustments and test procedures must be performed; this can only be made by qualified and authorized personnel. Products that need repair can be sent to the addresses:

See □ Chapter "3.7.1 Inquiries and ordering", page 10

Please enclose a detailed description of the error, malfunction or failure with the sent item and state the serial number and the purchase date. This will speed up the process and guarantees a fast and reliable repair.

See □ Chapter "3.7.1 Inquiries and ordering", page 10

In the case of a fault or a malfunction, your distributor can give you instructions on the phone or in writing before accepting a repair order. For service and repair, we offer experienced and qualified personnel. In case you need our assistance, please contact the address:

See □ Chapter "3.7.1 Inquiries and ordering", page 10

3.7.3 Cleaning, storage, transport

The product should only be transported and stored in the original packaging to ensure suitable protection against mechanical damage as well as electrostatic discharge.

- Keep the amplifier card away from moisture and dust
- Observe the allowed storage and transportation temperature range
- If it should be necessary to clean the amplifier, we recommend sending it back to the manufacturer or any distributor and partner:

See □ Chapter "3.7.1 Inquiries and ordering", page 10

CAUTION
Unpacking and handling should be left to suitably trained personnel. Beware of damaging the amplifier by electrostatic discharge

3.7.4 Delivery state (default setting)

The product is shipped in a ready-to-use state (default settings). After correct installation and setting of all parameters relevant for the application, the digital amplifier and controller card is ready for use.

3.8 Introduction

The digital amplifier and controller card “DAC-4x(A)-x” features leading edge technology. This electronic device meets the industrial standards for EMC. This ensures a high interference security and low interference emission.

The performance characteristics are possible through the use of the most current microprocessor technology (32-bit floating-point CPU) combined with other state of the art components. In addition to all control functions, the microprocessor also handles closed-loop control. The system features are essentially determined by the software and provide reserve capacity for further developments and adaptations.

The following features distinguish the “DAC-4x(A)-x” series:

- Fully digitized amplifier card with the advantage of
  - no on-board potentiometer
  - no jumper settings required
  - digital setting and display of all parameters by means of PC with HCSTool
  - user safety during parameterization
- flexible and reliable system:
  - use of a modern 32-Bit floating point µC
  - high performance and yet power reserve
  - high reliability and safety through the use of a integrated watch-dog and reset function
  - variable settings for magnetic systems making high flexibility possible
- functional use of the interface:
  - change of selected parameters “on-the-fly” without interference or interruptions of the working cycle
  - analyzing of system performance through selection of display parameters with the PC and by using the 4-channel oscilloscope function included in HCSTool
  - bus interfaces available (PROFIBUS/PROFIDRIVE, PROFINET, EtherNet/IP, CAN-OPEN)

3.9 General Applications

The amplifier card “DAC-4x(A)-x-PpQ-x” is generally used for

- Controlling of hydraulic motors, - installations and – systems, e.g.:
  - position
  - speed
  - pressure
  - revolutions per minute
  - torque
  - power etc.

- Volume flow control and pressure limiting function of pumps (pQ)
- Additional power/torque limitation function (PpQ)
- Master / slave operation of such pumps

- Controlling of different process values:
  - P/Q controlling
  - pump controlling
  - controlling of pressures
  - controlling of pilot- and main stage
  - cascade controlling of components etc.

This manual especially applies to the PpQ control of pumps with swash plate angel control (flow control), pressure limiting function and power limiting function.

4 Product overview and description

The DAC-4x(A)-x-PpQ is a fully digital PpQ controller unit for high pressure pump which enables users for different industries to achieve better control, faster response time, higher reliability, and cost savings through a reduced overall component count. The DAC-4x(A)-x-PpQ electronically controls displacement (flow), pressure and power on the pump and additional operational costs and environmental impact may be reduced through energy recovery as the control unit allows the pump to be used 100 percent over center, functioning as a motor for counter moving applications like, for example, lifting and lowering.
The DAC-4x(A)-x-PpQ can control a proportional or servo valve, which controls the pump for pressure, power and displacement, without hydraulic-mechanical control parts. It also adds intelligent mooring control and master/slave functions.
Flow control measures the actual swash-plate position from sensor data, comparing the swash-plate angle with the set value and driving the servo or proportional valve accordingly.

Pressure cut-off control measures pressure in both input and output lines with pressure sensors, reducing output levels if actual pressure exceeds the command signal. This adjusts the pump exactly to the application needs. Power cut-off control calculates actual power by measuring pressures and swash plate angle, which is directly proportional to flow.

A master to slave function allows several pumps to be used to facilitate large-scale applications with high flow demand. In this mode the master pump can be used over its full operational and flow span, while the slave pumps follow the master pump settings. A through drive allows multiple pumps from a single shaft.

4.1 Technical features

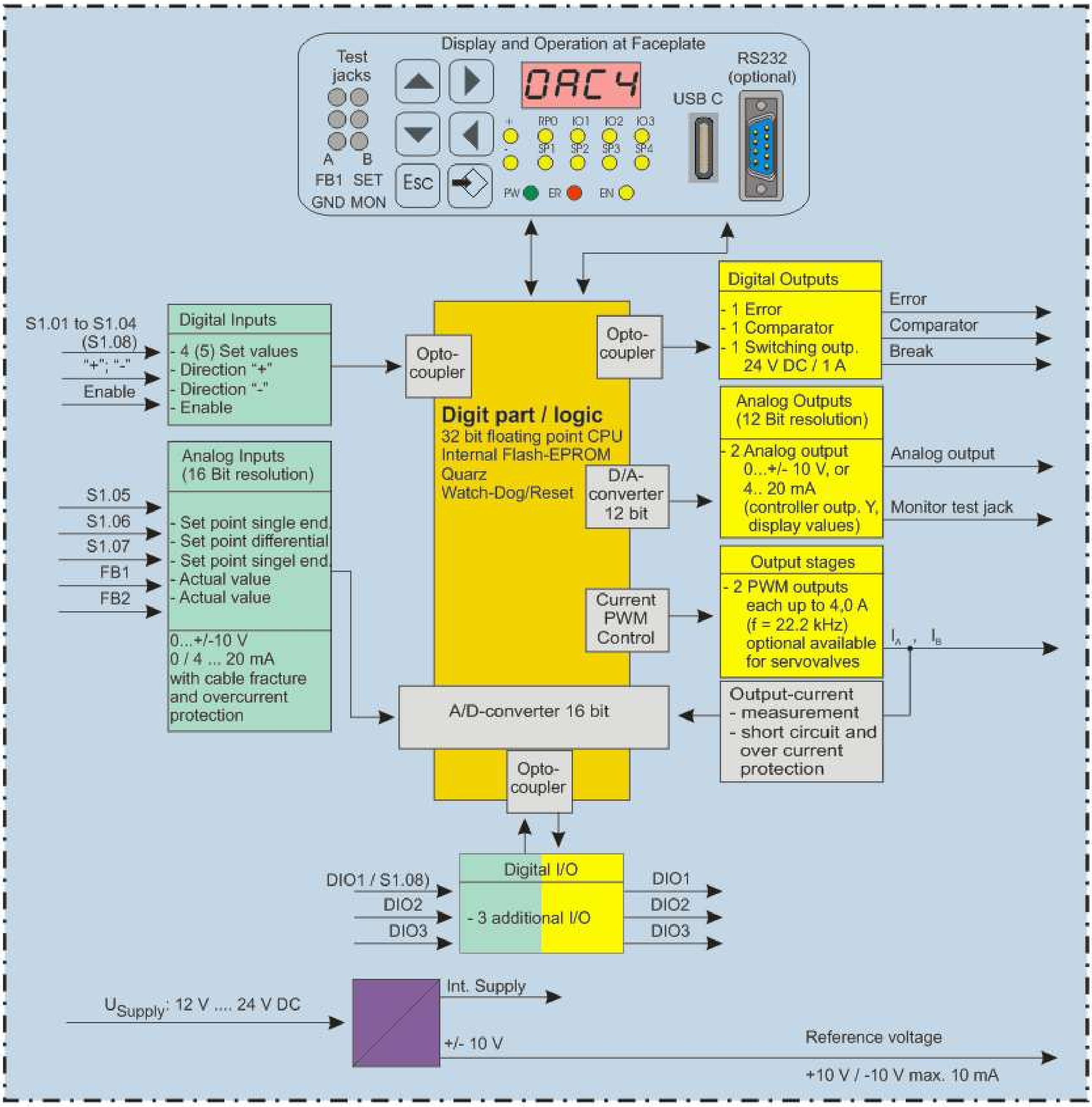
The system features of the DAC-4x(A) are the following:

- Differential amplifier input for set points in the range of 0 ± 10V, resolution 16 bit (flow).
- Single ended set point input in the range of 0 + 10 V, resolution 16 bit (pressure limit)
- Two single ended set point inputs in the range of 0 + 10 V, resolution 16 bit (power / torque limit)
- Integrated reference voltage supply of ± 10 V (10 mA max.), to supply set point potentiometer or actual value transducer.
- 4 recallable digital adjustable set points (2 x flow, 2 x pressure limit).
- Analog feedback input with 16-bit resolution and a high adjustment range. Input signal is selectable by software parameter individual for all feedback signals. All common voltage or current sensors are useable.
    - One analog feedback input for the flow or cylinder position
    - Two independent analog feedback inputs for pressure sensor A / B
- Direction externally set through “+“ and „-“ inputs for the Q-control.
- Enable signal for output stages.
- Reset-Ramp for fast ramp function (zeroing).
- Status outputs "$\overline{\text{error}}$“ and "comparator“.
- All digital inputs and outputs are optically isolated for functional security.
- Four 7-Segment displays and six buttons for easy handling and display.
- Function indication through front panel by LEDs.
- Two PWM output stages for either proportional valve solenoid systems with 0.8 A up to 3.5 A or for servo valves with torque motors and low current ratings from 30 mA to 550 mA (please ask for details regarding servo valve versions)
- Additional switching output (24 V, max 1 A); e.g. to directly disable safety valve.
- Two analog outputs to perform controller functions and / or enable subsequent electronic devices and monitoring (± 10 V, 12-bit resolution) . One is also selectable as current output 4..20 mA.
- Additional front panel test jacks for easy commissioning. Test jacks for set point (SET)[*1], for feedback X1 (FB1; swash plate), for output currents (A) and (B) and monitor (MON) display for analog display of all parameters (± 10 V, 12-bit resolution).
- USB interface with USB-C connector
- Optional available: PROFIBUS, PROFINET, ETherNet/IP and CANopen interfaces available.

4.2 Technical data

Parameters	Range, characteristics
Supply voltage and Control voltage for digital inputs	12 V DC -10 % … 24 V DC + 20 %... 32 V, residual ripple < 10 % (max. 50 VA power draw)
Nominal current selection (solenoid system selection)	0.8 A / 1.1A / 1.3 A / 1.6 A / 2.4 A / 2.7 A / 3.5 A (intermediate values adjustable) (others and special current for servo valves possible, on request)
Applicable fuse (quick reacting)	Max. 3.15 A
Ambient temperature range	0 °C ... +70 °C (other range on request)
Storage temperature range	- 20 °C ...+ 85° C
Plug connection	In accordance with DIN 41 612, 48 pole form F gold plated
EMC in accordance with	In accordance with the applicable industrial standard (CE- conformity)
Dimensions	
Front panel / PCB	50,5 x 128,4 mm; 10 TE / 3 HE / 100 x 160 mm Euro format
Front panel version with Profibus / PCB	71,1 x 128,4 mm; 14 TE / 3 HE / 100 x 160 mm Euro format
Input signals	
Analog set values: S1.06, S1.05, S1.09, S1.10 (shunt for current input = 250 Ohm)	1 input, (flow / swash plate angle) differential 16 Bit resolution voltage/current input. Signal range selectable by parameter E15
	1 input, (pressure limit) single ended 16 Bit resolution voltage/current input. Signal range selectable by parameter E16
	2 inputs, (power/torque limit positive, negative) single ended 16 Bit resolution, 0...+ 10 V
Analog feedback signals (sensor input): X1, $X2_A$, $X2_B$ (shunt for current input = 250 Ohm)	1 input, (flow / swash plate angle) 16 Bit resolution voltage/current input, signal range selectable by parameter C1.09
	2 inputs, (pressure A, pressure B) 16 Bit resolution, resolution voltage/current input, signal range selectable by parameter C2.09
Digital inputs: S1.01, S1.02, S2.01, S2.02; ENABLE, RAMP 0, SIGN +, SIGN -, DIO1, DIO2, DIO3	11 inputs, U_{in} > 8 V = high (1), U_{in} < 3V = low (0), U_{in} = 3 V …. 8 V = not defined, I_{in} @ 24 V < 2,2 mA; I_{in} @ 12 V < 0,8 mA; Rin = approx. 10 kOhm
Output signals	
Solenoid current	2 output stages for proportional valve solenoids rang 0.8 A to 3.5 A; Adaptation with factor parameter E10 = x 0,5 ... 1.10 (other values and standard solenoid currents for up to max. 3.5 A on request); with over-energization and quick de-energization Optional on request: for servo valve torque motors; 30 mA up to 550 mA
Auxiliary voltage	± 10 V, max. load 10 mA.
Analog output	1 output, 12 Bit resolution, selectable by parameter E 31 0 .. ± 10 V or 4 .. 20 mA for controlling of subsequent electronic
Monitor output	1 output, 12 Bit resolution, 0 ... ± 10 V; command signal for slave pump(s) or monitoring of internal values
Digital outputs: “$\overline{\text{Error}}$”, Comparator	2 outputs, voltage level 0 V / U_{Supply}, U_{out} @ 10 mA load = U_{Supply} – 6 V
Digital output: ”Break”	1 output, voltage level 0 V / 24 V, I_{out} max. = 1 A
Test jacks	Solenoid current, sensor 1, set value, Monitor and GND
Auxiliary voltage	± 10 V, max. load 10 mA
Interface	USB-C connector at front panel
Display and operation	4-digit display, 6 buttons (up, down, left, right, enter and Esc) Status-LED’s: PW (Power), ER (Error), EN (Enable), S1.01 …. S1.04, RP0 (Ramp = 0), IO1 ...IO3
Frequencies and cycle times	
PWM Frequency	22 kHz
Cycle times	Current controller, approx. 45 µsec inner closed loop controller 1, approx. 100 µsec (for swash plate angle feedback) pressure loop controller 2, approx. 100 µsec power/torque limiter loop controller 3, approx. 100 µsec

4.3 Hardware Block Diagram (without bus interface)



4.4 Order code

DAC - 42(A) - 14 - 010 - *PN* - *PpQ*

Digital
Amplifier
Controller

Board Version
44 = version with keypad and display
42 = version without keypad and display
((A) = new advanced version

Operation mode
No selection possible with this software version.
Fix: PpQ pump

Output current for torque motors
080 = 800 mA systems
110 = 1100 mA systems
130 = 1300 mA systems
160 = 1600 mA systems
240 = 2400 mA systems
276 = 2700 mA systems
350 = 3500 mA systems

Other on request!

Interface Options
PBDP = PROFIBUS DP Interface
PN = PROFINET interface
EIP = EtherNet/IP interface

Specific options
PpQ = Board for pump flow control with pressure and power limiting function Single operation and master or slave operation possible
pQ = Board for pump flow control with pressure limiting function Single operation

5 Installation

5.1 Mounting

- Compare card type (refer to label on rear connector) with part list / diagram.
- The card generally could be mounted in any direction. However, it is recommended to choose a vertical orientation for better convection cooling. Also, this orientation will be obviously better suited for adjusting parameters or monitoring display values via the keypad and display (applicable for DAC-4**4**(A) versions only).
- The amplifier card should be mounted in a shielded environment (e.g. control cabinet).
- The amplifier card module must be mounted either in a rack according to the 19" rack standards (EIA 310-D, IEC 60297 und DIN 41494 SC48D).
  it is also possible to install the card either in a appropriate card holder or HCS own universal rack:

Card holder (HCS article number: 5 741 010 00)	Universal rack (HCS article number: 5 741 000 00)
	

Figure 1 : Card holder and universal rack (not to scale!)

Dimensions Eurocard for 19" rack mounting:

For 3 HE: 100 mm × 160 mm, connector on small side
Faceplate dimensions DAC-4x(A): 3 HE x 10 TE (= 128,4 x 50,5 mm)

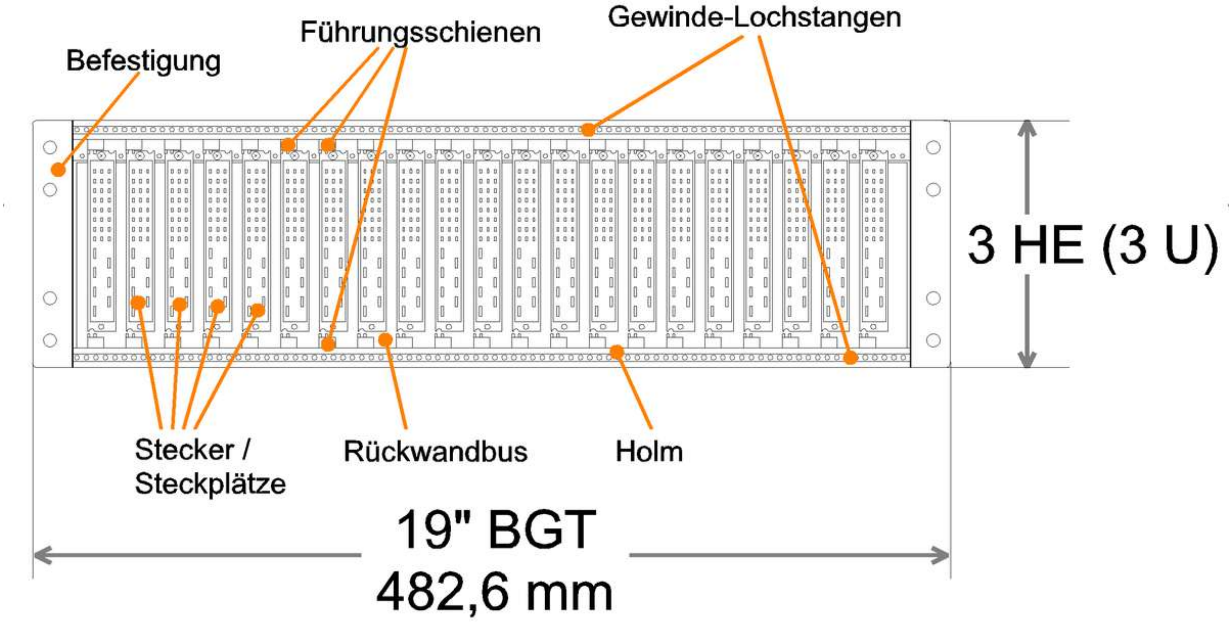


Figure 2 : General example for 19" Rack systems 3 HE

5.2 Connection

5.2.1 General recommendations

The general supply voltage for the unit is at the terminals:
[26bd] = 0 V and [32bd] = +UB is 12 V DC - 10 % … 24 V DC + 20 %; residual ripple < 10 %
(at supply voltage down to 12 V DC some limitations may be applicable).

Output stages are electronically protected against short circuit and overload. The amplifiers should be protected with a quick-acting fuse.

The solenoids are connected at terminals [22bdz] and [28bdz] for solenoid A; terminals [24bdz] and [30bdz] for solenoid B. The terminals "bdz" are bridged on the amplifier. We recommend using all three terminals for better load distribution.

If no electrical isolation of logic inputs or outputs is required, terminal [26bd] may be bridged to terminal [2d] and terminal [32z] to terminal [32bd].

Terminal [18d] is the GND for the digital signals.

5.2.2 Wires and preparation

Connection wires must comply to the following specifications:

Feature	Required
Wire type	Hookup cable; stranded
Cross section: Solenoids and supply	min AWG 16 / 1.5 mm²
Cross section: Signal, command and sensor:	min AWG 20 / 0.5 mm²
Wire length	Max. 50 m (> 50 m consult factory)
Skinning length	7 mm
Soldering of wires	Not permitted!

Table 4: Wires recommendation

⚠ WARNING

The assembly contains electronic components. Incorrect handling or operation can lead to damage through electrostatic discharge (ESD). Only trained personnel should work with the unit. All safety instructions must be observed. Damage may result if the card is disconnected while the power supply is still on. Avoid such actions under all circumstances. The information in this document is subject to change without notice.

⚠ WARNING

Avoid under all circumstances to use logical signals from the card (i.e. "Error") for switching machine safety circuits (refer also to EU standard EN13849)!

5.2.3 EMC

Devices DAC-4x(A) series are class “A” equipment and therefore only suitable for industrial surroundings.

The distance between a source of interference (device emitting interference) and an interference sink (a device under the influence of interference) is very important. The greater the distance between the source of interference and the sink, the smaller the effects on the equipment will be. In other words, the closer a device is placed to the source of interference, the greater the interference amplitudes. For this reason, a minimum gap of 0.25 m should be kept between the amplifiers and strong sources of interference. The following devices are to be regarded as strong sources of interference:

- Switching power supply units
- Frequency converters
- Digital drive modules
- Mains filters with wiring (even if shielded)
- AC/DC commutator motors
- Motor cables (even if shielded)
- Switched inductances, even if anti-interference measures have been taken (solenoid valves, contactors, relays, etc.)

One of the most common input points for interference is wiring. If interfering cables are laid at least 0.25 m away from cables susceptible to interference, the influence on each other can be minimized. Parts of the amplifier wiring may be susceptible to interference (analog set point and actual value, solenoid cables). If these cables are laid parallel over a distance longer more 10 m, the necessary distance between them must be increased. Cables susceptible to interference should never be laid parallel to motor cables. The influence is the least when the cables cross particularly at an angle of 90°.

However, interference can also arise from cables in the amplifier wiring system, in particular solenoid cables.
Examples of devices which are particularly susceptible to interference:

- Office PC’s
- Sensors with small output voltages / currents
- Capacity proximity switches
- Audio equipment (television, hi-fi, radio, etc.)
- Devices which do not meet the EMC guidelines

5.2.4 Specific recommendations for wiring and control cabinets

The following rules and tips are by no means to be complete. Since various electronic components are used in a variety of different ambient conditions, these guidelines only represent a compromise. The actual design of the wiring also depends on the interference emission and interference sensitivity of each individual component.

- Use shielded and twisted-pair cables for the solenoid connections. The shield must be grounded (PE Protective Earth) at both ends. The capacity should be ca. 120 pF/m. If the cables are up 100 m long, their cross-section must be 1.5 mm² and 2.5 mm² for cables longer than 100 m.
- Shields of digital signal lines are to be connected at both ends to a PE, a good conductivity of the connection should be provided.
- Set point and actual value connections should have shielded and twisted-pair cables. The analog signal line shields are to be connected, with low impedance, at both ends to PE
- In environments with high interference, use double shielded cables for set point and actual value connections. The inner shield is only grounded at one end, the outer at both ends.
- In the event of low-frequency interference on the analog signal lines (measured value fluctuations), the shield should be connected at one end. Preferably, use a corresponding compensation of potential (see also the following point).
- Use only cables with a Cu shielding grid and a covering of > 85 %. Avoid screening films. Metal foils must be avoided.
- The shield should not be interrupted along the entire length of the cable. If contactors, safety switches, chokes, etc. must be used in the wiring, the installation of a metallic housing with a high HF shield may be necessary.
- Shield terminals are to be connected over a large area to the shield rail to function well.
- The shield rail must be installed close to the cable duct in the control cabinet.
- The metallic parts of the electrical cabinet are to be connected with low impedance on large areas. Make the desired connection with mechanical aids such as scratch plates if necessary. Connect the doors of the cabinet with the shortest possible homogeneous tapes (multiple).
- Solenoid valves, contactors, relays, brakes, etc. must be suppressed directly at the interference source. Suitable suppression devices are, for example, RC networks, diodes or varistors.
- Analog and digital signal lines should preferably enter the control cabinet from only one side.
- Non-shielded lines of an electric circuit must be twisted.
- Auxiliary wires are to be grounded at both ends.
- Avoid unnecessarily long lines. This keeps the coupling impedance low.
- Wiring should preferably not be freely hanging in the cabinet. Lay cables, including auxiliary cables, as close as possible to mounting plates and cabinet housing.

- In the case of a potential difference between the shield connections, a compensation conductor of 〈10 mm² should be laid parallel to the shield to reduce the transient current. A multiple connection of the shield to the cabinet casing and thus PE is generally possible. Also, a multiple connection of the shield outside the cabinet is possible.
- If filters are installed, place them close to the source of interference and keep a good surface contact to the cabinet or mounting plate.
- If converters are used, converter filters must be provided. Variable speed motors may have to be connected using shielded lines. All further instructions of the converter manufacturer have to be observed.

The following two pages show illustrations of:

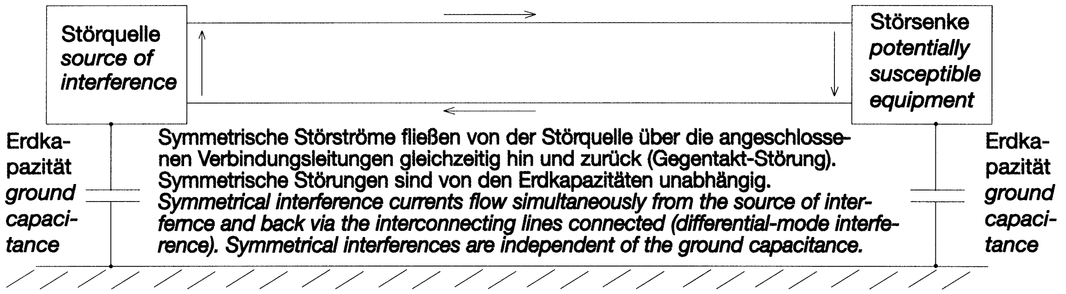
- The most important types of interference and their remedies
- Construction of EMC suitable electric cabinets and systems

The diagrams have been provided by our competent partners for all questions regarding EMC:

NKL GmbH
Birckichstr. 15
D-74549 Wolpertshausen

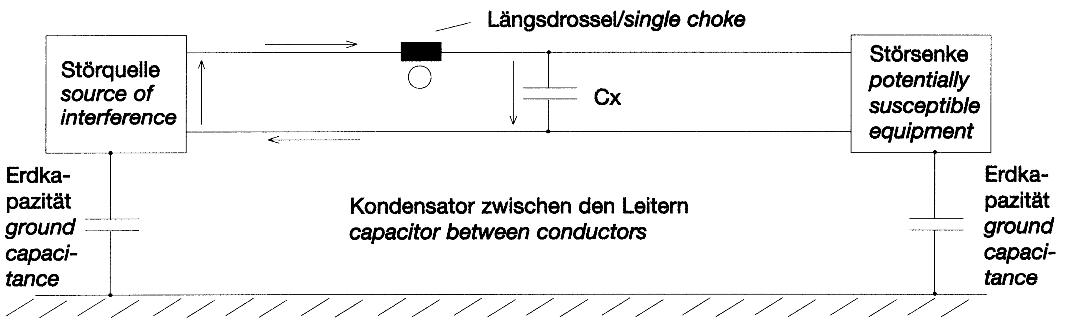
Die wichtigsten Arten von Störungen und Abhilfen:
The most important types of interference and remedies:

Symmetrische Störungen:
Symmetrical interference:



Typische Störquellen, die symmetrische Störungen erzeugen, sind:
Typical sources of symmetrical interferences:

Alle Arten von Gleichrichtern, Thyristor-Steuerungen wie z. B. Phasenanschnitt-Steuerungen, Halbleiter-Relais etc.
Symmetrische Störungen treten in der Praxis hauptsächlich leitungsgebunden im unteren Frequenzbereich bis ca. 1 MHz auf.
All types of rectifiers, thyristor controls such as e. g. generalized phase controls, semiconductor relays, etc.
In practice, symmetrical interferences occur mainly as conducted interference in the lower frequency range up to about 1 MHz.



Symmetrische Störungen werden entstört durch:
Symmetrical interferences are suppressed by:

- Kondensatoren zwischen den Anschlüssen („X"-Kondensatoren): Diese schließen die Störströme kurz, bevor sie die Störsenke erreichen.
- *capacitors between the terminals („X" capacitors):*
  they short-circuit the interference currents just before they reach the potentially susceptible equipment.

- Einzel-Drosseln im Strompfad der Zu- und Ableitungen. Diese Drosseln sind für symmetrische Störungen wirksam und erhöhen die Impedanz des symmetrischen Störstromkreises.
- *single chokes in the current path of the incoming and outgoing lines. These chokes are effective for symmetrical interferences and inrease the impedance of the symmetrical interference circuit.*

Figure 3 : EMC – interferences and remedies

EMC adequate design of switchgear cabinets and facilities

All devices with a metal housing or a connector for PE should be connected properly, i. e. short and with a large contact area to the mounting plate of the cabinet or the chassis of the machine to ensure a proper potential equalisation.
For that the insulation of the mounting plate has to be removed, especially below power drive systems and their respective filters.
The best solution is to use a conducting mounting plate that is zinc coated.

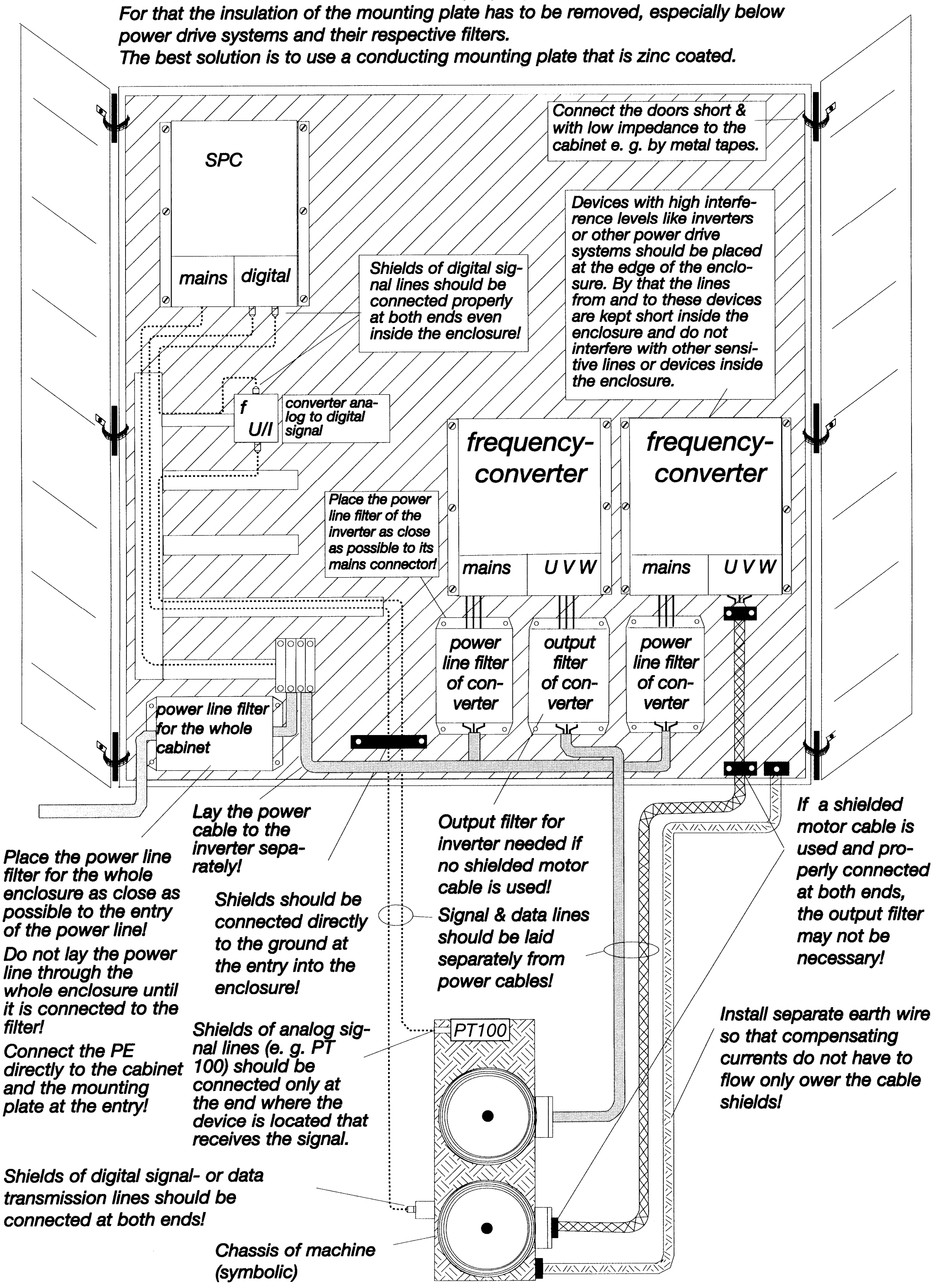


Figure 4 : EMC – adequate design of switchgear cabinets and facilities

5.3 Terminal assignment

Pin	d	b	z
2	0 V (External)	Pressure limiter activation (DIO 1)	- Sign (direction) digital set values
4	Digital set value 2 (S1.02); Flow	Power limiter activation (DIO 2)	+ Sign (direction) digital set values
6	Digital set value 3 (S2.01); Pressure	Monitor output (command signal for slave operation)	Digital set value 4 (S2.02), Pressure
8	ENABLE (DI 1)	Analog set value 9 U_{E+} (S1.09) **Power Limit A**	Digital set value 1 (S1.01); Flow
10	Sensor 1 (FB 1) (swash plate)	Analog output (for valves with OBE)	n/c
12	Analog set value 6 (S1.06) **Flow**	n/c	Analog set value 5 (S1.05) **Pressure limit**
14	$\overline{\text{ERROR}}$	COMPARATOR	Sensor 2 (X2A), Pressure B
16	Analog set value 6 (S1.06) **Flow**	Analog set value 10 U_{E+} (S1.10) **Power Limit B**	Sensor 2 (X2B), Pressure A
18	Digital GND	PE	Ramp = 0 / Slave mode selection
20	Reference output - 10.0 V	Break output 24 V / 1 A	Reference output + 10.0 V
22	Output A -	Output A -	Output A -
24	Output B -	Output B -	Output B -
26	0 V (Power)	0 V (Power)	Analog GND
28	Output A +	Output A +	Output A +
30	Output B +	Output B +	Output B +
32	+ 24 V (Power)	+ 24 V (Power)	24 V (External)

Table 5: Terminal assignment

5.4 Picture of rear connector

Connector: IEC 60603-2 form F 48 pins

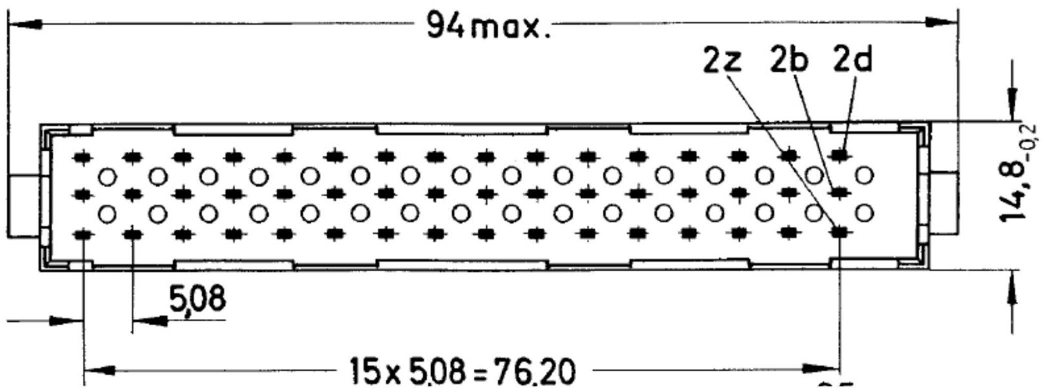
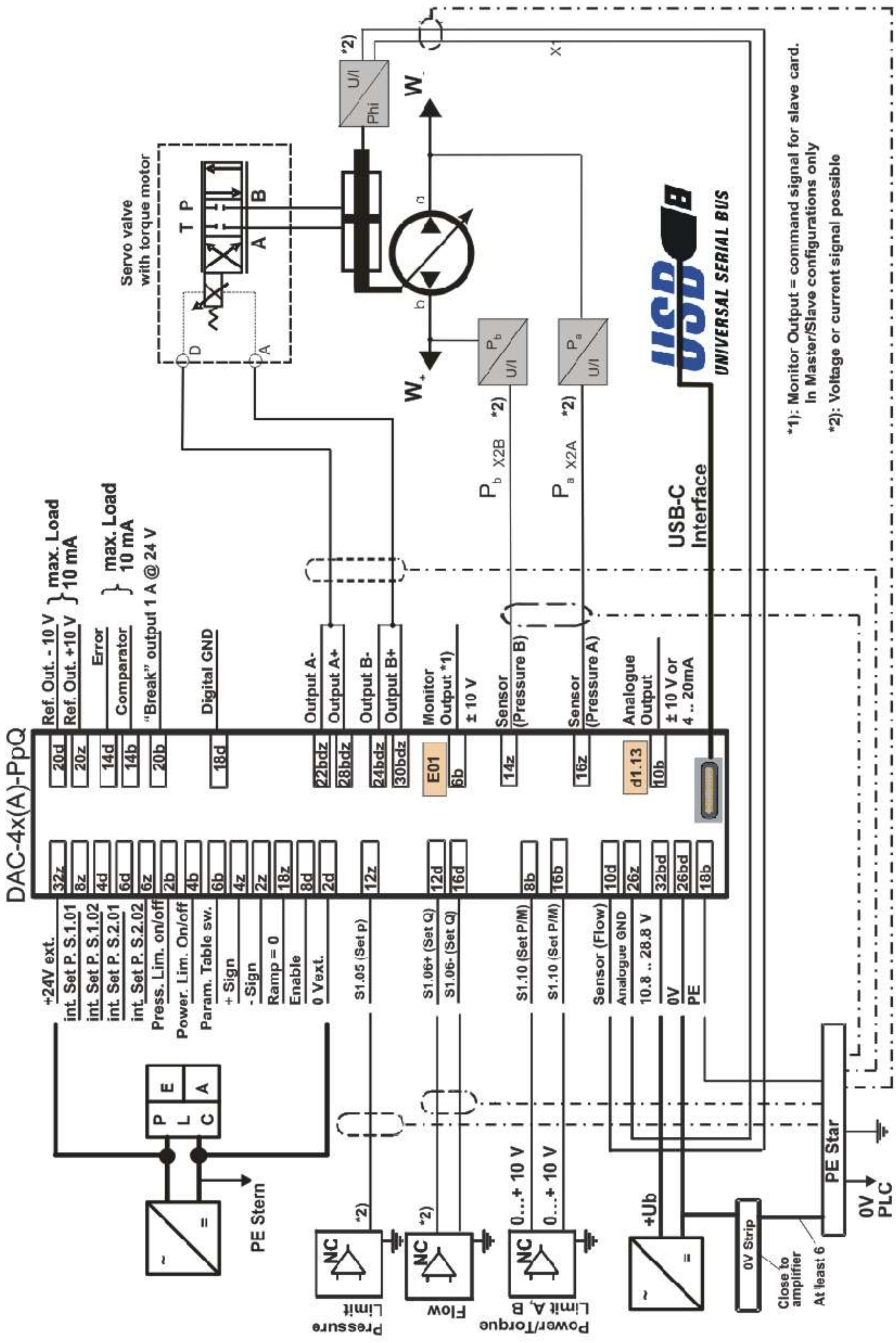


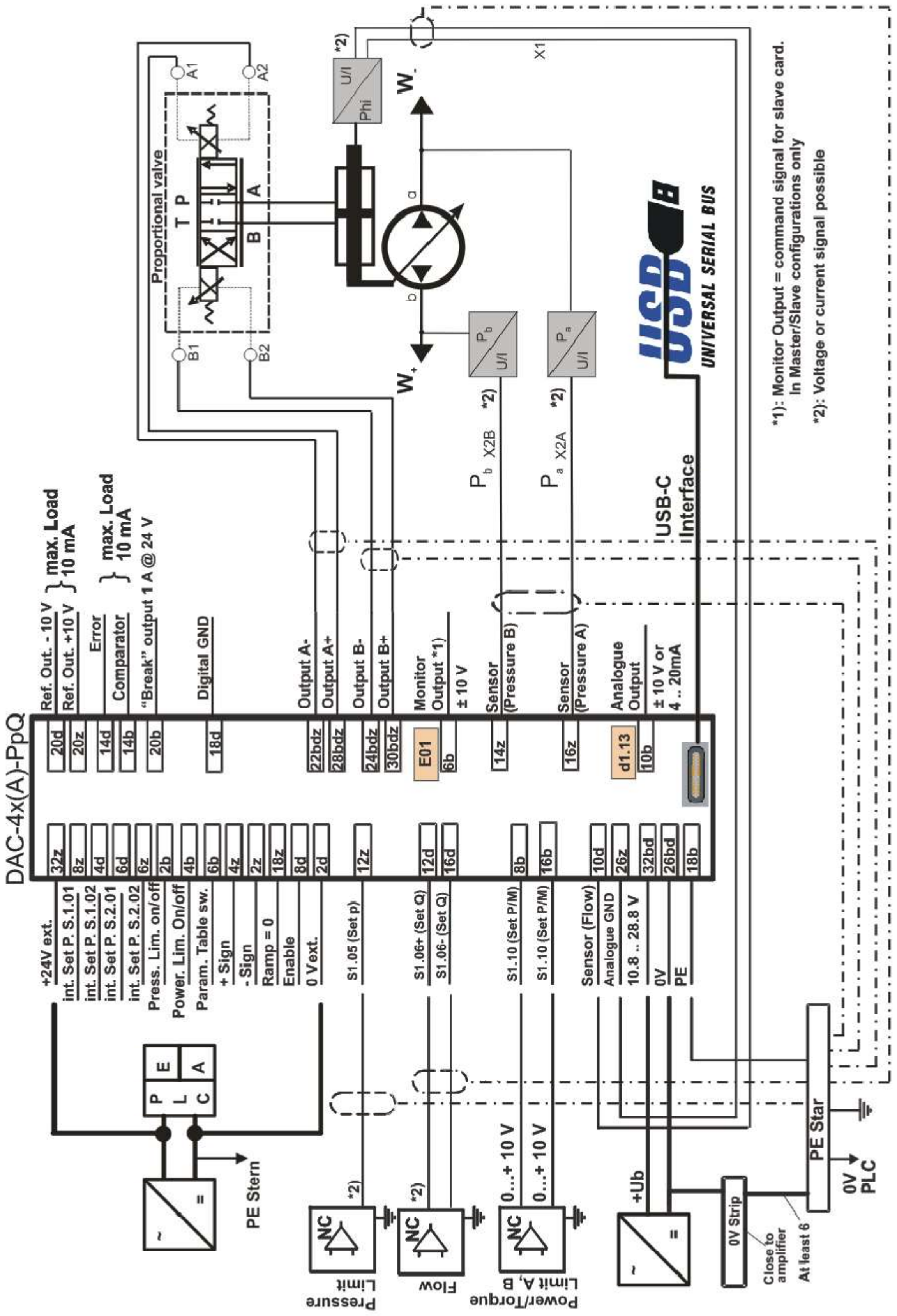
Figure 5 : Connector F48

5.5 Wiring Diagram

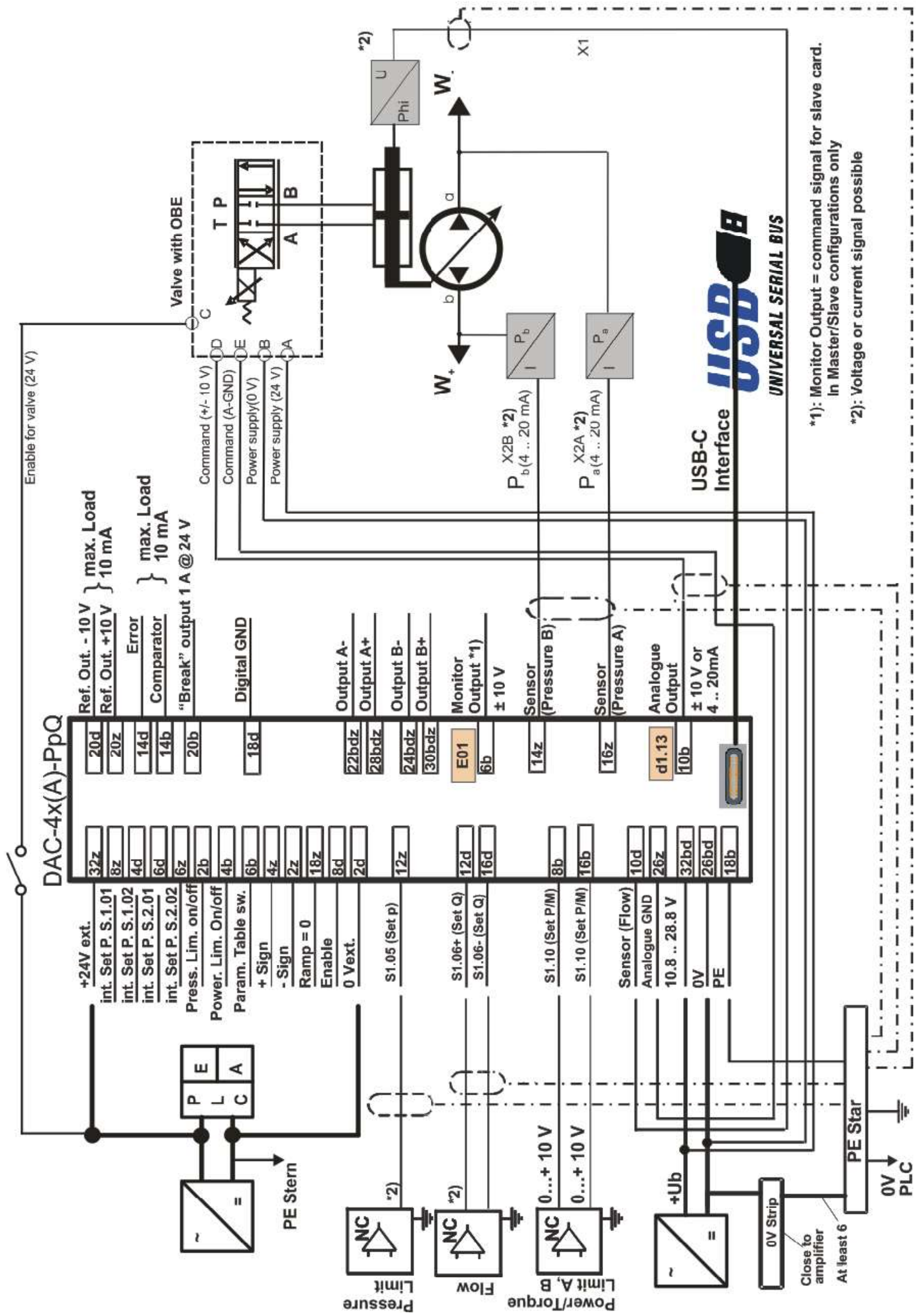
5.5.1 Wiring Diagram for applications servo valve (torque motor)



5.5.2 *Wiring Diagram for applications proportional valve solenoids*



5.5.3 Wiring Diagram for applications with valves with OBE (On-Board-Electronic)



6 Commissioning

6.1 Front elements

DAC-42(A)-x-PpQ has no controls for parameter entry and display

⚠ WARNING

The electrical wiring must be checked before switching on the supply voltage. Limit switches and safety devices must be activated to avoid uncontrolled movements. Carefully follow relevant safety regulations. Suitable emergency stop measures must be taken.

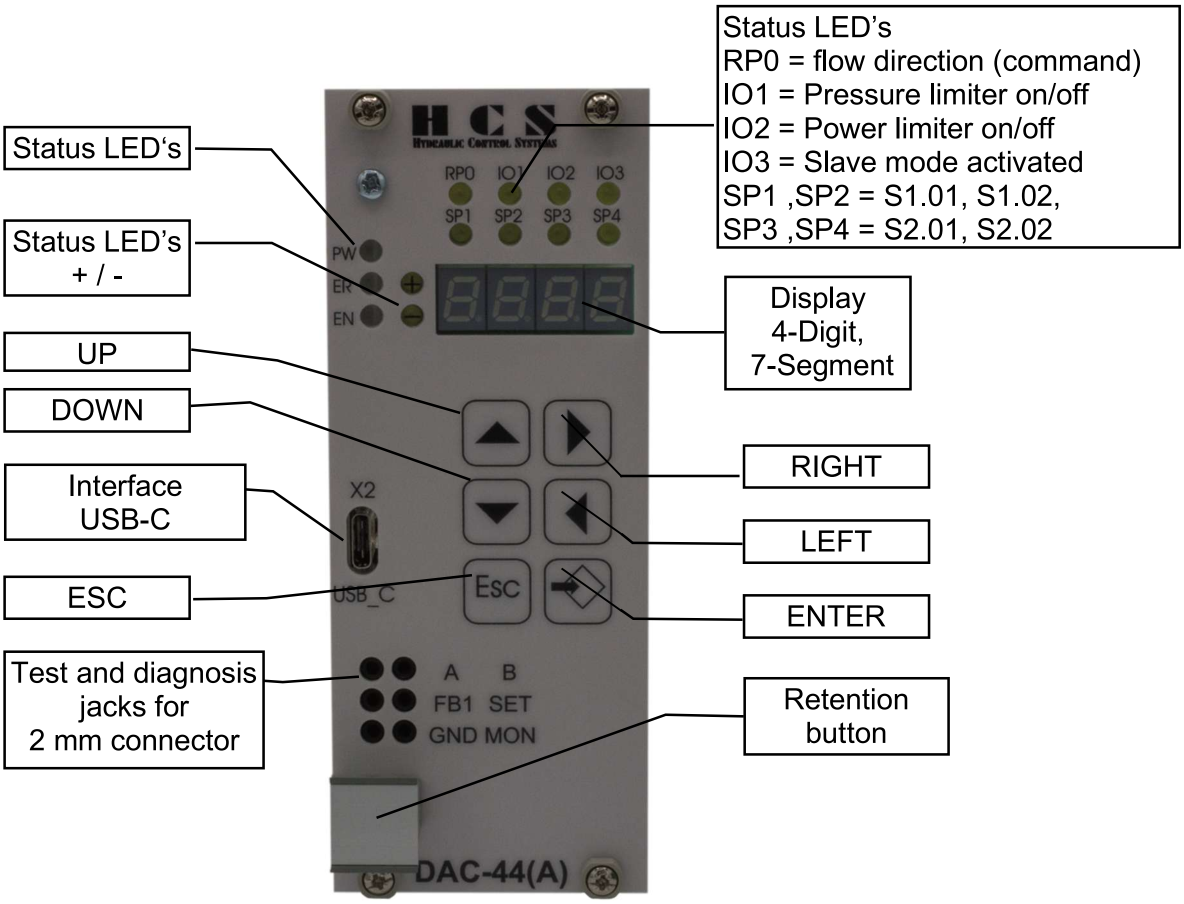


Figure 6 : Front elements DAC-4x(A)

Element	Function
Status LED's	Display of status and signals at the digital inputs and outputs
± LED's	Display of set point direction through polarity signs for parameters and measured values
Display	4-digit display of parameters and measured values
Buttons UP, DOWN, LEFT, RIGHT, ESC and ENTER	All operating, programming and saving may be performed with the buttons UP, DOWN, LEFT, RIGHT, ESC and ENTER
Serial interface	Trough which programing and accessing parameters via PC and HCSTool is executed. RS232 (optional)
Measuring and test jacks	Direct measurement of set point, actual value, solenoid currents and internal values via the monitor output. Use 2 mm sockets (S1.06, FB1, A, B, d1.01 ... d2.13)

Table 6: Front elements DAC-4x(A) explanation

6.2 Parameter setting

		SW version
1	Parameters only available for power limit	V53.xx, V54.xx, V55.xx
2	Parameters only available for torque limit	V63.xx, V64.xx, V65.xx, V66.xx
3	Parameters only available for PROFIBUS/PROFINET versions	V54.xx, V55.xx, V56.xx, V64.xx, V66.xx
3	Parameters only available for PROFIBUS versions	V54.xx, V64.xx
4	Parameters only available for EtherNet-IP versions	V65.xx
5	Slave parameters only available for SW version	V53.xx, V54.xx, V55.xx

display		Set point / ramps		Q-flow Controller		p-limit Controller		P-limit Controller		Extended	
d1.01		S1.01		C1.00		C2.00		C6.00		E01	
d1.02		S1.02		C1.01		C2.01		C6.03		E02	
d1.03		r1.01		C1.02		C2.02		C6.04		E03	
d1.04		r1.02		C1.03		C2.03		C6.05		E04	
d1.05		r1.03		C1.04		C2.04		C6.06		E05	
d1.06		r1.04		C1.06		C2.05		C6.07	2	E06	
d1.07		S2.01		C1.07		C2.06		C6.08	2	E07	
d1.08		S2.02		C1.08		C2.07				E08	5
d1.09		r2.03		C1.09		C2.08				E09	
d1.10		r2.04		C1.10		C2.09				E10	
d1.11				C1.11		C2.10				E11	
d1.12				C1.12		C2.11				E12	
d1.13				C1.13		C2.12				E13	
d2.01				C1.14		C2.13				E14	
d2.02				C1.15		C2.14				E15	
d2.10				C1.16		C2.15				E16	
d2.10b	2			C1.17		C2.16				E18	
d2.11				C1.18		C2.17				E19	
d2.12				C1.19		C2.18				E22	3,4
d2.13				C1.20		C2.19				E23	
d2.14				C1.21		C2.20				E24	
d2.15	2			C1.22		C2.26				E25	
d2.16	3			C1.23		C2.27				E26	
d6.01				C1.24		C2.28				E27	3
d6.02				C1.25		C2.29				E31	
d6.03				C1.26		C2.30				E33	
d6.04				C1.33	2	C2.31				E34	
				C1.34	2	C2.32				E35	
				L1		C2.33				E36	4
				C4.01	4	C2.34	2			E37	4
				C4.13	4					E38	4
				C4.14	4	C2.36	2			E39	4
				C4.15	4	C2.37	2			E40	4
				C4.16	4	C2.38	2			E41	4
				C4.17	4					E42	4
				C4.18	4						
				C4.19	4						
				C4.20	4						

Table 7: Parameter overview

A complete list of parameters is available. Refer to:

See □ Chapter "9 List of parameters", page 59

Also refer to “HCSTool”!

6.3 *Setting of default parameters values:*

It is possible to save default values as single parameters or a combination of parameters. The program HCS***Tool*** is used to adapt the default values to a combination of parameters, according to the client’s needs. If you have any requests, please contact your supplier.

Step	Action	Result
1	Select parameter with cursor keys	Parameter number is displayed,e.g. S1.03
2	Display current value of parameter with key “ENTER”	Value e.g. 2.345
3	Activate to alter content with key “ENTER”	Last digit of current value starts flashing, e.g. 2.34<u>5</u>
4	Alter content with keys “UP” or “DOWN”	Value is changed e.g. To 2.34<u>8</u>
5	Select higher digit if necessary with key “LEFT”	New digit starts flashing e.g. 2.<u>3</u>48
6	Alter content with keys “UP” or “DOWN”	Value is changed e.g. 2.<u>7</u>38
7	Store new value with “ENTER” or cancel with “ESC”	Value is stored or canceled, parameter number is displayed, e.g. S1.03

6.4 Software block diagrams

6.4.1 V53.xx PpQ function (with power limit)

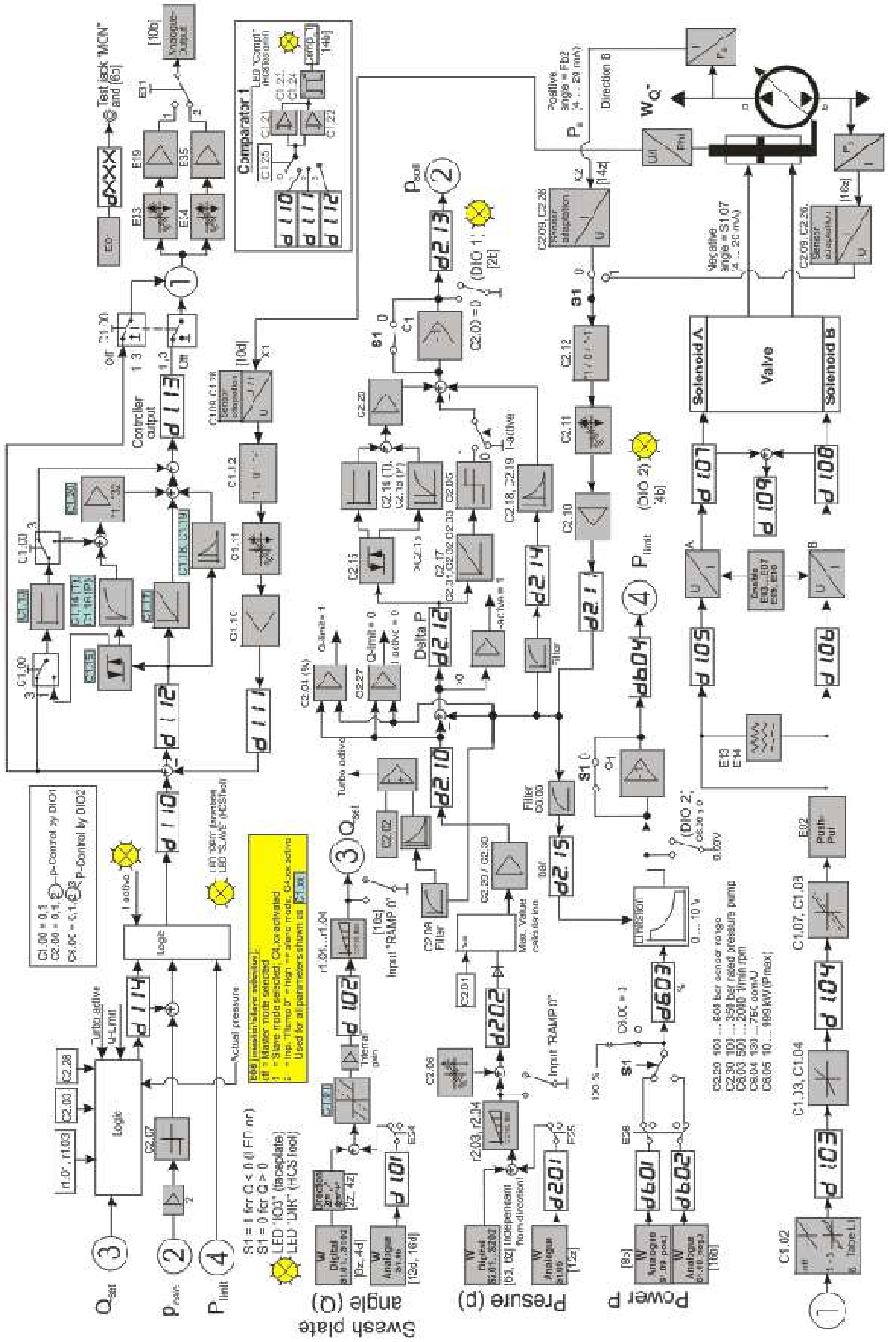


Figure 7 : Software block diagram PpQ power limit

6.4.2 V54.xx, V55.xx PpQ function (with power limit) with PROFIBUS/PROFINET

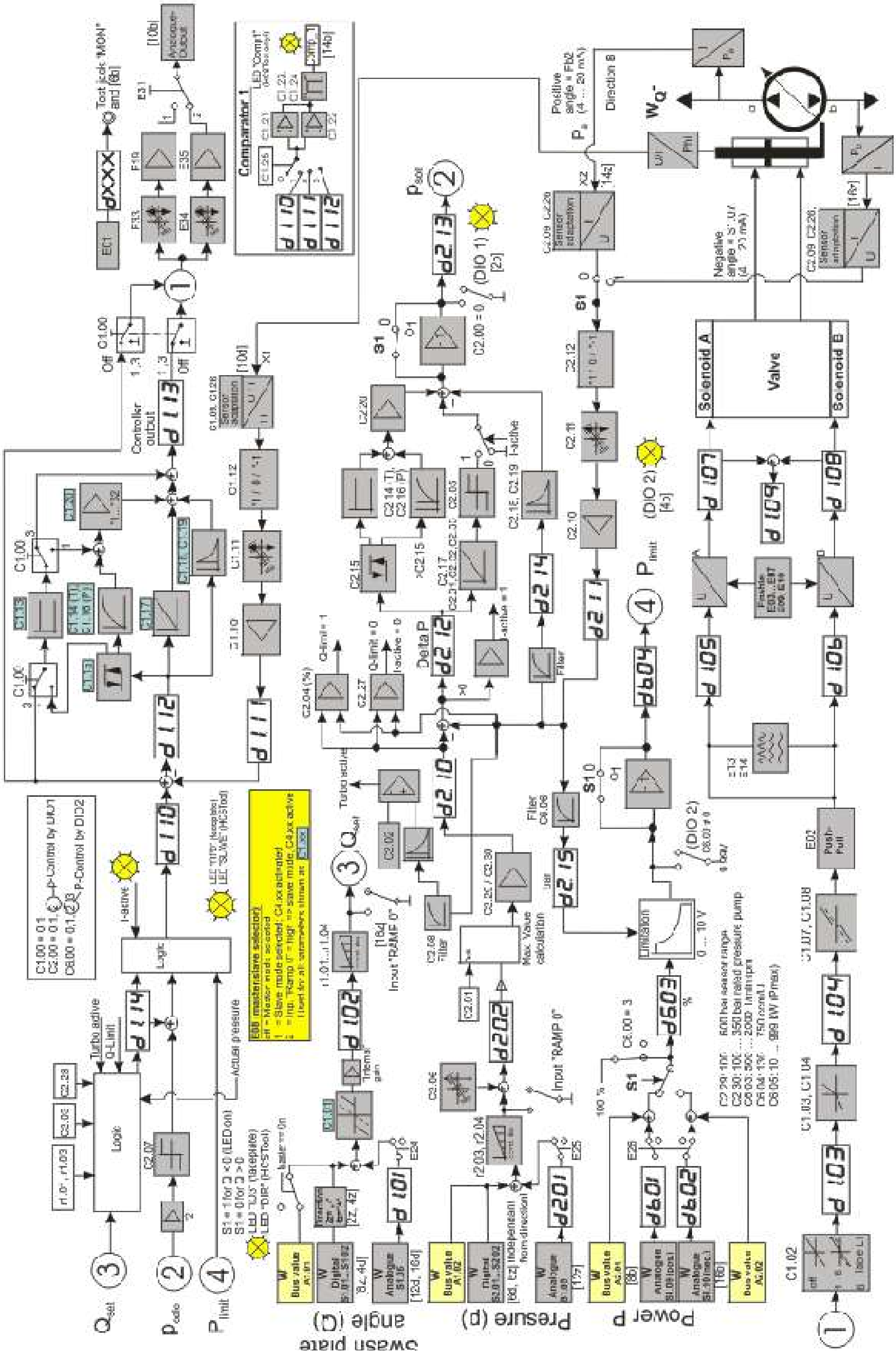


Figure 8 : Software block diagram PpQ power limit and bus function

6.4.3 V56.xx, cylinder pQ function with solenoid (without P-Limit)

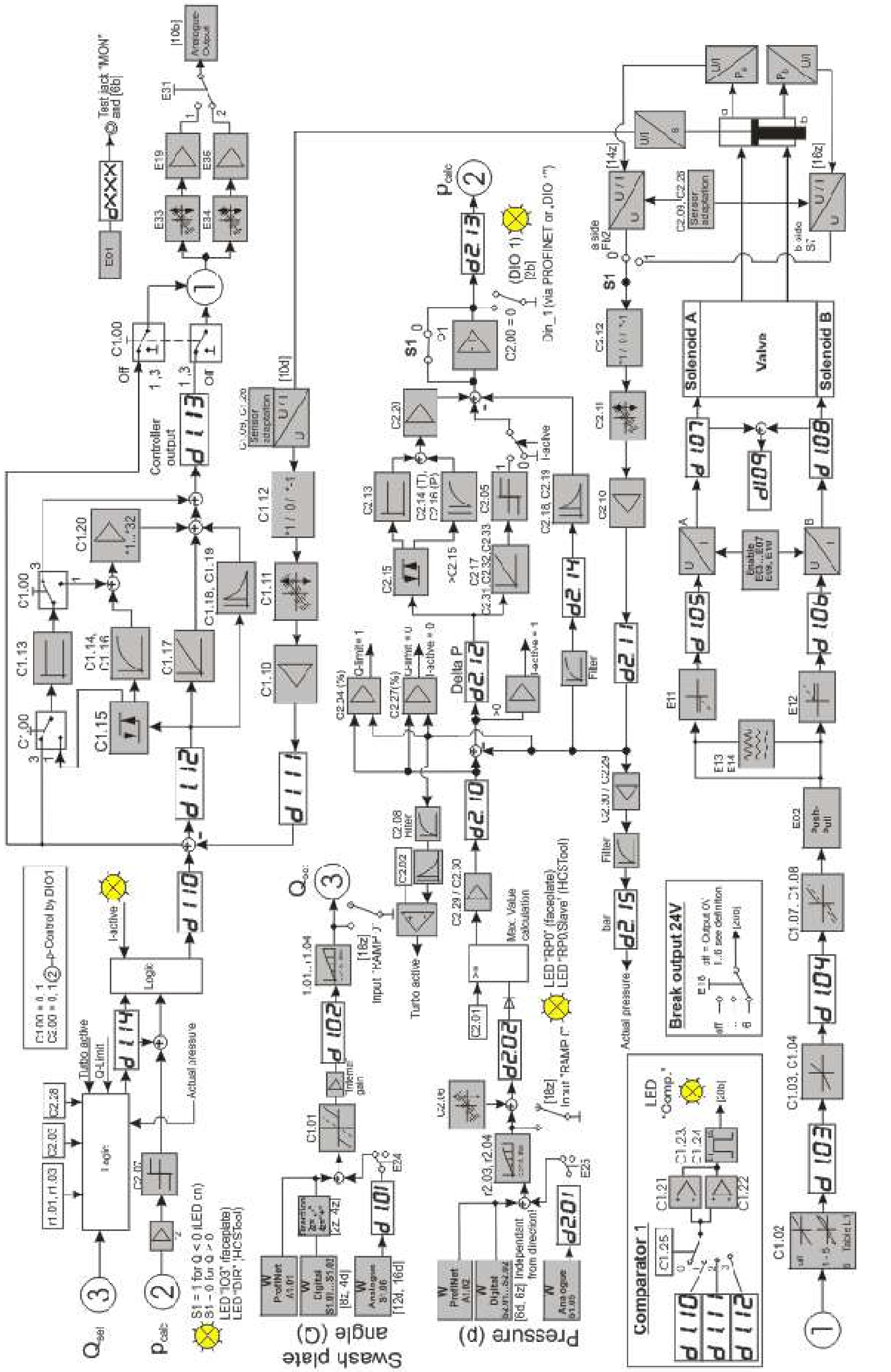


Figure 9 : Software block diagram pQ limit

6.4.4 V56.xx, cylinder pQ function with OBE (without P-Limit)

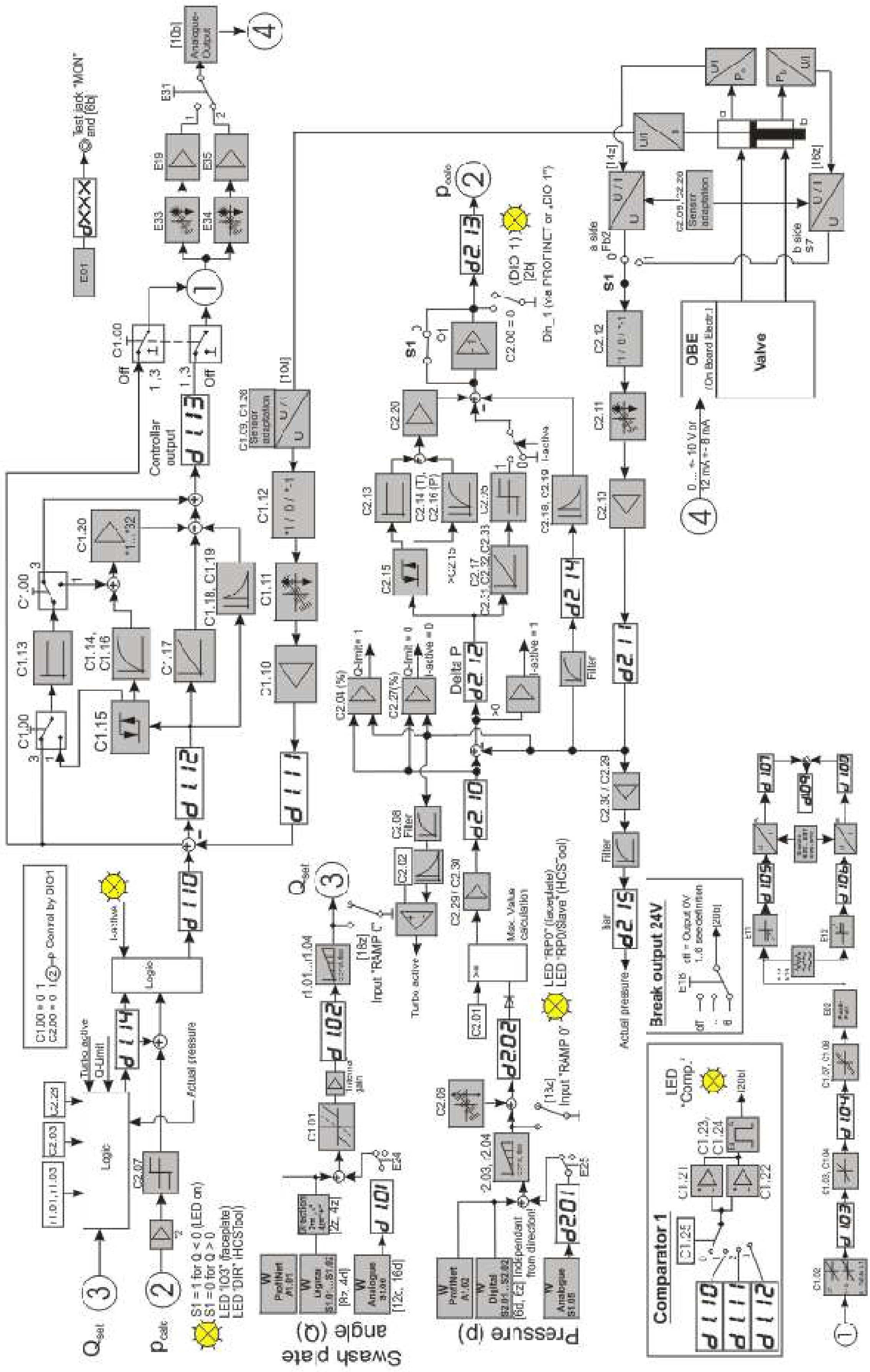


Figure 10 : Software block diagram pQ limit with OBE

6.4.5 V63.xx, PpQ function (with power or torque limit)

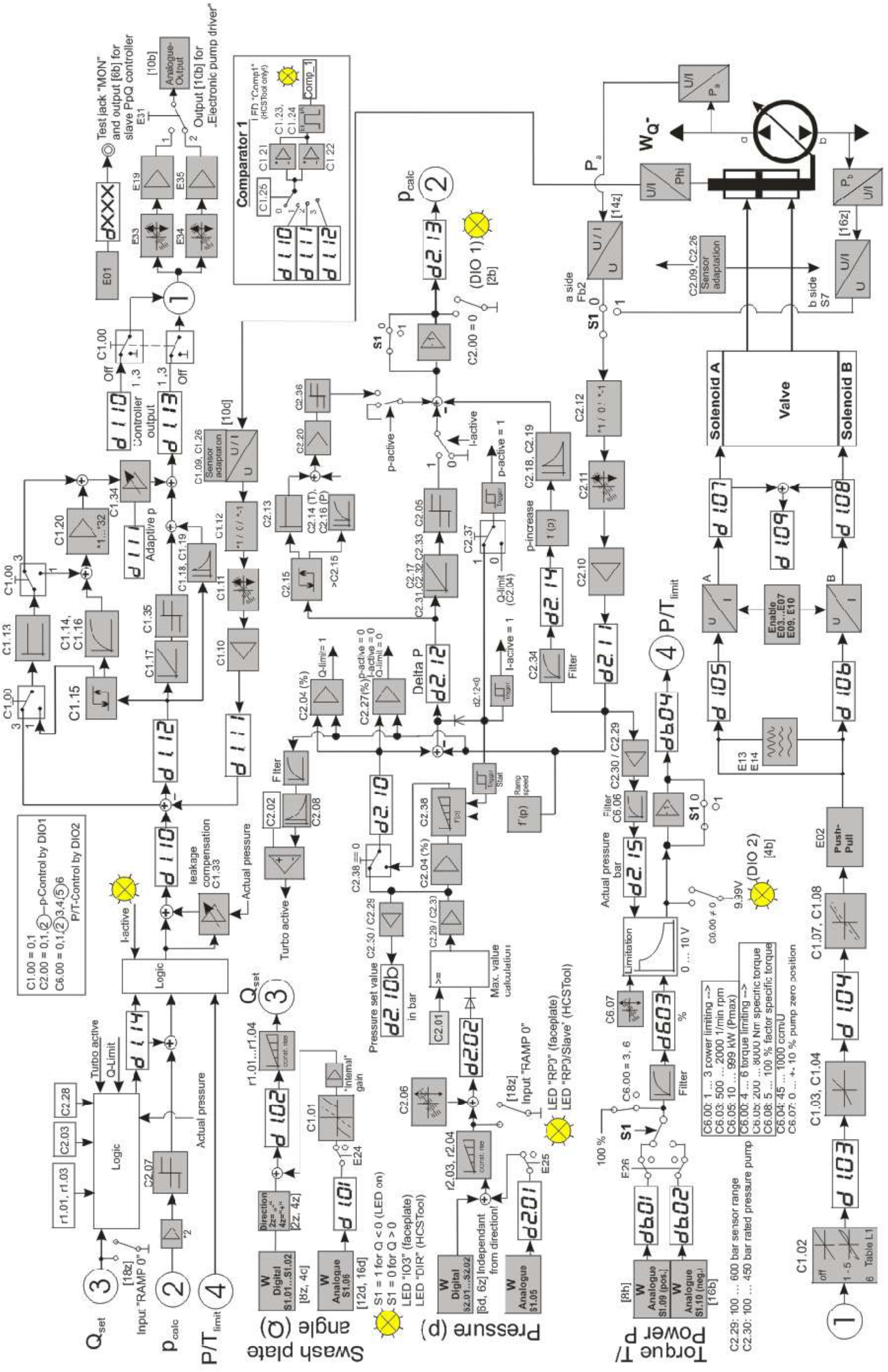


Figure 11 : Software block diagram PpQ power/torque limit

6.4.6 V64.xx, V65.xx, V66.xx PpQ function (with power or torque limit) with bus function

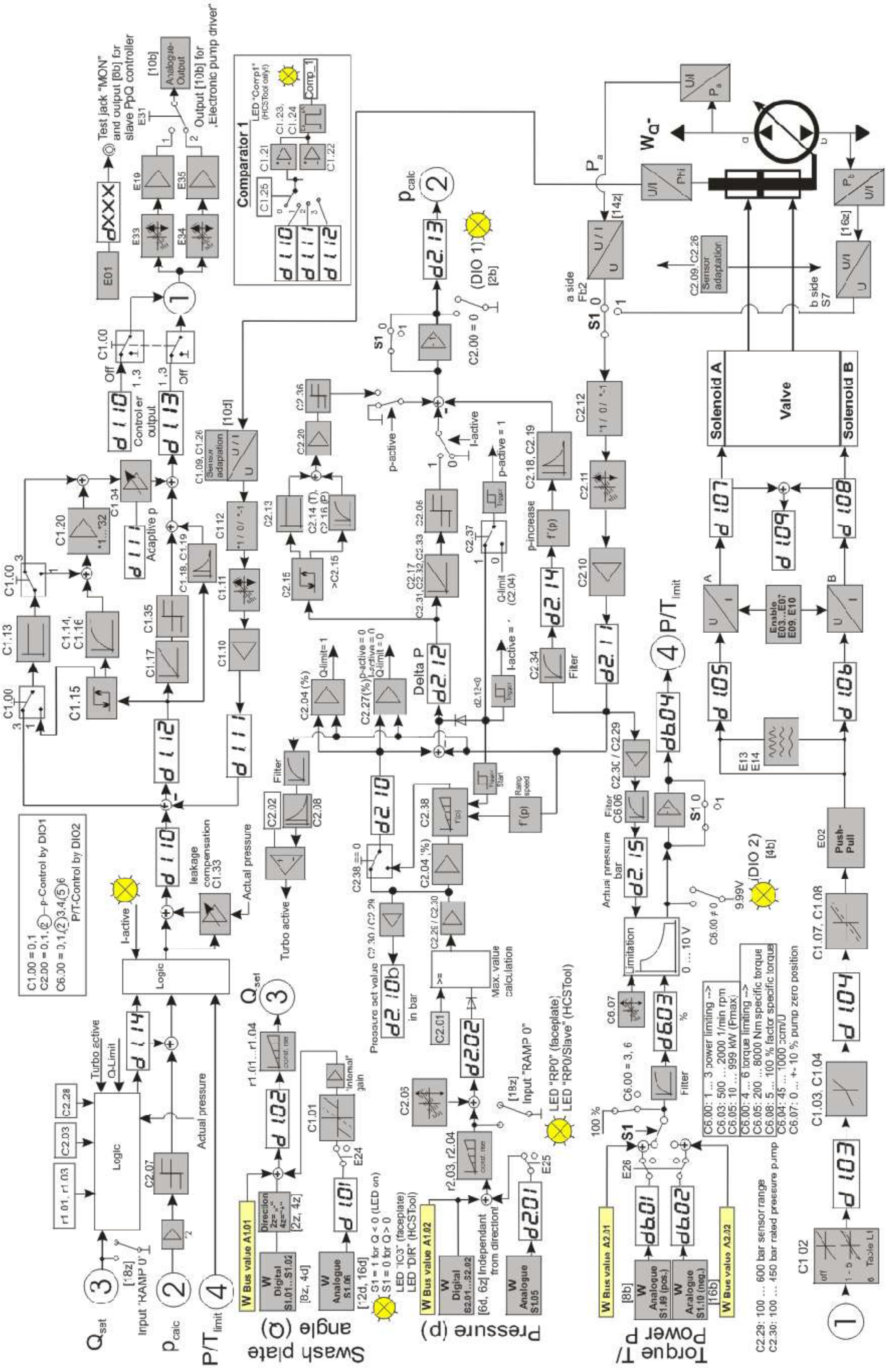


Figure 12 : Software block diagram PpQ power/torque limit and bus function

6.5 Operation modes

No selection possible with this software version. The fixed set-up is for PpQ pump in closed circuit operation with 2 pressure sensors connected.

6.6 Parameter description

⚠ WARNING

Only trained staff should make changes of the parameters. During changes the drive must be switched off. Every parameter change is immediately effective!

Due to an eventual lack of clearness, not all parameters are shown in the software block diagram

6.6.1 Set point and ramps <Sx.xx> and <rx.xx>

6.6.2 Programmable set points <S1.01> and <S1.02>, <S2.01> and <S2.02>

W digital S1.01 S1.02	W digital S2.01 S2.02

- Digital set points are internal programmable set points, activated by digital inputs
- The inputs are opto-decoupled and can be controlled directly from the PLC.
- If an electrical isolation between the PLC and the amplifier is not required, the customer must bridge terminal 2d to terminal [26bd] and terminal [32z] to terminal [32bd].
- Two of the programmable set points can be selected with the respective input and an associated direction “+“ or “-“ <S1.01> and <S1.02> for the flow)
- Two of the programmable set points can be selected with the respective input and without the influence of an associated direction “+“ or “-“ <S2.01> and <S2.02> for the pressure limiter setting)
- If both directions “+” and “-“ are selected at the same time, none of the selected set points will be activated
- If no direction is selected, no set point will be activated
- All digital set points are passed through the ramp function generator.
- All set points are additive and include no direction information themselves
- If several set points are selected at the same time, the sum of these set points is subsequently processed
- <S1.01> and <S1.02> are the set points for the flow
- <S2.01> and <S2.02> are the set points for the pressure limiter

To activate <S1.01> and/or <S1.02> additionally either the signal “+ sign” or “– sign“ is required.
<S2.01> and <S2.02> are independent from the sign selection.

6.6.3 Analog set points <S1.05>, <S1 06>, <S1.09> and <S1.10>

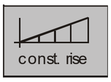
W **Analogue** **S1.05**	**W** **Analogue** **S1.06**	**W** **Analogue** **S1.09, S1.10**

- The set point <S1.05> is designed for voltage signals 0 ... + 10 V and <S1.06> for voltage signals 0 ... ± 10 V
- The set points are passed through the ramp function generator (ramp)
- The set point <S1.06> is calculated according to the polarity with the other set points <S1.01>, <S1.02>
- The input <S1.05> is measured against analog GND (terminal [26z])
- The input for <S1.06> is designed as a differential input within the operating voltage range ± 15 V.
- The signals for set point <S1.05> must be standardized to + 10 V otherwise the A/D converter is overloaded
- The signals for set point <S1.06> must be standardized to ± 10 V otherwise the A/D converter is overloaded
- Set point <S1.06> is assigned to the flow
- Set point <S1.05> is assigned to the pressure limiter
- The set points <S1.09> and <S1.10> are designed for voltage signals 0 ... + 10 V
- Set points <S1.09 and <S1.10> are assigned to the power limiter;<S1.09> for the A side and <S1.10> to the B side

To suppress interference, unused analog set points must be bridged to analog GND.
The analog set points <S1.05>, <S1.06>, <S1.09> and <S1.10> are not real parameters; they represent external set points.

6.6.4 Ramp function <r1.01> to <r1.04>; <r2.01> to <r2.04>

r1.01... r1.04;
r2.03 ... r2.04



Set points are integrated accordingly to the ramp function generator. For each change of direction, the ramp time can be set independently. Times from 0 to 39.5 s can be set. The resolution is 0.01s.
The ramp characteristic is assigned as follows:

For flow set points:
<r1.01> ramp from 0 to negative values <r1.03> ramp from 0 to positive values
<r1.02> ramp from negative values to 0 <r1.04> ramp from positive values to 0

For pressure set points:
<r2.03> ramp from 0 to positive values
<r2.04> ramp from positive values to 0

The ramp function is always constant time base and linear.

6.7 Parameters for flow control <C1.xx> pressure <C2.xx>

6.7.1 Selection of controller <C1.00>; <C2.00>

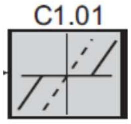
These parameters activate or deactivate the related controller function.

- <C1.00> acts on the swash plate angle controller (flow Q).
  <C1.00> = 0, the swash plate controller is working in open loop
  <C1.00> = 1, controller in closed loop.

- <C2.00> acts on the pressure limiter controller (pressure P).
  <C2.00> = 0, the pressure limiter is deactivated
  <C2.00> = 1, Pressure limiting is active
  <C2.00> = 2, the pressure limiter function can be activated by means of the digital input “DIO 1” at terminal 2b

6.7.2 Hysteresis for command signal (flow) <C1.01>

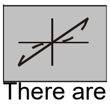
C1.01



This parameter allows setting of a “dead band” around zero for the flow command signal. This will ensure that with zero command the pump remains in center position without delivering flow.

6.7.3 Characteristic curve <C1.02>

C1.02

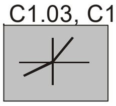


There are five characteristic curves available for the linearization of the valves characteristics:

Curve #1: general linearization
Curve #2: linearization for proportional directional valves with flow characteristic > 10 l/min (NG6)
Curve #3: linearization for proportional directional valves with flow characteristic ′ 10 l/min (NG6)
Curve #4: linearization for proportional directional valves with flow characteristic > 50 l/min (NG10)
Curve #5: linearization for proportional pressure valves
These available characteristic curves can be adjusted according to specific valves or demands.

6.7.4 Direction dependent amplification <C1.03>, <C1.04>

C1.03, C1.04



The amplification can be programmed with the parameters <C1.03> and <C1.04>, for both directions, “+” and “-”.

6.7.5 Inverter <C1.05>, <C1.12>; <C2.12>

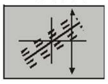
C1.05	C2.12	C1.12
*1 / 0 / *-1	*1 / 0 / *-1	*1 / 0 / *-1

The inverter functions are used to exchange the polarity sign of the set points <C1.05> and the actual values<Cx.12> or to completely deactivate these signals. This enables to change the direction of the process or a valve.

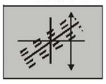
6.7.6 Offset for set point and actual value <C1.11>; <C2.06>, <C2.11>

A drift of the drive or the hydraulic system can be corrected with the offset parameters.

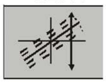
C1.11



C2.06



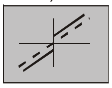
C2.11



The offset-set point <C2.06> can be regarded as an additional pressure set point.
The offset-for feedback signals <Cx.11> mainly compensate the offset of the feedback branch.

6.7.7 Spool overlap compensation <C1.07>, <C1.08>

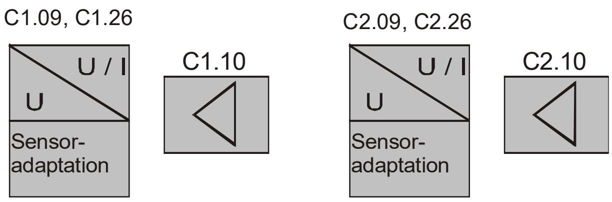
C1.07, C1.08



These parameters compensate a possible spool overlap independently for each solenoid. The compensation works as an additional set point that is activated as soon as the polarity of the set point changes. Overlaps of valve are empirically around 10 % to 15 % of FS. The setting has a decisive effect on the quality (precision and speed) when positioning the axis drives. The amplification in the small signal range is essentially determined by this function.
The programming is standardized in volt, 10 V equals the maximum set current.

6.7.8 *Sensor adjustment <C1.09>, <C1.10>, <C1.26>; <C2.09>, < C2.10>,< C2.26>*

To choose the appropriate type of sensor for the feedbacks, use parameter <C1.09> / <C2.09>.



The following types of sensors are available:
Possible selections <C1.09>:

Selection	Signal	Wire monitor	Selection	Signal	Wire monitor	
1	0 ... 20 mA	No	7	7,5 V ± 2,5 V	Yes	
2	4 ... 20 mA	Yes	8	6 V ± 5 V	Yes	
3	12 mA ± 8 mA	Yes	9	7,5 V ± 5 V	Yes	
4	0 ... 10 V	No	10	0 ... 20 mA	No	With selection 10, 11 and 12, no negative controller output is possible
5	0 ... ± 10 V	No	11	4 ... 20 mA	Yes	
6	6 V ± 2,5 V	Yes	12	0 ... 10 V	No	

The wire break monitor is activated automatically (if it is in the selection). To activate or deactivate manually, choose parameters <C1.26> and <C2.26>.
Selections 10 to 12 are for control loops where no negative value appears, so no negative controller output is possible!
To set the sensor for the first control loop (X1), use parameter <C1.09>. The adjustment of the sensor signal will be supported by the system hardware; the hardware also automatically sets the signal range and therefore guarantees the optimal resolution. Parameters <C1.11> (for the offset) and C1.10 (for the amplifying) allow an even finer, additional adjustment. This loop takes care of the swash plate angle control.
The maximum input voltage for <C1.09> = 9 is 2,3 V to 13 V.

The X1 input can optionally process current signals in the range of 0 ... 20 mA or 4 ... 20 mA. When these sensor signals are chosen, the required resistance of 100 Ω is automatically activated.
The selections 1 to 12 are available in the standard setting.

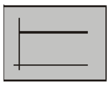
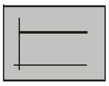
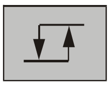
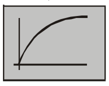
Possible selections <C2.09>:

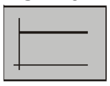
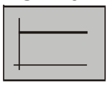
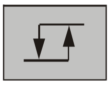
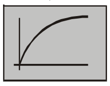
Selection	Signal	Wire monitor	
1	0 ... 20 mA	No	
2	4 ... 20 mA	Yes	
4	0 … 10 V	No	
---	---	---	
---	---	---	
10	0 ... 20 mA	No	With selection 10,11 and 12 no negative controller output is possible
11	4 ... 20 mA	Yes	
12	0 … 10 V	No	

<C2.09> is used to adjust the sensor of the pressure limiter control circuit (X2). Parameter <C2.11> is used to adjust the offset and parameter <C2.10> for the amplifying.

WARNING

For safety purposes it is preferable to use sensors with a 4 ... 20 mA interface which makes cable fracture detection possible. Also, this current signal is less prone to EMC disturbances.

C1.13	C2.13	C1.15	C1.14, C1.16
			

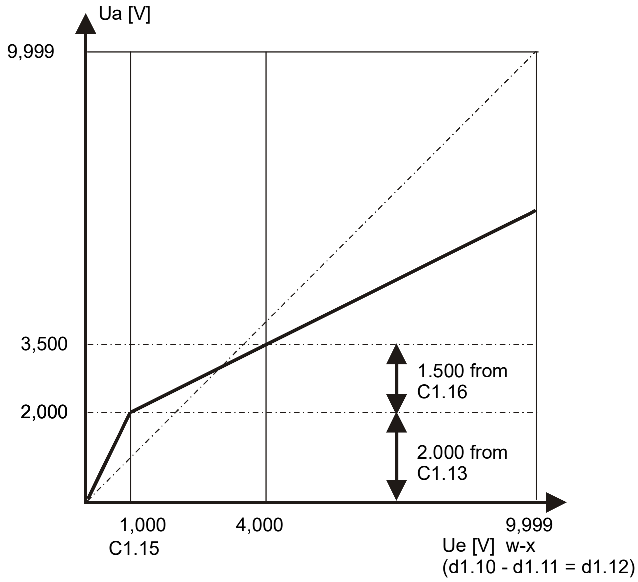
C1.16	C2.16	C2.15	C2.14, C2.16
			

6.7.9 P-portion, PT1-portion <C1.13>, <C1.16>; <C2.13>, <C2.16>

- <C1.13> / <C2.13> is the P-amplification (KP_1) for minor control deviations (proportional controller)
- <C1.14> / <C2.14> cooperates with <Cx.16> and forms therefore a PT_1 term
- <C1.15> / <C2.15> is the threshold to control the operation of <Cx.13> (KP_1) or <Cx.16> (KP_2)
- <C1.16> / <C2.16> is the P-amplification (KP_2) for large control deviations, results with <Cx.14> as a PT_1 part

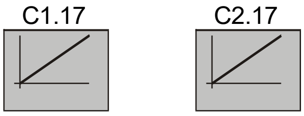
Description of the threshold function Cx.15 and the resulting effect of <Cx.13> and <Cx.16>:
<u>Case 1, the control deviation is smaller than the threshold (|w-x| < <Cx.15>):</u> only the P-portion KP_1 is activated (w-x* KP_1).
<u>Case 2, the control deviation is larger than the threshold (|w-x| > <Cx.15>):</u> from the threshold Cx.15 on, the P-portion KP_1 is activated with the value (w-x* KP_1). The other P-portion KP_2 only functions with the value ([[w-x] - <Cx.15>] * KP_2). The complete portion of both controllers is an addition of these values. See the following graph for explanation:

Example:
C1.15 = 1,000, C1.13 = 2,000, C1.16 = 0,500
d1.12 = 4,000 V (lag error w-x)



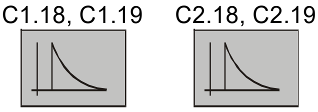
The division into two individually adjustable amplifications allows a more stable adjusting of the controller in non-linear systems (which is often the case for hydraulic applications), even if the control deviations are large. The possibility to suppress (attenuate) <Cx.16> (KP_2) with a time relay supports this effect and results in adjustable moderate (smooth) PT1-characteristics.

6.7.10 I-portion <C1.17>; <C2.17>)



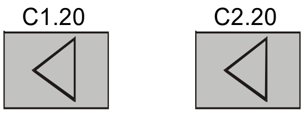
- <C1.17> / <C2.17> is the I-portion of the controller (integrating controller). <Cx.17> is limited to the maximum value to avoid an overdrive or saturation.

6.7.11 D-portion, DT1-portion <C1.18>, <C1.19>; < C2.18>, <C2.19>



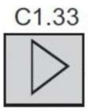
- <C1.18> / <C2.18> is a D-portion and together with Cx.19 forms a PT_1 term (differential controller).
- <C1.19> / <C2.19> is a T-portion for Cx.18 to form a DT_1 term.

6.7.12 Additional (P-) multiplier <C1.20>; <C2.20>



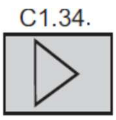
- <C1.1>9 / <C2.19> is an additional proportional factor to increase the effect of <Cx.13> and <Cx.16<.

6.7.13 Leakage compensation <C1.33>



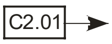
Since the leakage oil loss of the pump is pressure-dependent, the leakage oil loss per 100 bar is entered here. This parameter is used to compensate the Q-set value over the full pressure range.

6.7.14 Adaptive adaption of the P-Part <C1.34>



The gain in the pump circuit depends on the current position of the swivel swivel angle Due to this non-linear gain in the pump control loop, this parameter can be used to compensate for this non-linearity.

6.7.15 Pressure command signal minimum <C2.01>



<C2.01> defines a minimum pressure even when the pressure command signal should drop to “0”. This allows a trouble-free operation even in case of a minimum pressure level present at the pump (e.g. due to the feeding pressure from a pilot pump).

Also allows setting of a pressure limit even when no analog <S1.05>or digital pressure <S2.01>, <S2.02> limit command signal is present.

6.7.16 Q limitation activation of the “turbo” function <C2.02>

C2.02

With this parameter the “turbo” function can be turned on/off.
If the pressure raises with a gradient larger than (defined by internal threshold) is detected then the pressure limiter will already start to work even if pressure limiter values are not yet reached (look ahead function). This will immediately reduce the flow (swash plate angle will be reduced in direction of smaller flow).

If activated, the function is as follows:

- Up to a dV_p of level 1 = 200 bar / sec, the current Q-set value is maintained.
- above a dV_p of level 2= 1200 bar / sec, the return value of the current Q-set value is reduced to the value <C2.03> * actual Q set value.
- Between level 1 and level 2, the return value of the current Q-set value is linear calculated between <C2.03>* and 100% depending on the pressure dV_p value.

Level 1 and level 2 are internal fixed threshold values.

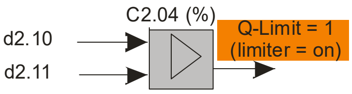
The turbo function, when activated by <C2.02>, is always in wait, regardless of whether the switch-on condition for the pressure limit has been reached. When the “turbo” function has been activated once, another activating is suppressed until the actual pressure is for a defined time (200ms) under the level of <C2.04>, to avoid an instable system.

6.7.17 Q reference value during active Q limitation <C2.03>

C2.03

As soon as the pressure limit function is activated the flow will be reduced to this value. This is also the “start” value for the flow command signal ramping up after the pressure limiter has left its activation level. The ramping up of the flow command signal is defined by the ramps <r1.01> to <r1.04>. The ramp times has to be set in accordance with the possible dynamic performance of the pump. It is recommended to adjust a ramp time of 5 to 10 times of the time the pump needs to step from maximum to zero flow and vice versa.
This function helps to have stable function and minimizes oscillations.

6.7.18 Q limitation activation level based on pressure ratio of pressure actual/command value <C2.04>



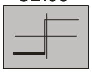
This parameter is controlling the activation of the pressure limiter. It defines at what level of the pressure command signal the limiter will become active.

If this parameter is set too low, the pressure may not or only very slowly reach the limit.

If this parameter is too high, higher overshoots can occur.

6.7.19 Positive I-portion output limitation <C2.05>

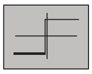
C2.05



This parameter helps to avoid a saturation of the I-Portion of the pressure limiter controller and such may enhance the dynamic behavior in changing conditions.

6.7.20 Limitation for pressure decrease (Displacement opposite of flow command <C2.07>

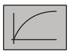
C2.07



<C2.07> limits the amount of swash plate angle over center in case of pressure limiting being active (direction of angle opposite to the direction given by the actual flow command signal).

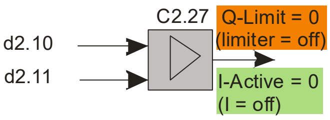
6.7.21 Q filter function <C2.08> for “turbo” function

C2.08
Filter



Filters the pressure signal (actual value) before signal is used for the activation of the “turbo” function. See C2.02 for activation.

6.7.22 Deactivation hysteresis (difference to activation) for the pressure and flow limiter <C2.27>



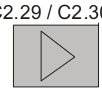
Parameter <C2.27> takes the signal from pressure limit command <d2.10> and the actual and unfiltered pressure <d2.11> into consideration. Depending on the adjusted value the integral portion for the pressure limiter will be de-activated as well as the Q-limit function.

6.7.23 Ramp flow limitation, from limit --> Q-set (leaving pressure limit) <C2.28>

Parameter <C2.28> defines the speed of the ramp for the Q-set value. When the actual pressure reaches the Q-limit activation level <C2.04> then the rising of the Q-set value is limited by the ramp <C2.28>.
The ramp <C2.28> is also active, when the “freezing” of the Q-set value is left. (when the actual pressure falls under the given p-set value, <d2.10>).

6.7.24 Pressure sensor range <C2.29> and rated pressure pump <C2.30>

C2.29 / C2.30



This parameter is used to adjust the pressure sensor range as given by the sensor installed. This will give the right scaling for the display parameter for the pressure at <d2.15> and works only properly together with the adjustment of <C2.30>.

Defines the rated pressure of the pump used.

The parameters <C2.29> and <C2.30> work together. The ration between both sets the scaling for the pressure limiter command signal and also for the scaling of the display parameter for the pressure value in “bar” at <d2.15>. The pressure range of the sensor (set by <C2.29>) must be higher than the maximum regular working pressure (rated pressure) of the system or pump otherwise pressure overshoots cannot be measured accurately and such limit the performance of the pressure limiter function. This mechanism also ensures that the command signal for the pressure limiter is “proportional” to the range of the actual pressure.

Example:

Pressure sensor range = 400 bar → <C2.29> = 0400
Rated pressure = 250 bar → <C2.30> = 0250
At 400 bar, then <d1.11> = 9.999 and <d2.15> = 0400
If now the pressure limiter should kick in at 125 bar the command signal would be 5.000 V (125 bar = 50 % of rated pressure). Even so at <d1.10> the signal will then only be 3.125 V. This would match an actual pressure of 125 bar at the sensor which also would give 3.125 V at <d1.11>.

6.7.25 Dynamic I-Portion <C2.31>, <C2.32>, <C2.33>

Explanation of the dynamic I-Portion, Parameters:
<C2.31> = Maximum value of the dynamic I-Portion
<C2.32> = Adaption rate of the dynamic I-Portion
<C2.33> = Activation level for the dynamic I-Portion

If the difference between command pressure <d2.10>and actual pressure <d2.11> is larger than the level defined in <C2.33> then the dynamic I-factor will be activated. This level is called “Activation level for the dynamic I-Portion”. The instantaneous lag error will then be multiplied by the factor defined in parameter <C2.32>. The result is the “dynamic I-portion”. The dynamic I-factor itself is limited to the maximum I-portion defined by parameter <C2.31>. The newly calculated factor then will be used to determine the level of the I-controller.
If the actual value level drops below the “Activation level for the dynamic I-Portion” then the regular value from parameter <C2.17> will be used again.

When <C2.33> is set to zero, or the calculation (with the factor <C2.32>) of the dynamic-I is zero, the dynamic function is deactivated, and the I-Portion <C1.17> is used.

6.7.26 Filter value for actual pressure of the pressure limiter controller loop <C2.34>

<C2.34> sets the filter factor applied to the actual pressure signal used within the pressure limiter control loop, in particular for the calculation of the rate of pressure change used by the ramp function <C2.38>.
<C2.34> = 0: no filter (fastest response).
<C2.34> = 8: maximum filtering (smoothest, slowest response).
Higher filter values reduce noise/oscillations on the pressure signal but slow down the reaction of the ramp function <C2.38> and the dynamic I-portion <C2.31> to <C2.33>.

6.7.27 Positive P-portion output limitation <C2.36>

Analogous to the positive I-portion output limitation <C2.05>, parameter <C2.36> limits the P-portion (and PT1-portion) of the pressure controller to a defined maximum positive value. The P-portion is calculated from <C2.13>/<C2.16> (and, if active, the PT1-portion <C2.14>/<C2.16>) and the additional multiplier <C2.20>; the result is then limited by <C2.36> before being added to the I- and D-portion of the pressure controller.
Whether, and under which condition, this limitation is active is defined by <C2.37>.

6.7.28 Mode of the P-portion limitation <C2.37>

<C2.37> selects the trigger condition which activates the positive P-portion limitation <C2.36> (internal signal “p-active”):
<C2.37> = 0: activation is triggered when the Q-limitation activation level <C2.04> is reached.
<C2.37> = 1: activation is triggered when the dynamic I-portion becomes active (“I-active”).

6.7.29 Ramp factor for the pressure set value at switch-on threshold <C2.38>

When the pump pressure <d2.11> falls below the switch-on threshold <C2.04>, the internal pressure set value is generally reduced to the value defined by <C2.04> (in relation to <C2.29>/<C2.30>). Once the pump pressure rises above <C2.04> again, the pressure set value is ramped up according to the actual rate of pressure increase. Parameter <C2.38> adjusts this ramp: values below 100 % (factor < 1.00) make the ramp slower, values above 100 % (factor > 1.00) make it faster.
<C2.38> = 0 deactivates the ramp function; the pressure set value then directly follows <C2.30> x <C2.04> until the trigger condition is fulfilled. The resulting pressure set value, scaled in bar, is displayed at <d2.10b>.

6.8 Parameters for power/torque limiter

6.8.1 Mode of operation: power/torque limiter <C6.00>

<C6.00> acts on the power/torque limiter controller (Power P, Torque M). The parameter <C6.00> automatically sets the other relevant parameters for the power / torque limitation and activates them.

Power limitation:

<C6.00> = 0, the **power** limiter function is deactivated
<C6.00> = 1, **power** limiting is active, by using the analog input for the power set value.
<C6.00> = 2, the **power** limiter function can be activated by means of the digital input “DIO 2” at terminal 4b.
<C6.00> = 3; the **power** limiter function is automatically set to 100 % (as defined by <C6.05>). In this case no analog command signal is necessary.

Torque limitation:
<C6.00> = 4, **torque** limiting is active, by using the analog input for the **torque** set value.
<C6.00> = 5, the **torque** limiter function can be activated by means of the digital input “DIO 2” at terminal 4b.
<C6.00> = 6; the **torque** limiter function is automatically set to 100 % (as defined by <C6.05>). In this case no analog command signal is necessary.

6.8.2 Power limiter, Drive rpm <C6.03>

This parameter is used to adjust the drive rpm. A proper set-up is important for correct calculation of the power draw of the pump for the power limiting function.
Power calculation is based on rpm, actual flow and actual pressure at pump outlet.
*) In mode Torque limiting, this parameter is not shown, not needed.

6.8.3 Maximum pump displacement <C6.04>

Flow range of the pump. Nominal value for 100 % stroke of the pump (nominal flow). The parameter value is entered in ccm/rpm.

6.8.4 Power limiter: Maximum drive power (kW) <C6.05>

Maximum possible power draw which can be handled by the drive. Pump delivery (Q x P) will be limited to this value for a 10 V command signal at the power limit inputs or when <C6.00> = 3. The parameter value is entered in kW.

6.8.5 Actual value filter for power/torque limiter <C6.06>

<C6.06> is used to filter the calculated actual power value. It may help to reduce oscillations under certain circumstances.

6.8.6 Pump zero position for power/torque limiter <C6.07>

<C6.07> is used to compensate an offset of the power/torque limiter.

6.8.7 Torque limiter: factor of corner torque<C6.08>

The factor is in the range of 5 … 99.99 %. The percentage value from parameter <C6.08> is the partial value of the maximum possible torque. Maximum torque is calculated from the values “max pump displacement” (parameter C6.04) and “rated pump pressure” (parameter <C2.30>).

6.9 Extended parameters <E xx>

6.9.1 Monitor output in standard systems <E 01>

Every internal measured value can be directed as an analog signal to the “Monitor output” at the test jack “MON. This signal is available as a voltage of 0 ... ± 10 V with a 12 Bit resolution.
Parameter <E 01> selects the display parameter <dx.xx> which is directed to this output at the faceplate. The selection ranges from 1 to 27 activates the according display parameter.

This function is used during commissioning or trouble shooting in order to monitor internal values and to analyze the system.

The signal “Monitor output” is also available on terminal [6b] and can be used as a command signal for the slave control.

6.9.2 Analog output <E 31>, <E 19> ,E 33>, <E 34>, <E 35>

The controller output from the swash plate angle controller (controller with index <C1.xx>) is automatically linked to as an analog signal to the "Analog output" at terminal 10b. This signal is available as a voltage with the range of 0 ... ± 10 V or as a current signal 4 … 20mA with 12 Bit resolution.
The type of signal, voltage or current, can be specified with parameter <E31>.

<E31>	Description
1	**Voltage output ± 10 V is selected**
2	**Current output 12 mA ± 8 mA is selected**

Table 8: <E31> selection

If the amplifier card is used as a controller without a valve, this signal is used to control the subsequent electronics.

- <E31>, with this parameter voltage or current output at pin [10b] is selected
- <E19>, <E35> can assign a factor to the output signal
- <E33>, <E34> an offset to the output signal can be defined.

6.9.3 Output stage mode <E 02>

E02

Output Stage mode

If the push-pull function is activated (<E 02> = 1), the solenoid current is divided between both solenoids, the set point = 0. If the set point value is increasing, the solenoid current of one solenoid is also automatically increasing, while the solenoid current of the other solenoid is reduced accordingly. The push-pull function sends an initial current to the solenoid and increases therefore the dynamic response.

6.9.4 Output stage parameters <E 03> to <E 07>, <E 09>, <E10>

Enable E03…E07 E09, E10

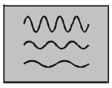
The PWM output stage has over-energization and high-speed de-energization function. The current at the output is measured, compared with the set point (activation value for the output stages) and controlled by a PI controller. This helps to avoid deviations of the solenoid current, e.g. through warming of the coil. Additionally, the programming of the controller has an important influence on the dynamic and static performance. Parameters <E04> to <E07> set the controller for energization as well as for de-energization.

Parameter <E03> selects the maximum current and therefore defines the amount of current available at set point = 10 V.
Parameter <E10> allows a fine and variable adjustment of the solenoid current and this allows adjusting the already set maximum current.
Parameter <E09> sets the time delay of the enable signal. The activation of the output stages will be delayed even though the enable signal is active.

The programming of the parameters <E03> to <E07> and <E10> has an effect on both output stages.

6.9.5 Dither signal <E 13>, <E 14>

E13, E14



The dither function can be matched to the valve or to the process with the parameters <E13> (for the amplitude) and <E14> (for the frequency). This is independent of the used operation modes and has an effect on both output stages. The frequency of the signal is adjusted stepwise. The dither signal reduces the hysteresis of the valve or drive-movement and improves the reaction of the system. This has positive effects on the precision and repeatability.

In general, low frequency signals are more effective, but they can result in noticeable disturbances (noise, oscillations). Values under 100 Hz are for systems with a low characteristic frequency, higher values are used for systems with a high characteristic frequency. Dither amplitudes are set for a range of 2% to 12% (related to current or set point).

Dither signals have an influence on the characteristic curve of the current caused by a physical dynamic correlation. In some cases, this has an effect on the linearity from U to I.

6.9.6 Activation of the analog command for the flow signal <E 24>

This parameter enables the analog input for the Q-set value; otherwise only digital set values are possible.

6.9.7 Activation of the analog command for the pressure limitation <E 25>

This parameter enables the analog input for the pressure set value.

6.9.8 Activation of the analog command for the power/torque limitation <E 26>

This parameter enables the analog input for the power/torque set value.

6.10 Display parameters <dx.xx>

Example: d 1.01

These parameters are used to display all parameter and internal digital values (for programming, commissioning and diagnosis).

6.11 Evaluation of the controller parameters

6.11.1 Current controller

$e(t) > 0$
$t_{pwm}(t) = kp_{err} * e(t) + ki_{err} * e(t)$
$kp_{err} =$ E04
$ki_{err} =$ E05 $* T_{ab}$

$e(t) < 0$
$t_{pwm}(t) = kp_{ent} * e(t) + ki_{ent} * e(t)$
$kp_{ent} =$ E06
$ki_{ent} =$ E07 $* T_{ab}$

$T_{ab} = 100\ \mu s$

6.11.2 Loop Q and Pressure Limiter

$U_p(t) = kp * e(t)$
$U_D(t) = kd * de(t)/dt$
$U_I(t) = ki * e(t)*t$
$U_{dff}(t) = k_{dff} * s(t)$

PT1: $u_a = Kp * - (T1p * du_a / dt)$
DT1: $u_a = Kd * du_e / dt - (T1d * du_a / dt)$

Kp = Cx.13 (evaluation of threshold Cx.15 refer to the chapter above)
Kp = Cx.16 (evaluation of threshold Cx.15 refer to the chapter above)
$Kd =$ Cx.18 $* T_{ab}$
$Ki =$ Cx.17 $/ T_{ab}$
$k_{dff} =$ Cx.13
$T1p =$ Cx.14 $* T_{ab}$
$T1d =$ Cx.19 $* T_{ab}$
$T_{ab} = 500\ \mu s$
e(t) = lag error
s(t) = set point
ue = input voltage
ua = output voltage

6.12 General functional description

6.12.1 Flow control

Assumption: The pump is working in flow control only and pressure limiter function is not active or activated.
The command for the desired flow is provided either by an analog command signal at <S1.06> or also by the digital command signals <S1.01> and <S1.02> (only if "+ sign" or "- sign" is activated in conjunction with <S1.01> and/or <S1.02>).

The card measures the actual position of the swash plate using an appropriate sensor. This actual value is then compared with the command signal which is <d1.10> versus <d1.12>. The resulting lag error (at <d1.12>) is then used for the swash plate angle control and such flow control. The swash plate angle and the flow can be considered to be proportional to each other without taking into the account the efficiency of the pump.

The output of the swash plate angle controller – defined by the input from <d1.12> and the parameter setting of the controller – is used as signal via the output stages to drive the proportional valve and the flow from the valve itself drives the pump actuator. This system constantly monitors the swash plate angle and compensates by varying the flow at the ports of the proportional valve keeping the actuator and such the swash plate in the desired position.

Upon changes in the command signal the controller will react and move the actuator by means of the signal to the proportional valve. The compensation will continue until the lag error will be reduced to "0".

The controller for the swash plate angle is a specialized PID-controller with features to improve performance (accuracy and dynamic behavior) of the swash plate angle positioning.

6.12.2 Pressure limiting function

The DAC-4x(A) card measures the actual pressures by means of a pressure sensor. Generally speaking, will the pressure limiter function become active as soon as the actual pressure reaches the limit set by the command signal provided either by an analog command signal at <S1.05> or also by the digital command signals <S2.01> and <S2.02>.

An additional function ramp can be activated (activation threshold level defined in parameter <C2.04>) to prevent pressure overshoots. The pressure limiter will be deactivated if the actual pressure drops below a threshold defined in parameter <C2.27>.

In case of fast rising pressure signals which can cause significant pressure overshoots (e.g. if a shut off valve is closed in the active pressure line) a special look-ahead compensation function can be utilized. The performance is defined by the parameters <C2.02> and <C2.08>.

In even more extreme cases of pressure rise rates a special detection function is activated to minimize pressure overshoots even under such conditions.

A special logic structure takes care of stable and smooth transition between the different control modes and at the same time ensures stable operation.

The controller for the pressure limiter function is maintained by a special PID-controller.

Max. Input signal 10V (or 20 mA) matches with the real pressure which is set up in parameter <C2.30>.

6.12.3 Power/Torque limiting function

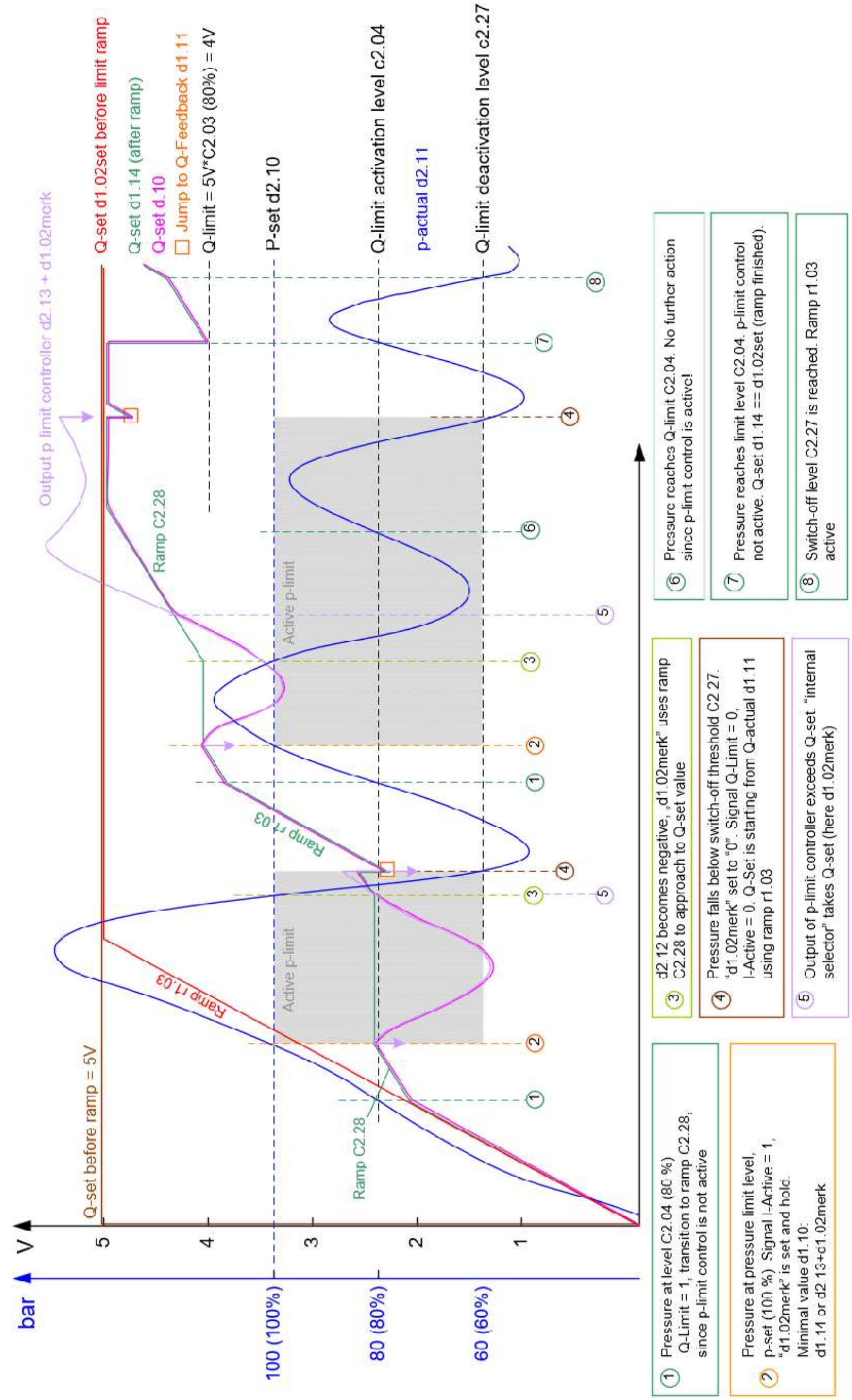
The DAC-4 card measures the actual pressures by means of a pressure sensor.
If power limiting is selected:
The flow is determined by the swash plate angle, the pump size (nominal flow value) and the drive rpm (value is automatically recalculated in each cycle). Both values than itself are used to calculate the actual power draw of the pump.

Generally speaking, will the power limiter function become active as soon as the actual power reaches the limit set by the command signal provided either by an analog command signal at <S1.09> (for side A), <S1.10> (for side B) or directly by the parameter <C6.05> if <C6.00> = 3.

If torque limitation is selected
The flow is determined by the swash plate angle, the pump size (nominal flow value) and the actual pressure (value is automatically recalculated in each cycle). Both values than itself are used to calculate the actual torque draw of the pump.

Generally speaking, the torque limiter function will become active as soon as the actual torque reaches the limit set by the command signal provided either by an analog command signal at <S1.09> (for side A), <S1.10> (for side B) or directly by the parameter <C6.05> if <C6.00> = 6.

6.12.4 Theoretical function diagram, graphical



6.12.5 Test and Monitoring

6.12.5.1 Test jacks

The sockets “A” and “B” can be used to measure the solenoid currents independently. The voltage is approximately 1 V at 1 A. The analog set point <S1.06> can be measured at the socket “SET”. The representation is 1:2 proportional to the measured value (half the set point voltage). At the socket “FB1” the analog actual value of the feedback at terminal [10d] can be measured. The reading is proportional to the actual value signal and has the relation of 1:2.

At the monitor socket “MON”, all display parameters are accessible in the form of an analog voltage being between 0 – 10 V.

In special cases, the signal of the “MON” socket can be directed at the connector X1 on the backside of the card at termina [6b].
For further information, please ask the manufacturer.

6.12.5.2 Display parameter

Internally calculated values can be displayed on the 4-digit display during normal operation and are especially helpful during commissioning and troubleshooting.
The values should be interpreted as voltage or current with a standardized display resolution of 1 mV to 9.999 V for currents between 0,001 A to 4,000 A. The relevant position in the software functions can be taken from the block diagrams. The polarity signs are represented through the LEDs “+” and “-“.

This is only an auxiliary function. For technical reasons, precise measured values, comparable to a multimeter, are not possible

Display-Parameter Swash Plate Angle Controller (flow Q)	Function	Display-Parameter Pressure Limiter (pressure P)	Function
<d1.01>	Sum analog set values	<d2.01>	Sum analog set values
<d1.02>	Sum set values after ramp function	<d2.02>	Sum set values after ramp function
<d1.03>	Set points after linearization	<d2.03>	N/A
<d1.04>	Set values after gain adjustment	<d2.04>	N/A
<d1.05>	Signal to solenoid A	N/A	N/A
<d1.06>	Signal to solenoid B	N/A	N/A
<d1.07>	Current solenoid A	N/A	N/A
<d1.08>	Current solenoid B	N/A	N/A
<d1.09<	Total current solenoid A and B	N/A	N/A
<d1.10>	Set point, reference input	<d2.10>	Set point, reference input
N/A	N/A	<d2.10b>	Set point, reference input (in bar)
<d1.11>	Feedback value, controlled value	<d2.11>	Feedback value, controlled parameter
<d1.12>	Lag error, control difference	<d2.12<	Lag error, control difference
<d1.13>	Controller output, controlling variable	<d2.13>	Controller output, controlling variable
<d1.14>	Internal Q set value	<d2.14>	Actual value pressure (filtered)
N/A	N/A	<d2.15>	Actual value pressure [bar]
N/A	N/A	<d2.16>	Profibus address (in PROFIBUS is used
<d6.01>	Analog power/torque limiting command A side	N/A	N/A
<d6.02>	Analog power/torque limiting command B side	N/A	N/A
<d6.03>	Power limiting command in %	N/A	N/A
<d6.04>	Power limiting command in V	N/A	N/A

6.12.6 Output stages

- PWM output stages are used to reduce power losses.
- The pulse frequency is 22 kHz
- The output stages are equipped with over drive and high-speed breaking to increase dynamic response.
- The output stages are designed for constant currents of up to 3.5 A. each.
- Parameter <E 03> sets the nominal output current. There are different standard settings available further; there is an infinitely variable reduction possible with the parameter <E 10>.
- All settings are concurrent for both output stages; it is not possible to have a different setting for just one.

6.12.7 Analog output

The analog output is fixed to the internal value of the swash angle controller output. The signal can be displayed as analog voltage or current on contact [10b]. This signal has a 12 bit resolution and can for example control subsequent electronics. Various parameters are available to adapt the output to the required current or voltage values.

See □ Chapter "6.9.2 Analog output <E 31>", page 46

Please note, that changes of other parameters can have an effect on the voltage of this output. The final setting of parameter E19 should therefore only be done after the adjustment of all the other parameters has been performed.

6.12.8 Monitor output

Using parameter <E01> (analog monitor output), each of the display values <d1.01> to <d1.13> can be displayed as an analog voltage on contact [6b]. This signal has a voltage of -10V to 10 V and 12 bit resolution and can for example control subsequent electronics.

⚠ CAUTION

Due to the nature of the analog output, a voltage of - 10.0 V will be present after applying supply voltage. If this should negatively affect your system, compensating measures must be taken.

6.13 Control circuit feedback signal adjustment (flow)

Closed-loop control can be switched on or off using the parameter C1.00.

6.13.1 Adjustment of the actual value signal X1 (swash plate angle; flow)

The actual value for the flow control circuit is to be connected at terminal [10d]. Signal range can be:

- 0 ... 10 V and 0 ...±10 V
- for wide range asymmetrical signals and LVDT systems between 2,3 V and 13 V (range for middle voltage and voltage variation)
- 0 ... 20 mA or 4 ... 20 mA. The measuring resistance for current signals is 100 Ω.

Setting is possible by parameter <C1.09>.

C1.09	Description
1 to 9	control output can be positive or negative (depending on the difference between actual value and set point). E.g. pump in closed circuit (transmission). Pump will be also working over center respectively operation in two quadrants.
10,11,12	the control output is limited to the positive range. E.g. pump in open circuit not going over center respectively operation only in one quadrant

To ensure utmost safety and best possible reproduction in a user-friendly way, all settings and adjustments are done digitally, supported by the hardware. All adjustments can be completed using the keyboard and controlling the display parameters. Through the combination of hardware and software functions for the actual value, adjustment guarantees highest resolution and precision. Therefore, the advantages to a system with analog adjustment using potentiometers are obvious.

Adjustment:

If <C1.09> = 10, 11 or 12, d1.11 will not show any values < 0.000.

Step	Adjustment
Zero point adjustment / general case	
1	Put the output signal of the sensor in its zero position
2	Set amplifier to monitor <d1.11>
3	Save inverted <d1.11> value in <C1.11>
4	Check <d1.11> again, repeat step 2 and 3 if necessary
Amplifier adjustment	
1	Set the system to achieve a maximum actual value
2	Check <d1.11> display
3	Adjust amplifying with <C1.10>
4	Check <d1.11> result
5	Repeat steps 7 and 8 if necessary

To invert the actual value signal, use parameter <C1.12>. If necessary, invert the set point signal with <C1.05> to determine and correct the controller direction.

The actual value signal is also available at the test jack “FB1”. If <d1.11> is shown in the display, the actual value signal is available in the form of analog voltage at the test jack “MON”.

Furthermore, by using parameter <E01> (Monitor output), each of the displays <d1.01> to <d1.13> can be given in the form of analog voltage at terminal [6b]. This signal can also be used for subsequent electronics.

6.14 Pressure limiting control

Pressure sensors are either designed using two or three-wire technology. The transducers signal is current (range from 0 ... 20 mA or 4 ... 20 mA).

When connecting the pressure transducer great care is recommended. The zero-volt wiring, screening and PE connection are critical points. A fault in the signal can lead to a triggering of the wire break monitor or cause instabilities in the control system.

The scaling of the actual value signal is very important for a high-quality pressure control and also guarantees maximum resolution exploitation. The maximum pressure to be controlled is a key factor. The measuring range of the sensor must be as near as possible to the maximum control pressure. The measuring range of the sensor must be adapted to the pressure range of the process. Furthermore, special attention must be given to actual value amplification adjustment. At the controlled maximum pressure, the monitor <d1.11> should read 9.900.

<C2.09> is used in order to select the sensor type. This parameter must be set before other adjustments are made.

When setting the zero point, pumps - due to their design - often do not permit
a setting of 0 bar or close 0 bar.

The pressure limiting function and the dynamic behavior are essentially determined by the system properties (pump size, valve design, flow rate, etc.), therefore a production pre-setting is not possible. Should amplification calculations not be possible, the adjustment of the controller must be determined by try and error.

Avoid control loop instability during adjustment since it may cause damage to the pump or machine.

6.15 Power / torque limiting control

Actual power or torque is automatically calculated by measuring actual pressure and flow (swash plate angle = flow). This calculated value is compared with the command value, defined either by the analog inputs or by <C6.05>.

If the calculated power is exceeding the command signal, then the flow will be reduced until it is meeting the defined max. power. A special filter (parameter <C6.06>) can be utilized in order to adapt to the dynamics of the system.

⚠ CAUTION
The correct power calculation and such power limiting function is depending on a proper setup of drive rpm, pump size and pressure sensors!

6.16 Control circuits with PPQ (flow, pressure and power/torque limiter)

The regulation of all three control loops is performed with a cycle speed of 100 µs. The first control loop is used for the flow control (swash plate angle control), the second loop is used for a pressure limiting function and the third loop takes care of the power limiting function.

Flow control is the basic function and the pressure as well the power limiter will override the flow control and may limit the pump output at any given moment if any of the defined limits is reached.

When using all three control loops, activate flow control loop first.

⚠ CAUTION
Due to their design, some pumps may not remain at center position when the flow control loop is not closed. This can cause significant flow from the pumps outlet port(s).

6.17 Comparator Functions <C1.21> to <C1.25>

Parameter <C1.25> activates the comparator function and also defines which values are compared. The available values are the set point <d1.10>, the actual value <d1.11> and the deviation or lag error <d1.12>. The comparator is only applicable to the flow control.

- <C1.25> = 0: Comparator is deactivated
- <C1.25> = 1: Comparator compares with the current set point <d1.10>
- <C1.25> = 2: Comparator compares with the current actual value <d1.11>
- <C1.25> = 3: Comparator compares with the current deviation <d1.12>.

Parameters <C1.21> and <C1.22> define the comparator window. They both can be set to a value of 0 ... ± 9.999 V. It is also possible, to define a positive, negative or asymmetrical window. <C1.21> and <C1.22> define the logic of the comparator output. Note the following dependencies:
If <C1.21> ≤ <C1.22>, the logic of the output is negated.
Comparing the comparator value to the control deviation, the window center is defined by:
Actual value = set point or (actual value - set point) = 0.

Depending on the set point, the window will be centered on it.

A on/off switching delay determined by the parameters <C1.23> and <C1.24> can be adjusted to maximum of 9.99 s with a
10 ms resolution. The optically decoupled comparator output signal is available at terminal [14b].

In general, the comparator is always linked by a logical "AND" with the “enable” signal, thus, if the enable” signal is “low”, the comparator output will also be “low”.

The comparator can be used to generate a “set point reached” (“in position” for swash plate angle control) signal. Simple feedback value checks can thus be performed. The control deviation <d1.12> is the most useful comparative value <C1.25> = 3), the comparator output signal is dependent of the comparison result.

When the value is within the defined window (using parameters <C1.21> and <C1.22>), the “reset Ramp” is slowly flashing.

7 Inputs, outputs and messages

7.1 General

- All inputs and outputs are electrically isolated through opto-coupler.
- Outputs are short circuit protected (except the Break output).
- If no electrical isolation is required the following terminals must be bridged:
  [2d] to [26d]
  [32z] to [32bd]

7.2 Supply

The LED ”24V” lights up when the supply voltage is present.

7.3 Enable

- After the enable signal has been applied to terminal [8d], the LED ”EN” lights on. If a time delay had been set in parameter <E 09>, LED ”EN” flashes for the period of the delay.
- Once the time delay elapses, the flashing signal becomes a continuous signal and the output stages are enabled

7.4 Reset ramp (ramp = 0)

A 24 V signal at the reset ramp input = 0 (terminal [18z]) deactivates the ramp function generator immediately and the set points are ineffective. This is shown with the LED ”RPO”. Once the signal is switched off, the ramp function generator starts again from zero.

The LED “RP0” is not used for indicating the status of the input Reset Ramp!
Only for SW V5x.xx: If the slave function is activated, the LED indicates, that slave is active.

7.5 Fault (error)

- The current in the output stages is monitored in the amplifier. If the total current exceeds a specific threshold value, the output stages are switched off automatically. At the same time, the signal at the output ”Fault” (terminal [14d]) is set to 0 V. The LED ”ER” will flash red and the display will show the fault message ”---3”. LED ”EN” then stops flashing. By using any of the keys, the fault message disappears and new operations are possible. The fault message is displayed again after about 10 seconds. Until the fault is corrected, the LED ”ER” will stay activated and the LED ”EN” will be deactivated.

Malfunction signals should not be corrected by switching off the supply voltage but by taking off the enable signal (after correcting the cause of the malfunction), otherwise a diagnosis is no longer possible.

It is possible to continue the setting of the card even though the malfunction signal flashes. This allows to find the cause of the error and to correct it. Afterwards, the enable has to be reset (deactivated and activated).

7.5.1 Comparator output

The output is short circuit protected and can drive noninductive loads until 50 mA.
For special function of the output as comparator output refer to

See □ 6.17 Comparator Functions <C1.21> to <C1.25> page 53

7.6 Programmable set points, directions and polarity signs

- 4 LEDs indicate the selected set points (SP1 for <S1.01>; SP2 for <S1.02>; SP3 for <S2.01>; SP4 for <S2.02>)
- 2 LEDs indicate the selected direction (”+” or ”-”)
- The LED’s ”+” and ”-” are also used to show the polarity signs of all measured values and parameters.

7.7 LED function ”+”, ”- ” and ”IO3”

7.7.1 LED function ”+”, ”-”

Selection of direction	polarity sign of the reading or of the parameter	direction for LED	
		+	-
none	positive	flashes	off
	negative	off	flashes
+	positive	flashes fast	off
	negative	on	flashes
-	positive	flashes	on
	negative	off	flashes fast
+		on	off
		off	on

7.7.2 LED function ”IO3” or at the HCSTool “DIR”

The LED “IO3” is used to indicate the flow direction determined by the command signal.

When S1 = 1 → Q < 0 = LED “on”
When S1 = 0 → Q > 0 = LED “off”

7.7.3 Display and error message

If an error occurs, it is displayed in the 7-segment display and in the HCSTool.
Defined error and other messages:

Error number	Description of error/message
1	**Error of operation**
2	**Wire break sensor 1 (Fb1)**
3	**Excess current or short circuit at the output stages**
4	**Wire break sensor 2 (FB2)**
5	**Wire break or over voltage at set value input S1.05**
6	**Wire break or over voltage at set value input S1.06**
7	**Wire break or over voltage at set value input S1.07**
8	**Wire break at the output stages**
10	**Profibus timeout (E23) occurred**
11	**Negative or overload current >22mA sensor 1 (Fb1)**
12	**Negative or overload current >22mA sensor 2 (Fb2)**
15	**Negative or overload current >22mA at input S1.05**
16	**Negative or overload current >22mA at input S1.06**
17	**Negative or overload current >22mA at input S1.07**

Table 9: List of error messages

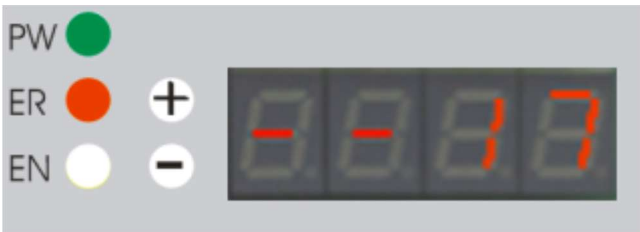


Figure 13 : Example of Error message at the 7-segment display

⚠ CAUTION

The general and safety instructions of this manual must be observed in any case!

8 USB-C interface

8.1 General

Remote operation or remote parameter adjustment may be executed through the USB-C interface.

With the use of the program **HCSTool,** all the parameters may be manipulated. It enables the editing, download and upload parameters and sets of parameters and has a wide range of other functions. The parameters of the amplifier card can be changed by a superior control (e.g. PLC) with a defined protocol. This way, the amplifier card can be inserted into the machine process in automated systems. For further information about the program **HCSTool** and the protocol please contact the manufacturer.

⚠ CAUTION
Any change of parameters with the USB-C interface should be carried out by trained personnel only. If possible, the drive must be stopped during parameter changes. Deactivation of the enable signal is recommended.

8.2 Physical interface data

The connection cable must the following conditions:

- USB-C connector on the DAC-4x(A) side
- Depending on the PC the other side of the cable has to be selected (USB-A; USB-B or USB-C)

8.3 Downloading HCSTool

Please follow this link to download the most recent version of HCSTool free of charge:

http://www.h-c-s-gmbh.de/en/download

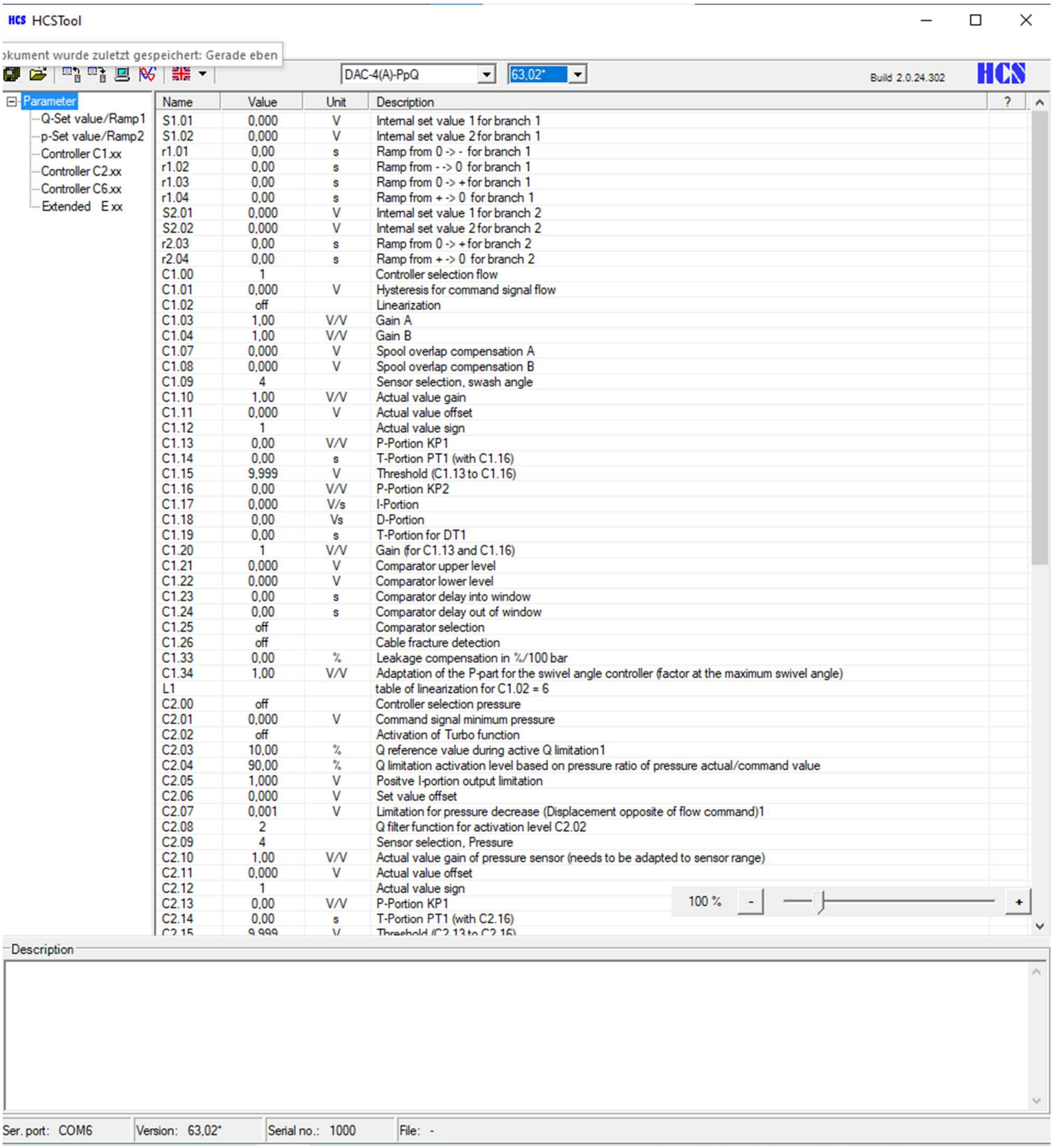
8.4 Using HCSTool

Figure 14 : HCSTool start screen

After starting HCSTool the program can either be used “offline” (without having a unit connected) or “online” in direct operation with a card.

After connection of the card with the USB-C interface it is the best to select the “Upload parameter from device” button to establish communication between the HCSTool and the unit. In this case the software and card version are automatically detected.

Example of HCSTool main screen (DAC-4x(A)-xPpQ with software version V63.02).



Name	Value	Unit	Description
S1.01	0,000	V	Internal set value 1 for branch 1
S1.02	0,000	V	Internal set value 2 for branch 1
r1.01	0,00	s	Ramp from 0 -> - for branch 1
r1.02	0,00	s	Ramp from - -> 0 for branch 1
r1.03	0,00	s	Ramp from 0 -> + for branch 1
r1.04	0,00	s	Ramp from + -> 0 for branch 1
S2.01	0,000	V	Internal set value 1 for branch 2
S2.02	0,000	V	Internal set value 2 for branch 2
r2.03	0,00	s	Ramp from 0 -> + for branch 2
r2.04	0,00	s	Ramp from + -> 0 for branch 2
C1.00	1		Controller selection flow
C1.01	0,000	V	Hysteresis for command signal flow
C1.02	off		Linearization
C1.03	1,00	V/V	Gain A
C1.04	1,00	V/V	Gain B
C1.07	0,000	V	Spool overlap compensation A
C1.08	0,000	V	Spool overlap compensation B
C1.09	4		Sensor selection, swash angle
C1.10	1,00	V/V	Actual value gain
C1.11	0,000	V	Actual value offset
C1.12	1		Actual value sign
C1.13	0,00	V/V	P-Portion KP1
C1.14	0,00	s	T-Portion PT1 (with C1.16)
C1.15	9,999	V	Threshold (C1.13 to C1.16)
C1.16	0,00	V/V	P-Portion KP2
C1.17	0,000	V/s	I-Portion
C1.18	0,00	Vs	D-Portion
C1.19	0,00	s	T-Portion for DT1
C1.20	1	V/V	Gain (for C1.13 and C1.16)
C1.21	0,000	V	Comparator upper level
C1.22	0,000	V	Comparator lower level
C1.23	0,00	s	Comparator delay into window
C1.24	0,00	s	Comparator delay out of window
C1.25	off		Comparator selection
C1.26	off		Cable fracture detection
C1.33	0,00	%	Leakage compensation in %/100 bar
C1.34	1,00	V/V	Adaptation of the P-part for the swivel angle controller (factor at the maximum swivel angle)
L1			table of linearization for C1.02 = 6
C2.00	off		Controller selection pressure
C2.01	0,000	V	Command signal minimum pressure
C2.02	off		Activation of Turbo function
C2.03	10,00	%	Q reference value during active Q limitation1
C2.04	90,00	%	Q limitation activation level based on pressure ratio of pressure actual/command value
C2.05	1,000	V	Positve I-portion output limitation
C2.06	0,000	V	Set value offset
C2.07	0,001	V	Limitation for pressure decrease (Displacement opposite of flow command)1
C2.08	2		Q filter function for activation level C2.02
C2.09	4		Sensor selection, Pressure
C2.10	1,00	V/V	Actual value gain of pressure sensor (needs to be adapted to sensor range)
C2.11	0,000	V	Actual value offset
C2.12	1		Actual value sign
C2.13	0,00	V/V	P-Portion KP1
C2.14	0,00	s	T-Portion PT1 (with C2.16)
C2.15	9,999	V	Threshold (C2.13 to C2.16)

Figure 15 : HCSTool working area screen

Each parameter can be edited individually and either directly changed in the card (selecting download) or only in the PC list (OK). In the latter case the parameter will be highlighted. Finally, all changed parameters can be downloaded.

Example for editing of parameter <C1.01>:

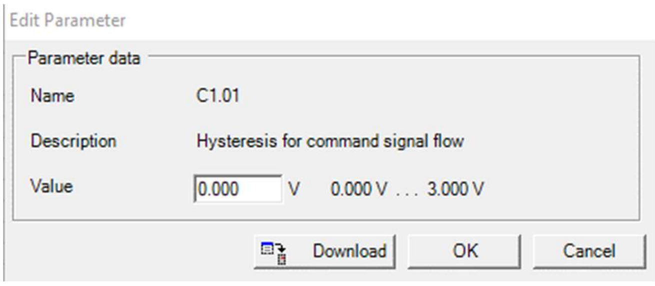


Figure 16 : HCSTool Parameter editing

To get information about internal values the display parameters can be used. For this purpose, the “Monitor” function must be activated (“Monitoring internal values).

Remark: The monitor also will display error codes and status of digital inputs.

For further information about HCSTool please contact the manufacturer or any of our distributors and partners.

9 List of parameters

		SW version
1	Parameters only available for power limit	V53.xx, V54.xx, V55.xx
2	Parameters only available for torque limit	V63.xx, V64.xx, V65.xx, V66.xx
3	Parameters only available for PROFIBUS/PROFINET versions	V54.xx, V55.xx, V56.xx, V64.xx, V66.xx
3	Parameters only available for PROFIBUS versions	V54.xx, V64.xx
4	Parameters only available for EtherNet/IP versions	V65.xx
5	Slave parameters only available for SW version	V53.xx, V54.xx, V55.xx

All values in decimal, for usage as data values they must be converted into Hex
R = read only parameter.
X = implemented, but not active (no access)
W/R = writing and reading possible.

9.1 Parameter for set values

ID_{Hex}	ID_{dec}	W/R	Name	Function	Unit	Min	Max	Def	Description
0x1F	31	R/W	A1.01	Bus set value (Flow)	V	-9999	9999	-	-1000 == -1.000 V; 1000 == 1.000 V This value is, when written, always active. Cleared by reset, or writing "0". For switching off of the analog set-value, set E24 = "0"
0x20	32	R/W	A1.02	Bus set value (Pressure)	V	0	9999	-	0 == 0.000 V; 1000 == 1.000 V This value is, when written, always active. Cleared by reset, or writing "0". For switching off of the analog set-value, set E25 = "0"
0x27	39	R/W	A2.01	Bus set value power B (positive)	V	0	9999	-	0 == 0.000 V; 1000 == 1.000 V This value is, when written, always active. Cleared by reset, or writing "0". For switching off of the analog set-value, set E26 = "0"
0x28	40	R/W	A2.02	Bus set value power A (negative)	V	0	9999	-	0 == 0.000 V; 1000 == 1.000 V This value is, when written, always active. Cleared by reset, or writing "0". For switching off of the analog set-value, set E26 = 0"

9.2 Complete list

ID_{Hex}	ID_{dec}	W/R	Name	Function	Unit	Min	Max	Def	Description
0x00	0	R	Vers	Software version	---	xx.xx	xx.xx	xx.xx	Depends on HW and SW version
0x01	1	R	d1.01	Sum of analog set value	V	-9999	9999	-	-1000 == -1.000 V; 1000 == 1.000 V
0x02	2	R	d1.02	Sum of all post ramp set values	V	-9999	9999	-	
0x03	3	R	d1.03	Set values after linearization	V	-9999	9999	-	
0x04	4	R	d1.04	Value after gain adjustment.	V	-9999	9999	-	
0x05	5	R	d1.05	Signal A	V	-9999	9999	-	
0x06	6	R	d1.06	Signal B	V	-9999	9999	-	
0x07	7	R	d1.07	Current A	A	0	5000	-	1000 == 1.000 A
0x08	8	R	d1.08	Current B	A	0	5000	-	
0x09	9	R	d1.09	Total current	A	0	5000	-	
0x0A	10	R	d1.10	Desired value	V	-9999	9999	-	-1000 == -1.000 V; 1000 == 1.000 V
0x0B	11	R	d1.11	Actual value, feedback value	V	-9999	9999	-	
0x0C	12	R	d1.12	Lag error	V	-9999	9999	-	
0x0D	13	R	d1.13	Controller output	V	-9999	9999	-	
0xAD	173	R	d1.14	Internal Q-Set value	V	-9999	9999	-	
0x0E	14	R	d2.01	Sum of analog set value	V	-9999	9999	-	
0x0F	15	R	d2.02	Sum of all post ramp set values	V	-9999	9999	-	
0x10	16	-	-	Reserved	-	-	-	-	
0x11	17	-	-	Reserved	-	-	-	-	
0x12	18	R	d2.10	Desired value	V	-9999	9999	-	
0xB7	183	R	d2.10b	Desired (command) pressure value, scaled in bar (companion to <d2.10>)	bar	0	600	---	1 == 1 bar (analogous to <d2.15> for the actual pressure value).
0x13	19	R	d2.11	Actual value, feedback value	V	-9999	9999	-	
0x14	20	R	d2.12	Lag error	V	-9999	9999	-	
0x15	21	R	d2.13	Controller output	V	-9999	9999	-	
0x9A	154	R	d2.14	Actual pressure (after filter)	V	-9999	9999	---	---
0x9F	159	R	d2.15	Regulated pressure	bar	0	600	---	1 == 1 bar
0xB5	181	R	d2.16	Profibus Address	-	0	127	-	
0x9B	155	R	d6.01	Command signal power/torque (positive side)	V	-9999	9999	---	1000 == 1.000 V

ID_{Hex}	ID_{dec}	W/R	Name	Function	Unit	Min	Max	Def	Description
0x9C	156	R	d6.02	Command signal power/torque (negative side)	V	-9999	9999	---	1000 == 1.000 V
0x9D	157	R	d6.03	Power/torque limit command [%]	%	-9999	9999	---	9999 == 99.99%
0c9E	158	R	d6.04	Nominal Power/torque [V]	V	-9999	9999	---	1000 == 1.000 V
0x16	22	R/W	S1.01	Set Value1 (Flow)	V	-9999	9999	0	1000 == -1.000 V; 1000 == 1.000 V
0x17	23	R/W	S1.02	Set Value2 (Flow)	V	-9999	9999	0	
0x18	24	-	S1.03	Reserved	-	-	-	-	
0x19	25	-	S1.04	Reserved	-	-	-	-	
0x1A	26	-	S1.08	Reserved	-	-	-	-	---
0x1B	27	R/W	r1.01	Ramp from 0 -> - (Flow)	s	0	3950	0	1 == 10ms 0 == Ramp function off
0x1C	28	R/W	r1.02	Ramp from – -> 0 (Flow)	s	0	3950	0	
0x1D	29	R/W	r1.03	Ramp from 0 -> + (Flow)	s	0	3950	0	
0x1E	30	R/W	r1.04	Ramp from + -> 0 (Flow)	s	0	3950	0	
0x1F	31	R/W	A1.01	Bus set value (Flow)	V	-9999	9999	0	-1000 == -1.000 V; 1000 == 1.000 V This value is, when written, always active. Cleared by reset, or writing "0". For switching off of the analog set-value, set E24 = "0"
0x20	32	R/W	A1.02	Bus set value (Pressure)	V	-9999	9999	0	0 == 0.000 V; 1000 == 1.000 V This value is, when written, always active. Cleared by reset, or writing "0". For switching off of the analog set-value, set E25 = "0"
0x21	33	R/W	S2.01	Set Value1 (Branch 2)	V	-9999	9999	0	-1000 == -1.000 V; 1000 == 1.000 V
0x22	34	R/W	S2.02	Set Value2 (Branch 2)	V	-9999	9999	0	
0x23	35	-	-	Reserved	-	-	-	-	1 == 10ms 0 == Ramp function off
0x24	36	-	-	Reserved	-	-	-	-	
0x25	37	R/W	r2.03	Ramp from 0 -> + (Pressure)	S	0	3950	0	
0x26	38	R/W	r2.04	Ramp from + -> 0 (Pressure)	S	0	3950	0	
0x27	39	R/W	A2.01	Profibus set value power B (positive)	V	-9999	9999	0	0 == 0.000 V; 1000 == 1.000 V This value is, when written, always active. Cleared by reset, or writing "0". For switching off of the analog set-value, set E26 = "0"
0x28	40	R/W	A2.02	Profibus set value power A (negative)	V	-9999	9999	0	0 == 0.000 V; 1000 == 1.000 V This value is, when written, always active. Cleared by reset, or writing "0". For switching off of the analog set-value, set E26 = 0"
0x29	41	R/W	C1.00	Controller selection	---	0	3	1	0 = off 1 = $P\text{-}PT_1\text{-}I\text{-}DT_1$ 2 = not applicable 3 = dff
0x2A	42	R/W	C1.01	Hysteresis for command signal Flow	---	-9999	9999	0	-1000 == -1.000 V; 1000 == 1.000 V
0x2B	43	R/W	C1.02	Linearization	---	0	6	0	0 = linear 1 ... 5 = standard curves 6 = customized curve
0x2C	44	R/W	C1.03	Gain A	V/V	0	200	100	100 == Factor 1.00
0x2D	45	R/W	C1.04	Gain B	V/V	0	200	100	100 == Factor 1.00
0x2E	46	-	-	Reserved	-	-	-	-	-
0x2F	47	-	-	Reserved	-	-	-	-	-
0x30	48	R/W	C1.07	Dead band compensation A	V	0	9999	0	1000 == 1.000 V
0x31	49	R/W	C1.08	Dead band compensation B	V	0	9999	0	9.999 V = max. current depending on solenoid selection
0x32	50	R/W	C1.09	Sensor type Attention: No negative controller output possible when 10, 11 or 12 is selected!	---	1	12	4	off = Deactivated 1 = 0...20mA 2 = 4...20mA 3 = 12mA ±8mA 4 = 0...10V 5 = 0...±10 V 6 = 6 V ±2.5 V 7 = 7.5 V ±2.5 V 8 = 6 V ±5 V 9 = 7,5 V ±5 V> 10 = 0…20 mA (positive contr. outp. only) 11 = 4…20 mA (positive contr. outp. only) 12 = 0...10 V (positive contr. outp. only)
0x33	51	R/W	C1.10	Actual value gain	V/V	0	400	100	100 == Factor 1.00
0x34	52	R/W	C1.11	Actual value offset	V	-9999	9999	0	-1000 == -1.000 V; 1000 == 1.000 V
0x35	53	R/W	C1.12	Actual value sign	---	- 1	+ 1	1	- 1 = negative 0 = off + 1 = positive
0x36	54	R/W	C1.13	P-Portion Kp_1	V/V	0	400	0	100 == Factor 1.00
0x37	55	R/W	C1.14	T-Portion for PT1 (to C1.16)	S	0	1000	0	100 == 1.00

ID$_{Hex}$	ID$_{dec}$	W/R	Name	Function	Unit	Min	Max	Def	Description
0x38	56	R/W	C1.15	Threshold <C1.13, C1.16)	V	0	9999	9999	1000 == 1.000 V
0x39	57	R/W	C1.16	P-Portion K_{P2}	V/V	0	400	0	100 == Factor 1.00
0x3A	58	R/W	C1.17	I-Portion	V/s	0	4000	0	1000 == 1.000
0x3B	59	R/W	C1.18	D-Portion	Vs	0	400	0	100 == 1.00
0x3C	60	R/W	C1.19	T-Portion for DT1	S	0	1000	0	100 == 1.00
0x3D	61	R/W	C1.20	Gain (C1.13 and C1.16)	V/V	1	32	1	2 = Factor 2.00
0x3E	62	R/W	C1.21	Comparator upper level	V	-9999	9999	0	-1000 == -1.000 V; 1000 == 1.000 V
0x3F	63	R/W	C1.22	Comparator lower level	V	-9999	9999	0	
0x40	64	R/W	C1.23	Comparator delay into window	S	0	9999	0	1 == 10 ms 0 == no delay
0x41	65	R/W	C1.24	Comparator delay out of window	S	0	9999	0	
0x42	66	R/W	C1.25	Comparator selection COMP_1	---	0	3	0	0 = off 1 = Set value 2 = Actual value 3 = Lag error
0x43	67	R/W	C1.26	Cable fracture detection feedback	---	0	1	0	0 = off; 1 = active
0xbb	187	R/W	C1.33	Leakage compensation	%/100 bar	1	500	0	1 == 0.01
0xbc	188	R/W	C1.34	Adaptation of P-part for swivel angle controller (factor at maximum swivel angle)	V/V	100	500	100	100 == 1.00

ID$_{Hex}$	ID$_{dec}$	W/R	Name	Function	Unit	Min	Max	Def	Description
0x44	68	R/W	C2.00	Controller selection	---	0	2	1	0 = off 1 = Pressure limiter active 2 = Pressure limiter selected by DIO1
0x45	69	R/W	C2.01	Pressure command signal minimum	V	0	9999	0	1000 == 1.000 V
0x46	70	R/W	C2.02	Activation of Turbo function	---	0	1	0	0 = off 1 = on
0x47	71	R/W	C2.03	Q reference value during active Q limitation	%	0	9999	1000	9999 == 99.99 %
0x48	72	R/W	C2.04	Q limitation activation level based on pressure ratio of pressure actual/command value	%	0	9999	9000	9999 == 99.99 %
0x49	73	R/W	C2.05	Positive I-portion output limitation	V	0	9999	0	1000 == 1.000 V
0x4A	74	R/W	C2.06	Set value offset	V	-9999	9999	0	-1000 == -1.000 V; 1000 == 1.000 V
0x4B	75	R/W	C2.07	Limitation for pressure decrease (Displacement opposite of flow command)1	V	0	9999	0	1000 == 1.000 V
0x4C	76	R/W	C2.08	Q filter function for activation level C2.02	V	0	8	0	Filter factor 0 == no Filter, 8 == maximal filter
0x4D	77	R/W	C2.09	Sensor type (pressure FB-A and FB-B) Attention: No negative controller output possible when 10, 11 or 12 is selected!	---	0	12	4	off = Deactivated 1 = 0...20 mA 2 = 4...20 mA 3 = not applicable 4 = 0...10 V 5..9 = not applicable 10 = 0..20 mA (positive contr. outp. only) 11 = 4..20 mA (positive contr. outp. only) 12 = 0..10 V (positive contr. outp. only)
0x4E	78	R/W	C2.10	Actual value gain	V/V	0	400	100	100 == Factor 1.00
0x4F	79	R/W	C2.11	Actual value offset	V	-9999	9999	0	-1000 == -1.000 V; 1000 == 1.000 V
0x50	80	R/W	C2.12	Actual value sign	---	- 1	+ 1	1	- 1 = negative 0 = off + 1 = positive
0x51	81	R/W	C2.13	P-Portion K_{P1}	V/V	0	400	0	100 == Factor 1.00
0x52	82	R/W	C2.14	T-Portion for PT1 (to C1.16)	S	0	1000	0	100 == 1.00
0x53	83	R/W	C2.15	Threshold <C1.13, C1.16)	V	0	9999	9999	1000 == 1.000 V
0x54	84	R/W	C2.16	P-Portion K_{P2}	V/V	0	400	0	100 == Factor 1.00
0x55	85	R/W	C2.17	I-Portion	V/s	0	4000	0	1000 == 1.000
0x56	86	R/W	C2.18	D-Portion	Vs	0	400	0	100 == 1.00
0x57	87	R/W	C2.19	T-Portion for DT1	S	0	1000	0	100 == 1.00
0x58	88	R/W	C2.20	Gain <C1.13 and C1.16)	V/V	1	32	1	2 = Factor 2.00
0x5E	94	R/W	C2.26	Cable fracture detection feedback	---	0	3	0	off = Cable fracture detection off 1 = Cable fracture detection only FB-A (14z) 2 = Cable fracture detection only FB-B (16z) 3 = Cable fracture detection of all sensors on

ID_{Hex}	ID_{dec}	W/R	Name	Function	Unit	Min	Max	Def	Description
0xA6	171	R/W	C2.27	Deactivation hysteresis (difference to activation) for the pressure and flow limiter	%	0	9999	0	9999 == 99.99 %
0xA7	172	R/W	C2.28	Ramp Flow limitation, from limit --> Q-set (leaving pressure limit)	s	0	9999	0	1000 == 1 s
0x5B	91	R/W	C2.29	Pressure sensor range	bar	100	600	600	
0x5C	92	R/W	C2.30	Rated pressure pump	bar	100	450	300	
0xB8	184	R/W	C2.31	Maximum dynamic I-Portion	---	0	4000	100	1000 == 1.000
0xB9	185	R/W	C2.32	Adaptation rate dynamic I-Portion	---	0	800	100	100 == 1.00
0xBA	186	R/W	C2.33	Activation level for dynamic I-Portion (0 => dyn. off)	bar	0	50	10	10 == 10 bar
0xBF	191	R/W	C2.34	Filter value for actual pressure of the pressure limiter controller loop	---	0	8	1	Filter factor 0 == no Filter, 8 == maximal filter
0xB2	178	-	-	reserved	---	---	---	---	
0xB3	179	R/W	C2.36	Positive P-portion output limitation	---	0	9999	0	Analogous to <C2.05> (I-portion). Limits the P-/PT1-portion (after multiplier <C2.20>) to a maximum positive value. Activation condition set by <C2.37>
0xB4	180	R/W	C2.37	Mode of P-portion limitation	---	0	1	0	0 = activation via Q-limitation activation level <C2.04> 1 = activation via dynamic I-portion active ("I-active")
0xC0	192	R/W	C2.38	Ramp factor for pressure set value at switch-on threshold <C2.04>	---	0	400	100	100 == factor 1.00. Values <100 slow down, values >100 speed up the ramp. 0 = ramp deactivated.

ID_{Hex}	ID_{dec}	W/R	Name	Function	Unit	Min	Max	Def	Description
0x59	89	R/W	C6.00	Mode of operation power/torque limiter	---	0	6	0	0 = limiter off 1 = Power limiter with analog and digital input active 2 = Power limiter active by input DIO2 3 = Power limiter active 100%, analog inputs de-activated 4 = Torque limiter with analog input active 5 = Torque limiter active by input DIO2 6 = Torque limiter active 100%, analog inputs de-activated
0x5A	90	R/W	C6.03	Drive rpm	1/min	500	2000	1500	
0x5D	93	R/W	C6.04	Maximum pump displacement	ccm/ rmp	45	1000	45	45 == 45 ccm/rmp
0xA2	162	R/W	C6.05	Maximum drive power nominal corner torque of the drive	kW Nm	10 200	999 8000	125 500	200 == 200 Kw 200 == 200 Nm
0xA3	163	R/W	C6.06	Actual value filter for power limiter Actual value filter for torque limiter	---	0	8	4	Filter factor 0 == no Filter, 8 == maximal filter
0xBD	189	R/W	C6.07	Pump zero position for power and torque limitation	---	-1000	1000	100	100 == 10.00 %
0xBE	190	R/W	C6.08	Factor of corner torque	---	0	9999	9999	9999 == 99.99 %

ID_{Hex}	ID_{dec}	W/R	Name	Function	Unit	Min	Max	Def	Description
0x5F	95	R	E00	Operation mode	---	14	14	14	PpQ control
0x60	96	R/W	E01	Analog output	---	1 and 14	13 and 21	1	1 = d1.01 to 13 = d1.13 and 14 = d2.01 to 21 = d2.13
0x61	97	R/W	E02	Push-Pull function (depends on HW + SW version)	---	0	1	0	0 = off (no push pull) 1 = active 2 = common "+" for solenoids (Remark: only for max 0,8 A current) 3 = full bridge 4 = off + detection low current to solenoid 5 = active + detection low current to solenoid
0x62	98	R/W	E03	Solenoid selection Solenoid selection A (depends on HW + SW version)	---	1	7	6	Standard solenoid definition 1 = 0,8 A 2 = 1,1 A 3 = 1,3 A 4 = 1,6 A 5 = 2,4 A 6 = 2,7 A 7 = 3,5 A (depends on HW + SW version)

ID_Hex	ID_dec	W/R	Name	Function	Unit	Min	Max	Def	Description
0x63	99	R	E04	P-Portion current contr. Energization A	---	500	9999	500	Default for 2,700 A solenoid
0x64	100	R	E05	I-Portion current contr. Energization A	---	500	9999	500	
0x65	101	R	E06	P-Portion cur. contr. de- energization A	---	1300	9999	1300	
0x66	102	R	E07	I-Portion cur. contr. De- energization A	---	500	9999	500	
0x67	103	R/W	E08	Input “RAMP 0” and Master <-> Slave	---	1	2	1	0 = Master mode selected 1 = Slave mode selected 2 = Input “RAMP 0” defines slave mode
0x68	104	R/W	E09	Time delay enable signal	s	0	9999	0	1000 = 1.00 s
0x69	105	R/W	E10	Solenoid current adaptation A	---	50	110	100	Variable adjustment of max. current 100 == Factor 1.00
0x6A	106	R/W	E11	Initial current solenoid A	V	0	9999	0	3.000 V = 30 % of max. rated current
0x6B	107	R/W	E12	Initial current solenoid B	V	0	9999	0	
0x6C	108	R/W	E13	Dither Amplitude A	V	0	3000	0	
0x6D	109	R/W	E14	Dither Frequency A	Hz	1	300	0	---
0x6E	110	R/W	E15	Selection of Q-setpoint S1.06	---	0	11	1	off = Deactivated 1 = Voltage -10 V...+10 V 2 = Voltage 0…10 V 3 = Voltage 5 V ± 5 V 4 = Voltage 5 V ± 4.5 V w/o signal observation 5 = Voltage 5 V ± 4.5 V with signal observation 6 = 0…20 mA w/o cable fract. det. 7 = 10 ± 10 mA w/o cable fract. det. 8 = 4...20 mA w/o cable fract. det. 9 = 4…20 mA with cable fract. det. 10 = 12 ± 8 mA w/o cable fract. det. 11 = 12 ± 8 mA with cable fract. det.
0x6F	111	R/W	E16	Selection of Pressure setpoint S1.05	---	0	9	2	off = Deactivated 1 = not applicable 2 = Voltage 0...10 V 3 ... 5 = not applicable 6 = 0...20 mA w/o cable fract. det. 7 = 10 ± 10 mA w/o cable fract. det. 8 = 4..20 mA w/o cable fract. det. 9 = 4..20 mA with cable fract. det.
0x70	112	-	-	reserved	---	---	---	---	
0x71	113	-	-	reserved	---	---	---	---	
0x72	114	R/W	E19	Factor for analog output	V/V	-400	400	100	100 == Factor 1.00 Sign and gain!
0xA4	164	R	E 22	Activate/Deactivate bus function	---	0	1	0	0 = No bus function 1 = Standard bus function
0xA5	165	R/W	E23	BUS timeout	s	0	9999	0	1000 == 1 s, 0 = function off
0xA6	166	R/W	E24	Activation of analog command signal flow (swash plate angle)	---	0	2	0	0 = In master mode: Analog input deactivated; As slave: analog always active 1 = In master mode: Digital and Profibus and analog; As slave: analog always active 2 = In master mode: Only Profibus active; As slave: analog always active
0xA7	167	R/W	E25	Activation of analog command signal pressure	---	0	1	1	0 = Analog input deactivated 1 = Analog input is activated
0xA8	168	R/W	E26	Activation of analog command signal power limitation	---	0	1	1	0 = Analog input deactivated 1 = Analog input is activated
0xCE	206	R/W	E27	BUS timeout error handling	---	0	1	0	0 = Profibus/ProfiNet timeout causes only error LED to flash (no internal error) 1 = Profibus/ProfiNet timeout causes error
0xD2	210	R/W	E31	Mode of the analog output	---	1	2	1	1 = Voltage mode 0 V ± 10 V active 2 = Current mode 12 mA ± 8 mA active
0xD4	212	R/W	E33	Offset for analog voltage output	V	-9999	9999	0	-1000 == -1.000 V; 1000 == 1.000 V
0xD5	213	R/W	E34	Offset for analog current output 4..20mA	V	-9999	9999	0	-1000 == -1.000 V; 1000 == 1.000 V
0xCB	203	-	-	reserved	---	---	---	---	
0xCC	204	R/W	E37	IP-address "aaa" from "aaa.bbb.ccc.ddd"	---	0	255	192	
0xCD	205	R/W	E38	IP-address "bbb" from "aaa.bbb.ccc.ddd"	---	0	255	168	
0xCE	206	R/W	E39	IP-address "ccc" from "aaa.bbb.ccc.ddd"	---	0	255	1	
0xCF	207	R	E40	IP-address of low-byte DIP switch "ddd" (read only)	---	0	255	85	
0xD0	208	R/W	E41	Input buffer length in byte	---	0	32	12	
0xD1	209	R/W	E42	Output buffer length in byte	---	0	32	12	

ID$_{Hex}$	ID$_{dec}$	W/R	Name	Function	Unit	Min	Max	Def	Description
0xB0 **0xC3**	176 195	R/W	E Int	Internal Digital Switches (Read/Set)	---	0	0xFFFF		0x0001 = Input **DIO1** active (Read/Write) 0x0002 = Input **DIO2** active (Read/Write) 0x0004 = Comp_1 (Read) 0x0008 = reserved 0x0010 = Input **Dir+** active (Read/Write) 0x0020 = Input **Dir-** active (Read/Write) 0x0040 = Input **Ramp_0** active (Read/Write) 0x0080 = negative direction of Q-set value (Read only); signal S1 0x0100 = Input SP1 active (Read/Write) 0x0200 = Input SP2 active (Read/Write) 0x0400 = Enable active (Read only) 0x0800 = Error active (Read only) 0x1000 = Input SP3 active (Read/Write) 0x2000 = Input SP4 active (Read/Write) 0x4000 = General enabled (Read only) 0x8000 = Bus Disable Card (Read/Write)
0xC4	196	R	E sta	Internal status	---	0	0xFFFF		0x0100 = Slave Mode is active 0x0200 = Warning is detected (E.g. pressure Sensor failure in slave mode) 0x0400 = General enabled active 0x08xx = Error is detected. xx is the error/warning number 0x1000 = Q control is active 0x2000 = p (pressure) limitation is active 0x4000 = P (power) M (torque) limitation is active 0x8000 = reserved Detailed explanation of xx error/warning number: 01 = General failure 02 = Wire break at yoke angle Sensor FB1 03 = Overvoltage or short circuit at solenoid connections 04 = Wire break at pressure sensor FB2 (side A) 05 = Wire break or overload at pressure set value S1.05 06 = Wire break or overload at Q-set value S1.06 07= Wire break at pressure sensor FB2 (side B) 08 = Wire break at solenoid connections 09 = PROFIBUS/PROFINET timeout (E23) occurred 11 = Overload of current >22mA swash plate sensor FB1 12 = Overload of current >22mA pressure sensor FB2 06 = Overload of current >22mA pressure sensor FB2 (Side A) 07 = Overload of current >22mA pressure sensor S7 (Side B) 15 = Overload of current >22mA at pressure set value input S1.05 16 = Overload of current >22mA at Q-set value input S1.06 17 = Overload of current >22mA pressure sensor S1.07

ID$_{Hex}$	ID$_{dec}$	W/R	Name	Function	Unit	Min	Max	Def	Description
0xE6	230	R/W	L1.x0	Linearization curve branch 1 [0,0]	V	0	0	0	1000 == 1.000 V
0xE7	232	R/W	L1.y0	Linearization curve [0,0]	V	0	9999	0	
0xE8	232	R/W	L1.x1	Linearization curve [1,1]	V	0	9999	1250	
0xE9	233	R/W	L1.y1	Linearization curve [1,1]	V	0	9999	1250	
0xEA	234	R/W	L1.x2	Linearization curve [2,2]	V	0	9999	2500	
0xEB	235	R/W	L1.y2	Linearization curve [2,2]	V	0	9999	2500	
0xEC	236	R/W	L1.x3	Linearization curve [3,3]	V	0	9999	3750	
0xED	237	R/W	L1.y3	Linearization curve [3,3]	V	0	9999	3750	
0xEE	238	R/W	L1.x4	Linearization curve [4,4]	V	0	9999	5000	
0xEF	239	R/W	L1.y4	Linearization curve [4,4]	V	0	9999	5000	
0xF0	240	R/W	L1.x5	Linearization curve [5,5]	V	0	9999	6250	
0xF1	241	R/W	L1.y5	Linearization curve [5,5]	V	0	9999	6250	

ID_{Hex}	ID_{dec}	W/R	Name	Function	Unit	Min	Max	Def	Description
0xF2	242	R/W	L1.x6	Linearization curve [6,6]	V	0	9999	7500	
0xF3	243	R/W	L1.y6	Linearization curve [6,6]	V	0	9999	7500	
0xF4	244	R/W	L1.x7	Linearization curve [7,7]	V	0	9999	8750	
0xF5	245	R/W	L1.y7	Linearization curve [7,7]	V	0	9999	8750	
0xF6	246	R/W	L1.x8	Linearization curve [8,8]	V	0	9999	9999	
0xF7	247	R/W	L1.y8	Linearization curve [8,8]	V	9999	9999	9999	
..	..								

ID_{Hex}	ID_{dec}	W/R	Name	Function	Unit	Min	Max	Def	Description
0xF8	248	R/W	C4.01	Hysteresis for command signal Flow	---	-9999	9999	0	-1000 == -1.000 V; 1000 == 1.000 V
0xF9	249	-	-	reserved	---	---	---	---	
0xFA	250	-	-	reserved	---	---	---	---	
0xFB	251	R/W	C4.13	P-Portion KP1	V/V	0	400	0	100 == Factor 1.00
0xFC	252	R/W	C4.14	T-Portion for PT1 (to C1.16)	S	0	1000	0	100 == 1.00
0xFD	253	R/W	C4.15	Threshold <C1.13, C1.16)	V	0	9999	9999	1000 == 1.000 V
0xFE	254	R/W	C4.16	P-Portion KP2	V/V	0	400	0	100 == Factor 1.00
0xFF	255	R/W	C4.17	I-Portion	V/s	0	4000	0	1000 == 1.000
0x100	256	R/W	C4.18	D-Portion	Vs	0	400	0	100 == 1.00
0x101	257	R/W	C4.19	T-Portion for DT1	S	0	1000	0	100 == 1.00
0x102	258	R/W	C4.20	Gain (C4.13 and C4.16)	V/V	1	32	1	2 = Factor 2.00

Table 10: Parameter list

10 Declaration of Conformity

EC Declaration of Conformity in accordance with EMC Directive 2014/30/EU

HCS Hydraulic Control Systems GmbH
Neuffener Str. 29
D-72636 Frickenhausen

Hereby declares that the product described as follows complies in terms of its design, as well as in the version placed in the stream of commerce by us, with the relevant requirements of the directive. This declaration is void in the event of any change to the product without our written agreement.

Product:	Digital Amplifier and Controller Card
Intended use	Automation systems (industrial applications)
Model:	**DAC-4x(A)-x**
Rated voltage:	24 V DC; SELV, PELV
Rated power:	max. 100 VA
Protection class:	III
Protection degree:	IP00 (IP20 on request)
Relevant EU Directive:	EMC Directive 2014/30/EU
Applicable EU Standards:	
Emissions:	EN 61000-6-4:2007 + A1:2011; EN 61000-6-3:2007 + A1:2011
Immunity:	EN 61000-6-2: 2019

Date/manufacturers signature

01.01.2026
Details of signatory: Dipl.-Ing. (FH) Peter Deuschle (General Manager)

Figure 17 : Declaration of conformity

- End -