Manual for

DAC-4x(A)-LVDT

DIGITAL AMPLIFIER AND CONTROLLER CARD FOR ALL KIND OF PROPORTIONAL VALVES

	Model Code	SW Version	Remarks
Applicable for SW Versions:	One LVDT 3 wire feedback input • DAC-4x(A)-x-SLVDT-1X-3W One LVDT 4 wire feedback input • DAC-4x(A)-x-SLVDT-1X-4W Operation Mode: 3,4,6	**V 21.xx**	xx = 01 or higher * = a, b, …. x = additional options
	Two LVDT 3 wire feedback inputs • DAC-4x(A)-x-SLVDT-2X-3W Two LVDT 4 wire feedback inputs • DAC-4x(A)-x-SLVDT-2X-4W Operation Mode: 6	**V 20.xx**	

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Revision History

Revision	Date	Author	Description
1.0	14.02.2024	Bm	First finalized release,
1.0	20.02.2024	Bm	Wire diagrams revised, some few texts modification
1.0	25.06.2024	Bm	Few corrections
1.0	04.10.2024	Bm	Additional explanation page 25
1.0	12.11.2025	Bm	4 wire sensor types A and B added

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	**m**eters **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

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
USB-C connector	Connector type used on the USB interface
LVDT	Linear variable differential transformer

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)” in addition of using the LVDT feedback input.

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 have to be observed in any case!

Electronic equipment of all kind can have component failures or software may lead to unpredictable reactions. Secondary safety measures must be taken in order 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 have to 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’s 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
«ER»	LEDs of the amplifier (for example, «ER»
< >	parameter name
[xx]	Pin number of the rear connector
"…"	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 have to 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. In order 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)” are used for the following applications:

- Controlling of proportional valves (namely directional control valves); with or without feedback (depending of operation mode).
- To convert set point signals into a current signal to control one proportional valve and spool position feedback in the aforementioned valves.
- 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)” 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 "4.4 Model code", page 16

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:

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.

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) 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) 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

3.9 General Applications

The amplifier card DAC-4x(A) is used for:

- With or without electrical feedback transducers
  - proportional directional valves direct and pilot operated
  - proportional flow control valves
  - proportional pressure reducing valves
  - proportional pressure regulating valves

  - cartridge valves
  - servo valves with torque motors
- Controlling of hydraulic motors, - installations and – systems, e.g.:
  - position
  - speed
  - pressure
  - revolutions per minute
  - torque
  - power etc.
- Volume flow control and pressure control of pumps (if the occasion arrives: power limiting function; controlling valve spool position)
- Controlling of different process values:
  - P/Q controlling
  - pump controlling
  - controlling of pressures
  - controlling of pilot- and main stage
  - cascade controlling of components etc.

4 Product overview and description

4.1 Technical features

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

- One differential command input (set point). Range of 0 ± 10 V respectively 0 or 4 ... 20 mA, resolution 16-bit.
- Two single ended command point inputs. Range of 0 ± 10 V respectively 0 or 4 ... 20 mA, resolution 16-bit.
- Two single ended feedback inputs. For current and voltage. Wide range of adjustability, resolution 16-bit.
- Two optional inputs for LVDT signals. 1 or 2 inputs with optional extension board; information on request.
- Integrated reference voltage supply of ± 10 V (10 mA max.), to supply set point potentiometer or actual value transducer.
- 4 (optional 5) recallable digital adjustable set points.
- Direction externally set through “+“ and “-“ inputs.
- Enable signal for output stages.
- Reset-Ramp for fast ramp function zeroing.
- Status outputs "error“ and "comparator“.
- All digital inputs and outputs are optically isolated for functional security.
- Display with four 7-segment indications and six keys for easy handling and operation.
- Function indication through front panel by LEDs.
- Additional switching output (24 V, max 1A) to directly disable safety valves.
- 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 (2 mm) for easy commissioning. Test jacks for set point (SET)*1, for feedback 1 (FB1), for solenoid currents (A) and (B) and monitor input (MON) display for analog display of all parameters
  (± 10 V, 12-bit resolution).
- USB interface with USB-C connector
- Serial interface RS232 (instead of USB_C interface; optional on request)

4.2 Technical data

4.2.1 General technical data

Feature	Range, characteristics
Supply voltage and Control voltage for digital inputs	12 V DC - 10 % … 24 V DC + 20 %; residual ripple < 10 % (max. 50 VA power draw) current draw per input < 20 mA
Solenoid system selection	0.8 A; 1.1 A; 1.3 A; 1.6 A; 2.4 A; 2.7 A and 3.5 A (intermediate values adjustable) Servo valve current ranges available on request!
Ambiant operating temperature	- 40 °C to + 70 °C
Storage temperature	- 45 °C … 85 ° C
Humidity (relative air humidity)	max. 95 % non condensing
Max. elevation	2,000 m (mamsl)
Class of protection	IP20 when installed in 19" rack system
Connector	In accordance with DIN 41612, 48 pol form F gold plated
EMC	In accordance with the applicable industrial standards (CE - conformity) *3
Dimensions front panel / PCB	50,5 x 128,4 mm; 10TE / 3 HE; 100 x 160 mm euro format
Analogue set values inputs	3 inputs with 16 Bit resolution (1 x differential; 2 x single ended; 0 … +-10 V, 0/4 … 20 mA)
Analogue feedback U/I	2 inputs with 16 Bit resolution (current and voltage with wide range of adjustability)
Analogue feedback LVDT *2	1 or 2 inputs with optional extension board; detailled information on request
Digital inputs	8 inputs (S1.01 … S1.04, ENABLE, RAMP 0, DIRECTION +, DIRECTION -)
Solenoid current (output)	2 PWM output stages, each for up to 3,5 A (with over-energ. and quick de-energization)
Analogue output	1 output with 12 Bit resolution, 0 … +-10 V or 4 ... 20 mA (selectable)
Monitor output	1 output with 12 Bit resolution, 0 … +-10 V
Digital outputs	2 outputs, voltage level 0 V / 24 V, 10 mA (ERROR, COMPARATOR)
Test jacks at front *2	Current A and B, sensor 1 (Fb1) set value (S1.06), Monitor and GND
Auxiliary reference voltage	+- 10 V, max. output 10 mA
Optional digital I/O signals	3 for variable usage, voltage level 24 V or 5 V
Interface 1	USB-C or (optional) RS232, 9-pol SUB-D-conncetor at face plate
Optional interface 2 *2	PROFIBUS DP; PROFNET; other bus interfaces on request
Display and keypad *2	4-digit 7-segment display, 6 keys, status LED's
PWM frequency	22.2 kHz - independant from dither frequency (customer specific frequencies available)
Cycle times	Closed loop 1 and 2: 0.1 msec

Table 4: General Technical Data

Detailed electrical information:

See □ Chapter "9 Detailed electrical data", page 50

4.3 The LVDT principle

A LVDT (Linear Variable Differential Transformer) is an analogue sensor for position measuring. Used in order to determine a position, for example in hydraulic or pneumatic cylinders and also in proportional or servo valves or hydraulic pumps.
Depending on the application up to two LVDT can be used at one DAC-4x(A). The additional add-on board processes the signal from the sensor and passes on the measured values to the DAC-4x(A) main board. The add-on board has its own CPU and software tailored to the respective sensor type. This board is parameterized via the main board of the DAC-4x(A).

⚠ CAUTION

Please note that the hardware and software of the additional board are compatible with the intended LVDT configuration! Otherwise, proper position measurement may not be possible.

4.3.1.1 3-wire LVDT

In case of a 3-wire sensor the system has a primary coil with middle connection. A linear movement is converted into an electrical signal and digitally acquired. The digital system used in this case records the step function and based on this the actual position is calculated.
A ferromagnetic core is moved inside of the coil-system and changes the inductance of the system which is measured and used in the LVDT-software for the position calculation.
For the correct connection of the 3-wire LVDT sensor:

See □ Chapter "0

⚠ WARNING

Please note that not only the electrical data must match for the sensor to function, but also the internal structure. If the calibration cycle is completed correctly, the sensor will function fully.

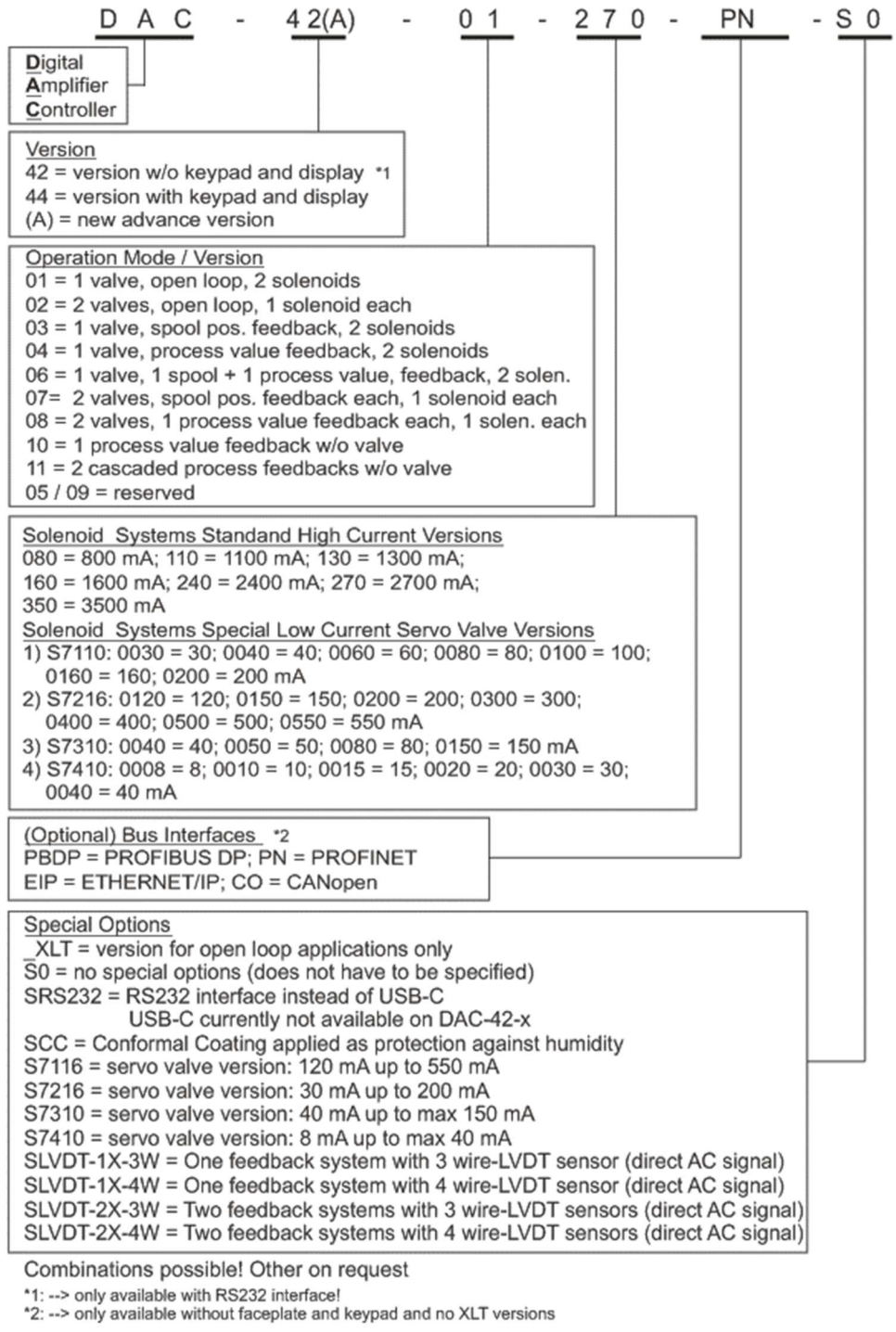
Connection of 3- wire LVDT sensors, model code ….-SLVDT-3W", page 24

4.3.1.2 4-wire LVDT

Inside the system consists of coils. In case of the 4-wire LVDT it consists of a primary and two secondary coils. The measuring principle is basically comparable to the 3-wire principle. The two coils must be connected to each other in such a way that the signals can be evaluated via the add-on board.
For the correct connection of the 4-wire LVDT sensor:

See □ Chapter "5.5.2 Connection of 4- wire LVDT sensors, model code ….-SLVDT-4W", page 25

4.4 Model code



Model examples:

Version with display for one valve with
2.7 A solenoids closed loop operation
in mode 6, one 3-wire LVDT feedback.
With USB-C interface:

DAC-44(A)-06-270-SLVDT-1X-3W

Figure 1 : Model code

Remark: Servo valve versions are covered in a separate manual

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-44(A) versions only).
- The amplifier card should be mounted in a shielded environment (e.g. control cabinet).
- The amplifier card module has to 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 an 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 2 : 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)

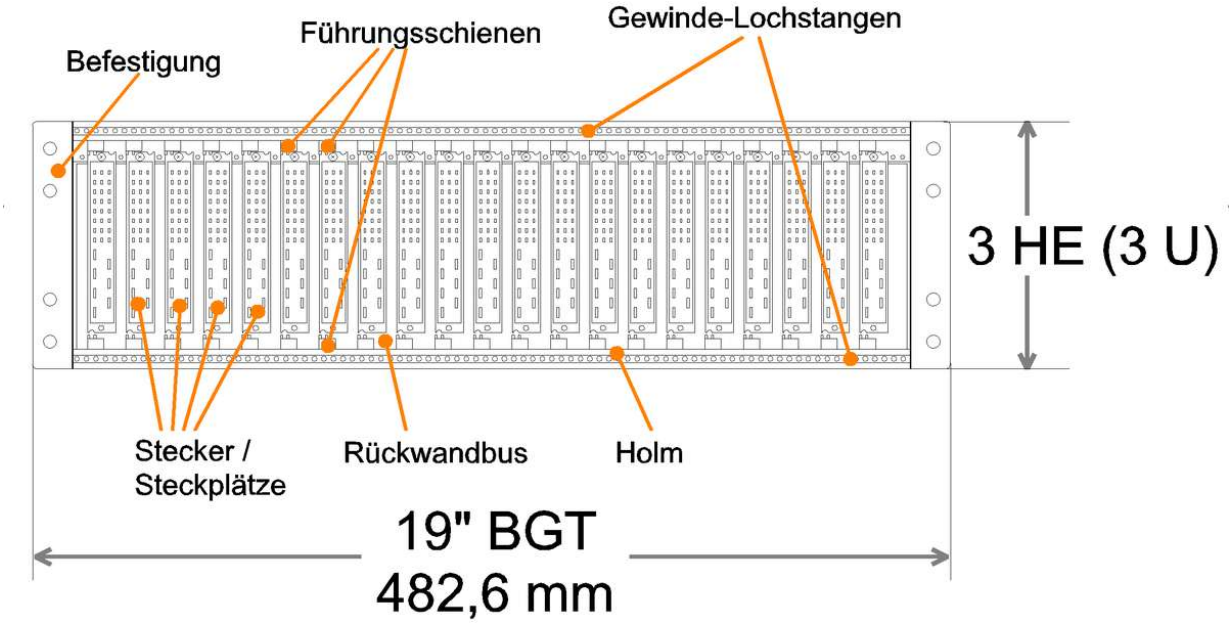


Figure 3 : General example for 19” Rack systems 3 HE

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 have to 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 5: 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 has to be 1.5 mm 2 and 2.5 mm 2 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. have to 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 mm ^{2} 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:

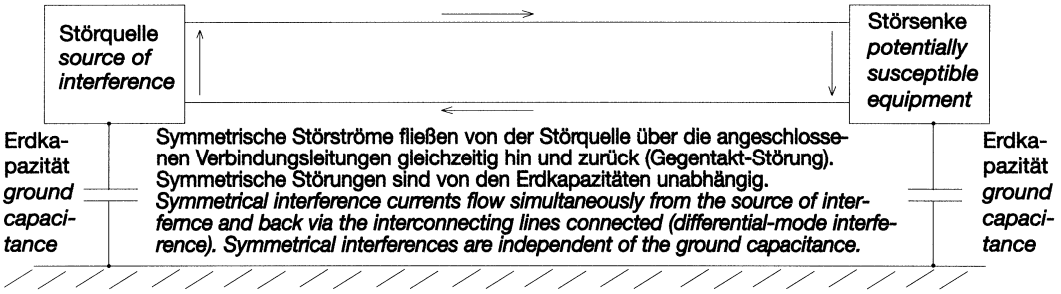
- The most important types of interference and their remedies
- Construction of EMC suitable electric cabinets and systems

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

NKL GmbH
Birckichstr. 15
D-74549 Wolpertshausen

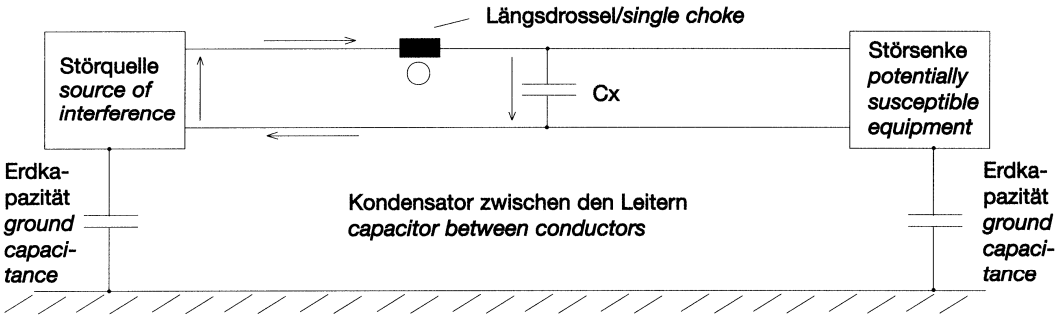
Die wichtigsten Arten von Störungen und Abhilfen:
The most important types of interference and remedies:

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 interfernces 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 4 : EMC – interferences and remedies

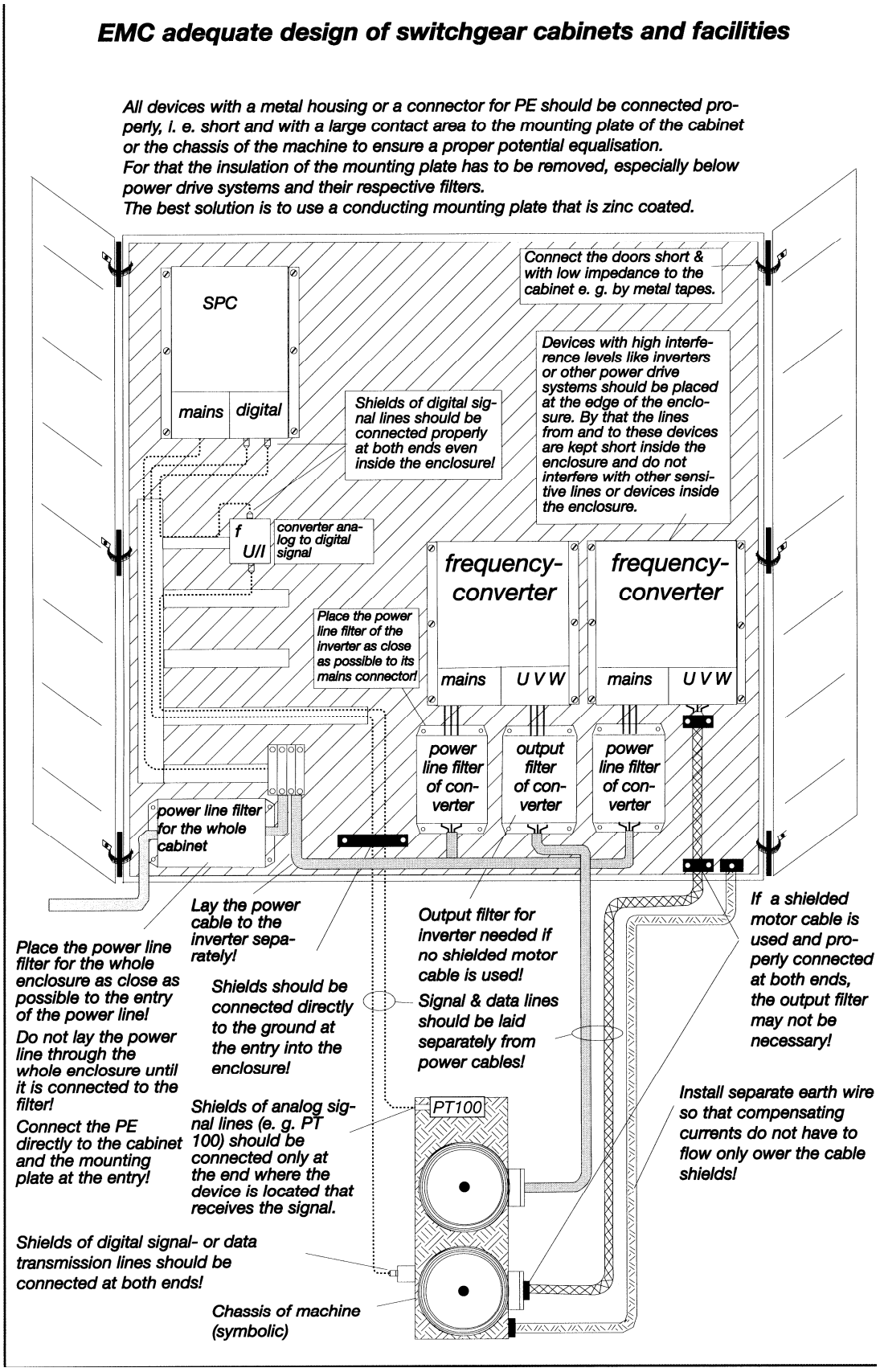


Figure 5 : EMC – adequate design of switchgear cabinets and facilities

5.3 Terminal assignment X13 (back connector)

Pin	d	b	Z
2	0 V (External)	LVDT_1-Out	LVDT_2-In 2)
4	Digital set value 2 (S1.02)	LVDT_1-In	LVDT_2-GND 2)
6	Digital set value 3 (S1.03)	LVDT_1-GND	LVDT_2-Out 2)
8	ENABLE (DI 1)	Analog input 1 (Option)	Digital set value 1 (S1.01)
10	Sensor (FB 1) U_E, I_E 1)	Analog output	n/c
12	Analog set value 6 U_{E+} (S1.06)	n/c	Analog set value 5 U_{E+} (S1.05)
14	ERROR (DO 1)	COMPARATOR (DO 2)	(FB 2) Not used.
16	Analog set value 6 U_{E-} (S1.06)	Analog input 2 (Option)	Analog set value 7 I_E (S1.07)
18	Digital GND	PE	Reset Ramp (DI 2)
20	Reference output - 10.0 V	Break output 24 V / 1 A	Reference output + 10.0V
22	Solenoid output A -	Solenoid output A -	Solenoid output A -
24	Solenoid output B -	Solenoid output B -	Solenoid output B -
26	0 V (Power)	0 V (Power)	Analog GND
28	Solenoid output A +	Solenoid output A +	Solenoid output A +
30	Solenoid output B +	Solenoid output B +	Solenoid output B +
32	+ 24 V (Power)	+ 24 V (Power)	24 V (External)

1) To ensure compatibility with the old DAC-4X(A) software versions, the feedback FB2 is mapped to the connection pin of FB1.
2) If Hardware Version …-SLVDT-2X is used (Two LVDT sensors)

Table 6: Terminal assignment

5.4 Picture of rear connector

Connector: IEC 60603-2 form F 48 pins

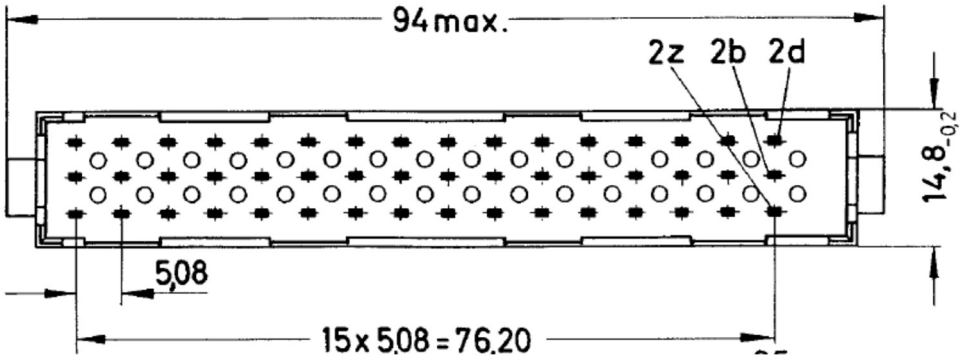


Figure 6 : X13 Connector F48

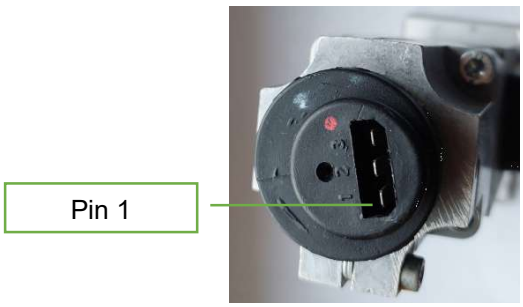
5.5 Connection LVDT

⚠ WARNING

Please note that not only the electrical data must match for the sensor to function, but also the internal structure. If the calibration cycle is completed correctly, the sensor will function fully.

5.5.1 Connection of 3- wire LVDT sensors, model code ….-SLVDT-3W

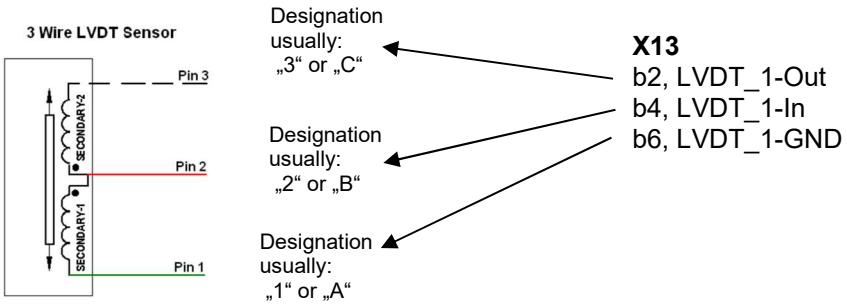
The inductance and the resistance of the internal coils should be in the range:
Single coil inductance: 2..8 mH @ 1Khz
Single coil resistance: 8.. 20 Ohm DC



Picture 7: Example of 3-wire sensor

Terminal 1 and 3 of the LVDT can be connected in reverse order!
The pin designation on the sensor may vary

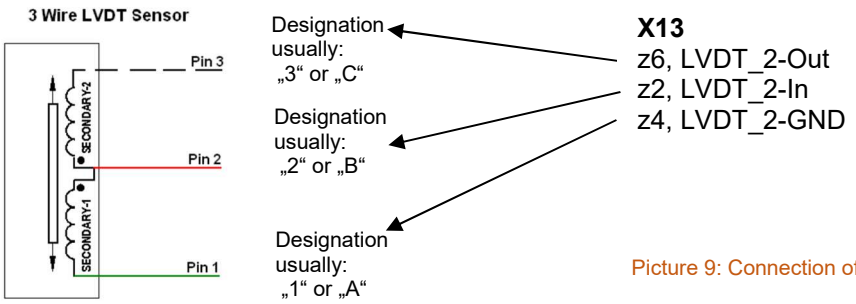
5.5.1.1 Connection at X13 (back connector) for LVDT sensor 1



Picture 8: Connection of 3-wire sensor (sensor 1)

5.5.1.2 Connection at X13 (back connector) for LVDT sensor 2

Please note that the pin number on X13 doesn’t match that of sensor 1



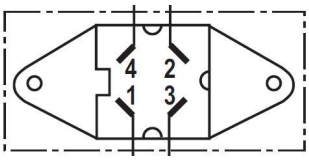
^

Picture 9: Connection of 3-wire sensor (sensor 2)

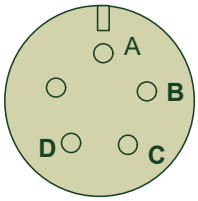
5.5.2 Connection of 4- wire LVDT sensors, model code ….-SLVDT-4W

On this page, the connection of the 4-wire LVDT sensor is explained. Please note that for the 4-wire sensor, two of the wires must be combined in a specific way so that the sensor can be connected to our LVDT measurement system. Additionally, the electronics for sensor evaluation must be factory-configured to accommodate this specific connection. This is why there is a different order code for the 3-wire and 4-wire versions.

Examples of connector types



Picture 10: Example 4-wire sensor connector



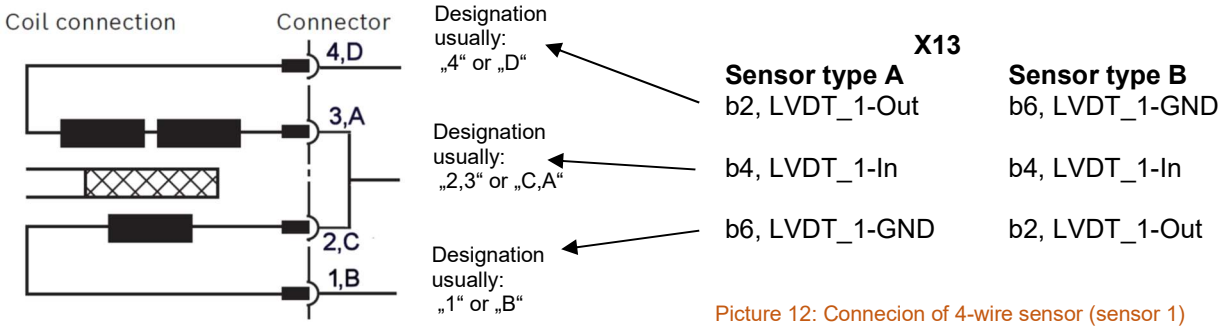
Picture 11: Example 4-wire sensor connector 7-pin DIN (M16)

The inductance and the resistance of the internal coils should be in the range:

- Sensor types A:
  E.g.
  Inductance 3,4 or A,D: 0.4 .. 23 mH @ 1Khz
  Resistance 3,4 or A,D : 30 .. 120 Ohm DC
  Inductance 1,2 or B,C 2 .. 46 mH @ 1Khz
  Resistance 1,2 or B,C 60 .. 180 Ohm DC
  Tested sensor types Bosch-Rexroth type (R900724225), Messotron DPH50
- Sensor types B:
  E.g. Bosch-Rexroth type (R902422162, R9025411632)
  Inductance 3,4 or A,D: 30 mH @ 1Khz
  Resistance 3,4 or A,D : >500 Ohm DC
  Inductance 1,2 or B,C ca. 14 mH @ 1Khz
  Resistance 1,2 or B,C ca. 114 Ohm DC

The connection to connector X13 may vary depending on the internal architecture of the sensor. Owing to design differences between sensor variants, the pin assignments of connector X13 are not identical for all models. The following connection diagrams provide recommended wiring configurations according to the respective sensor type in use.

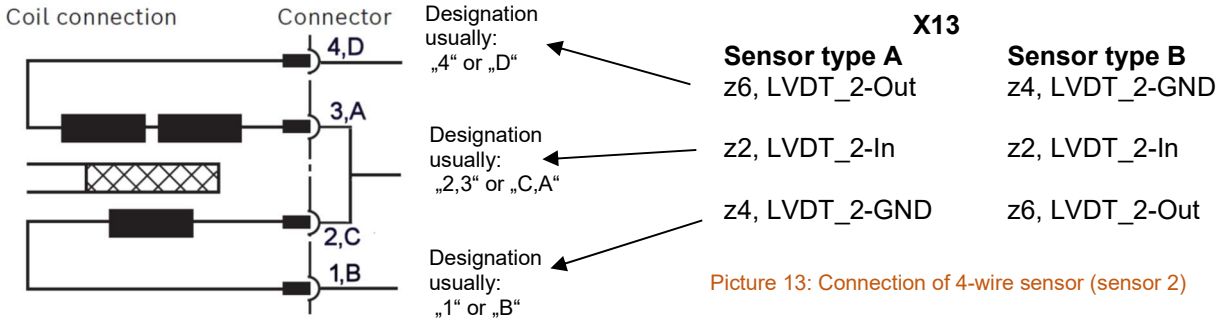
5.5.2.1 Connection at X13 (back connector) for LVDT sensor 1 (sensor type A.B)



Picture 12: Connecion of 4-wire sensor (sensor 1)

5.5.2.2 Connection at X13 (back connector) for LVDT sensor 2 (sensor type A)

Please note that the pin number on X13 doesn't match that of sensor 1



Picture 13: Connection of 4-wire sensor (sensor 2)

5.6 Wiring diagrams for all operation modes

5.6.1 Wiring diagram for operation mode 03, …-SLVDT-1W

Closed loop, 1 proportional valve with 2 solenoids and LVDT spool position feedback

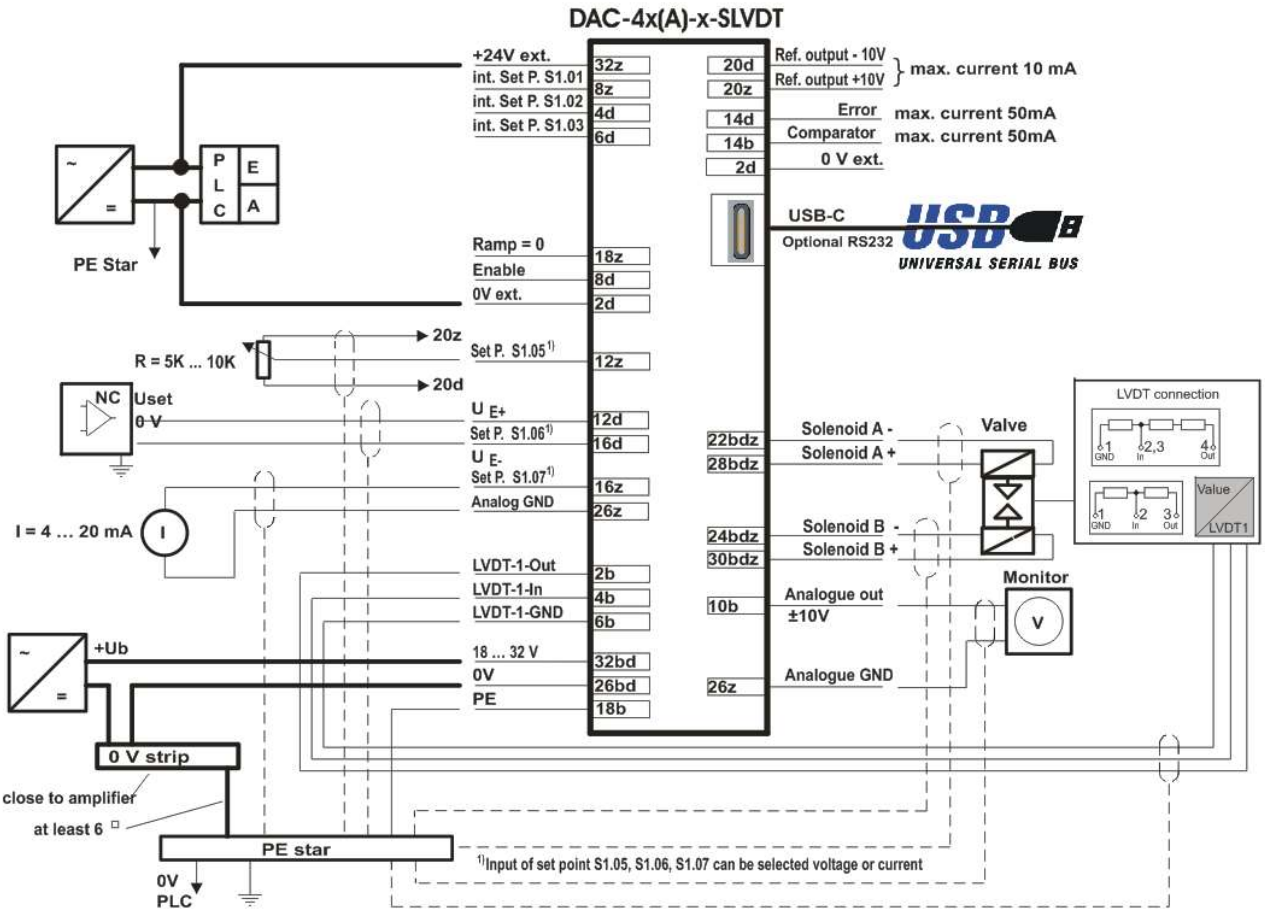


Figure 14 : Wiring diagram Mode 03

5.6.2 *Wiring diagram for operation mode 04, …-SLVDT-1W*

Closed loop double, 1 proportional valve with 2 solenoids and LVDT feedback of a process value

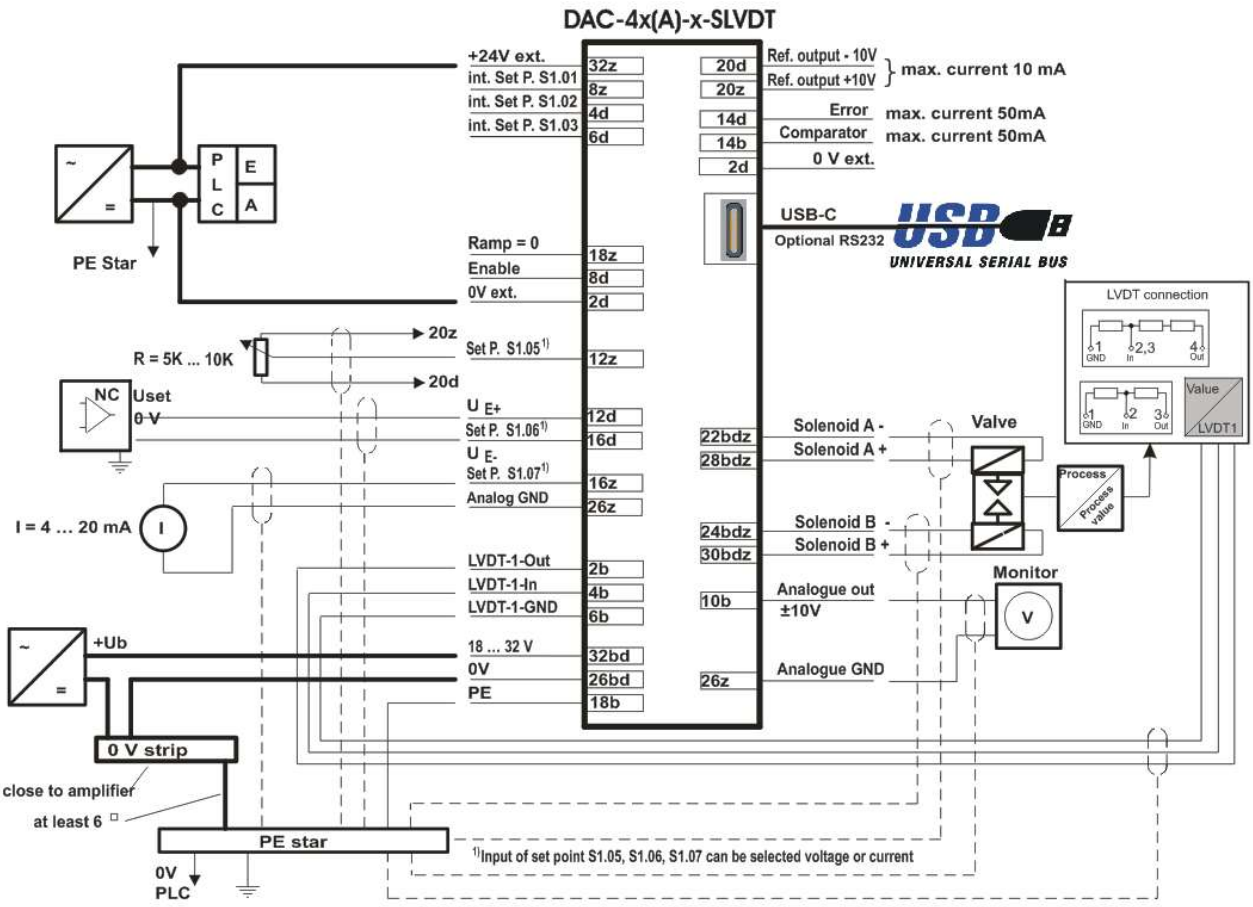


Figure 15 : Wiring diagram Mode 04

5.6.3 *Wiring diagram for operation mode 06 …-SLVDT-1X (one LVDT, one U/I sensor)*

Closed loop double, 1 proportional valve with 2 solenoids and LVDT spool position and U/I process value feedback

Please note that the position of parameter E 20 determines the assignment of the feedback inputs.

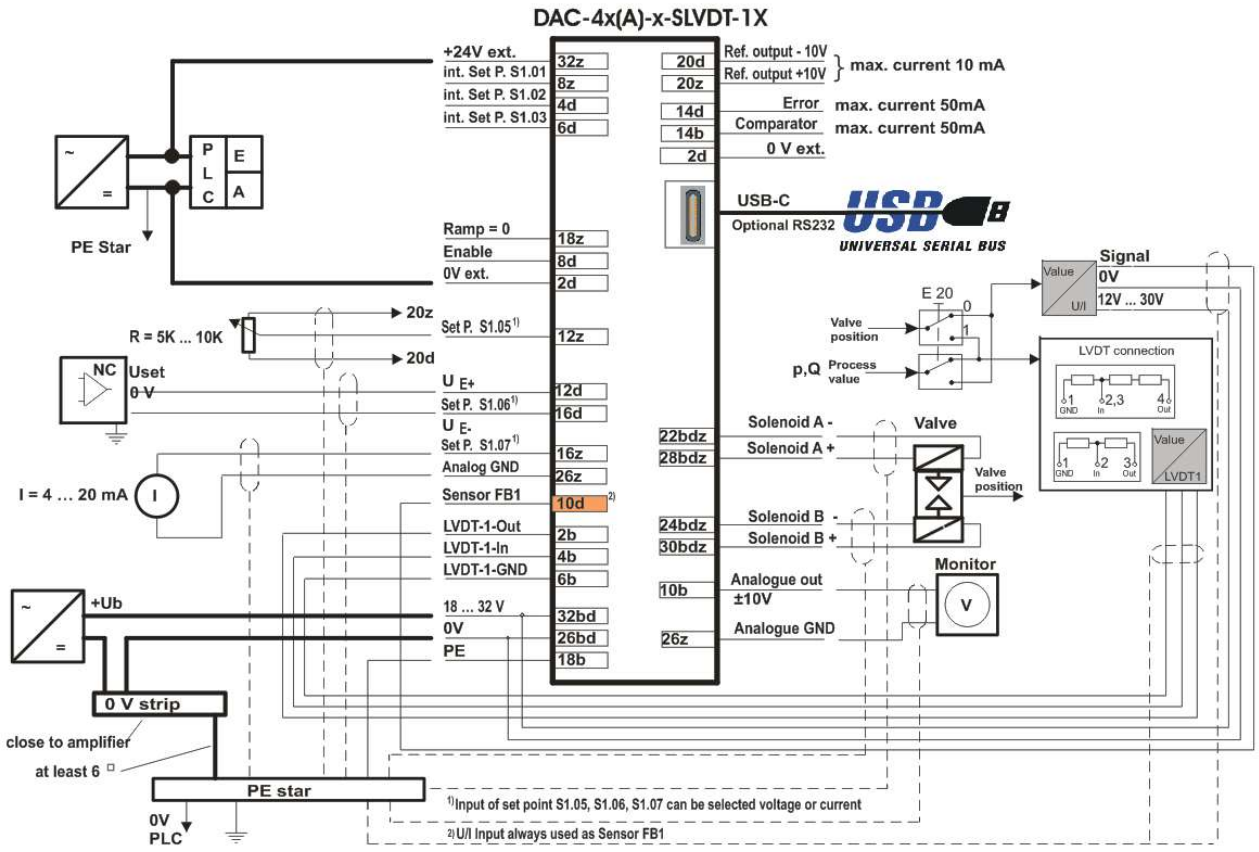


Figure 16 : Wiring diagram Mode 06 with one LVDT sensors

5.6.4 *Wiring diagram for operation mode 06 …-SLVDT-2X (two LVDT sensors)*

Closed loop double, 1 proportional valve with 2 solenoids and LVDT spool position and LVDT process value feedback

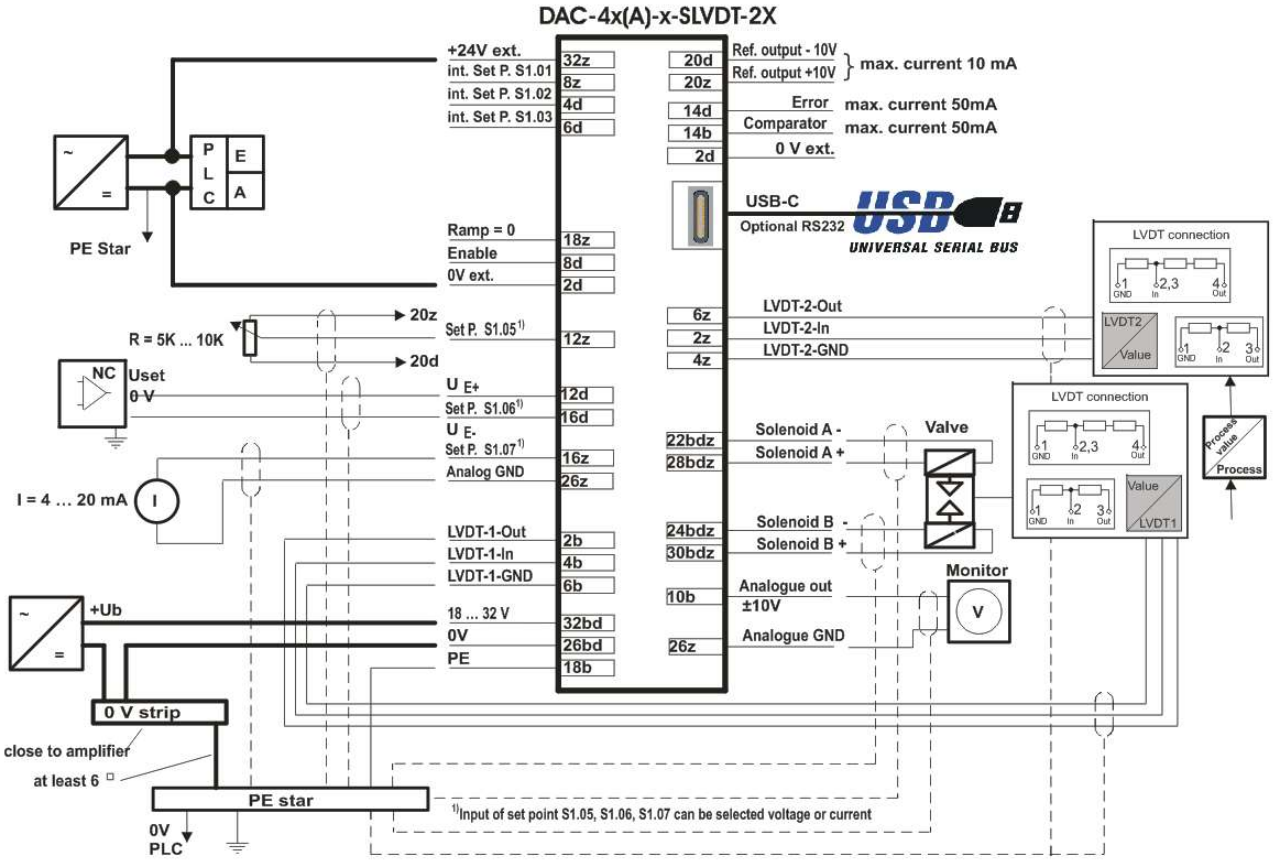


Figure 17 : Wiring diagram Mode 06 with two LVDT sensors

5.6.5 Commissioning

5.7 Front elements

⚠ 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.

5.7.1 DAC-44(A)

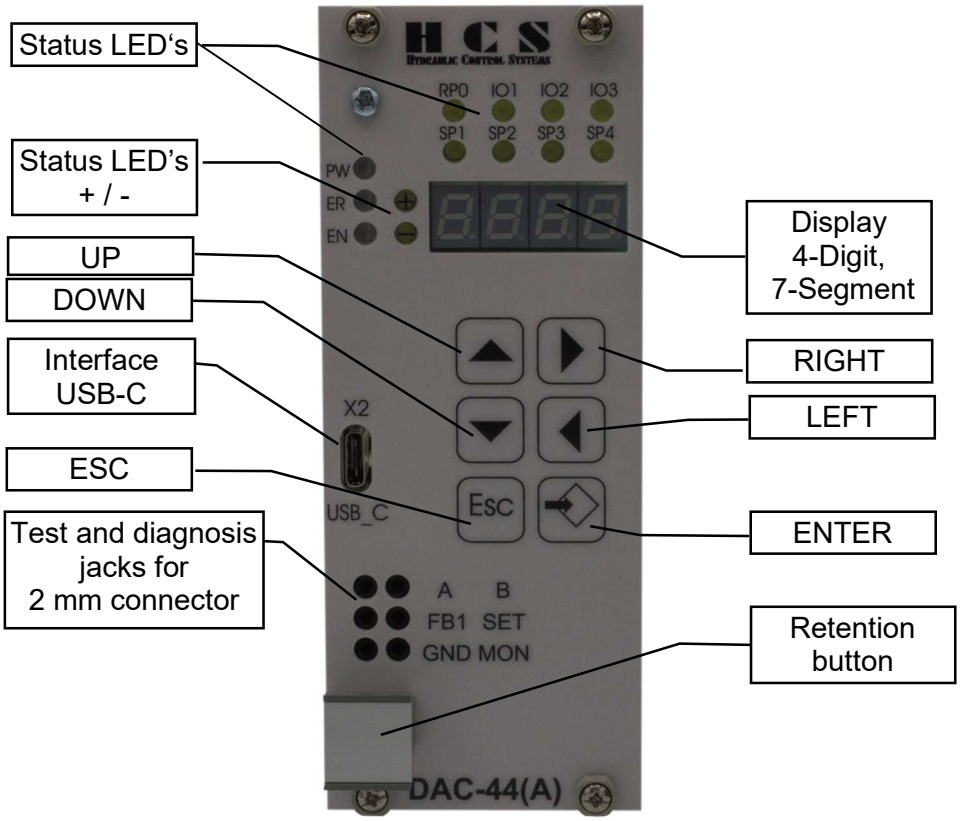


Figure 18 : DAC-44 Front elements DAC-44(A)

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
USB-C interface	Trough which programing and accessing parameters via PC and HCSTool is been 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 7: Front elements DAC-44 explanation

5.8 Operation modes

The setting of parameter <E00> is determining which operation mode is activated. This parameter is factory preset!
Only the mode relevant parameters are made available for each of the modes.

Available operation modes:

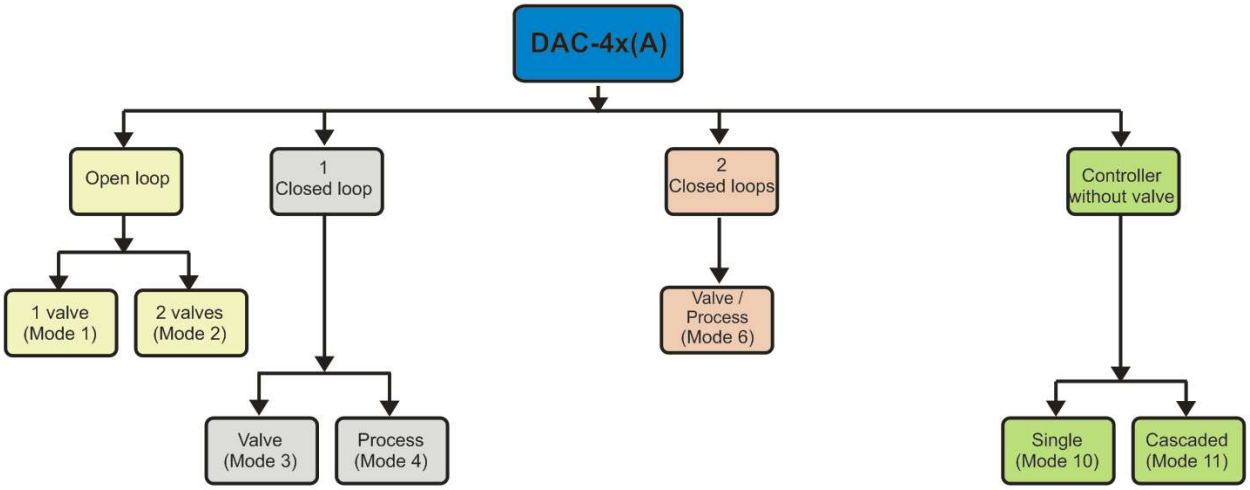


Figure 19 : Available Operation Modes

With the use of parameter <E00> any basic mode of operation may be selected. A change in operation modes will be effective immediately. Recalling the parameters for the newly chosen mode takes only a few seconds. During this time, the display flashes. Only the mode relevant parameter are made available.

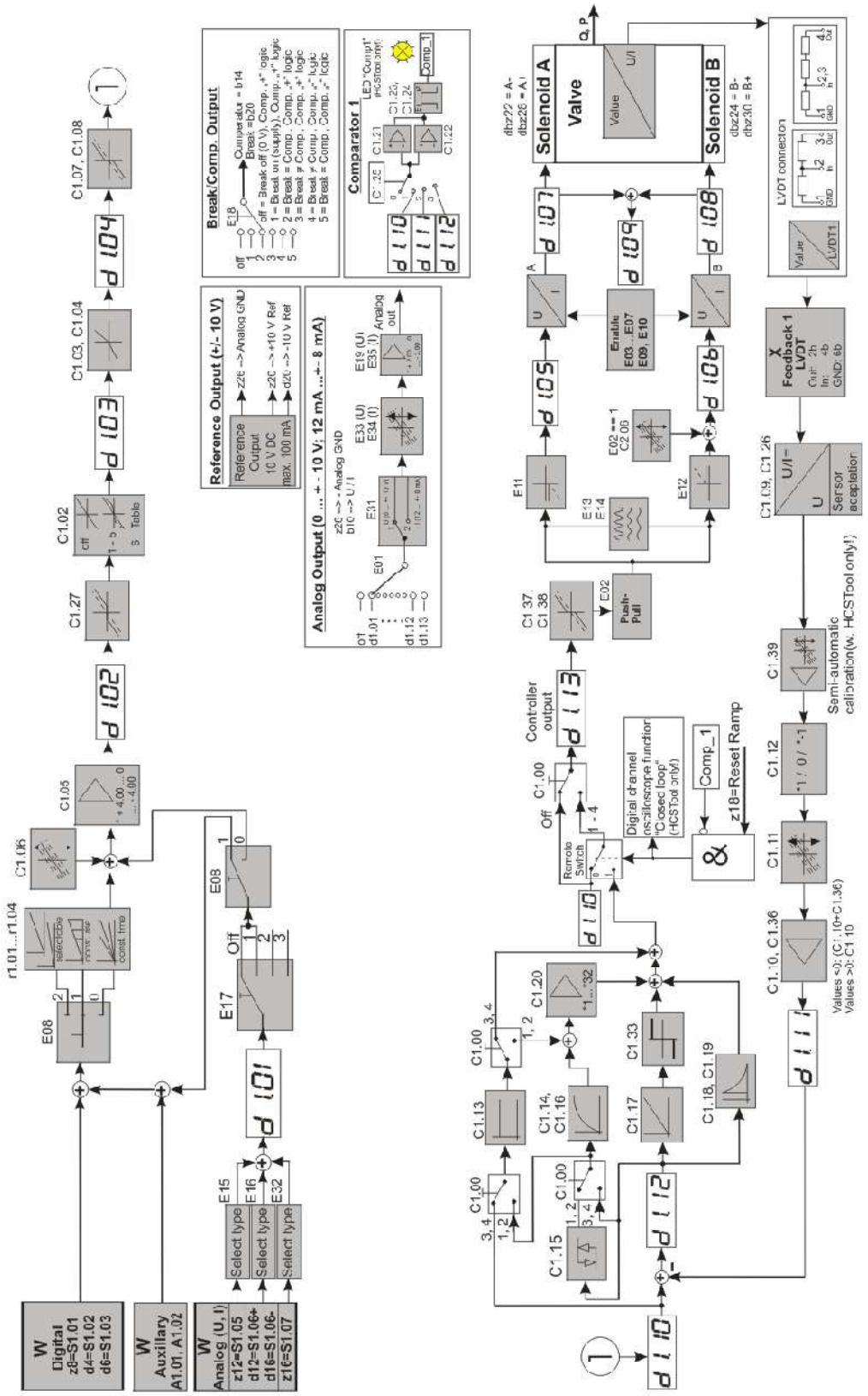
<E00>	Mode description
1	Open loop, 1 proportional valve with 2 solenoids without feedback
2	Open loop, 2 proportional valves with 1 solenoid each without feedback
3	Closed loop valve, single, 1 proportional valve with 2 solenoids and feedback of spool position
4	Closed loop process, single, 1 proportional valve with 2 solenoids and feedback of process value (position, velocity, pressure, force, torque etc.)
5	Reserved
6	Closed loop valve and process, double, 1 proportional valve with 2 solenoids and feedback of spool position and additional feedback of process value (cascaded controller)
7	Reserved
8	Reserved
9	Reserved
10	Controller function without valve, control of 1 process value; provide set value to follow up electronics (e.g. valve with integrated electronics, frequency converter for AC motor etc.)
11	Controller function without valve, control of 2 process values (cascaded controller, e.g. position and velocity controller); provide set value to follow up electronics (e.g. valve with integrated electronics, frequency converter for AC motor etc.)

Table 8: Operation modes

5.9 Software block diagrams

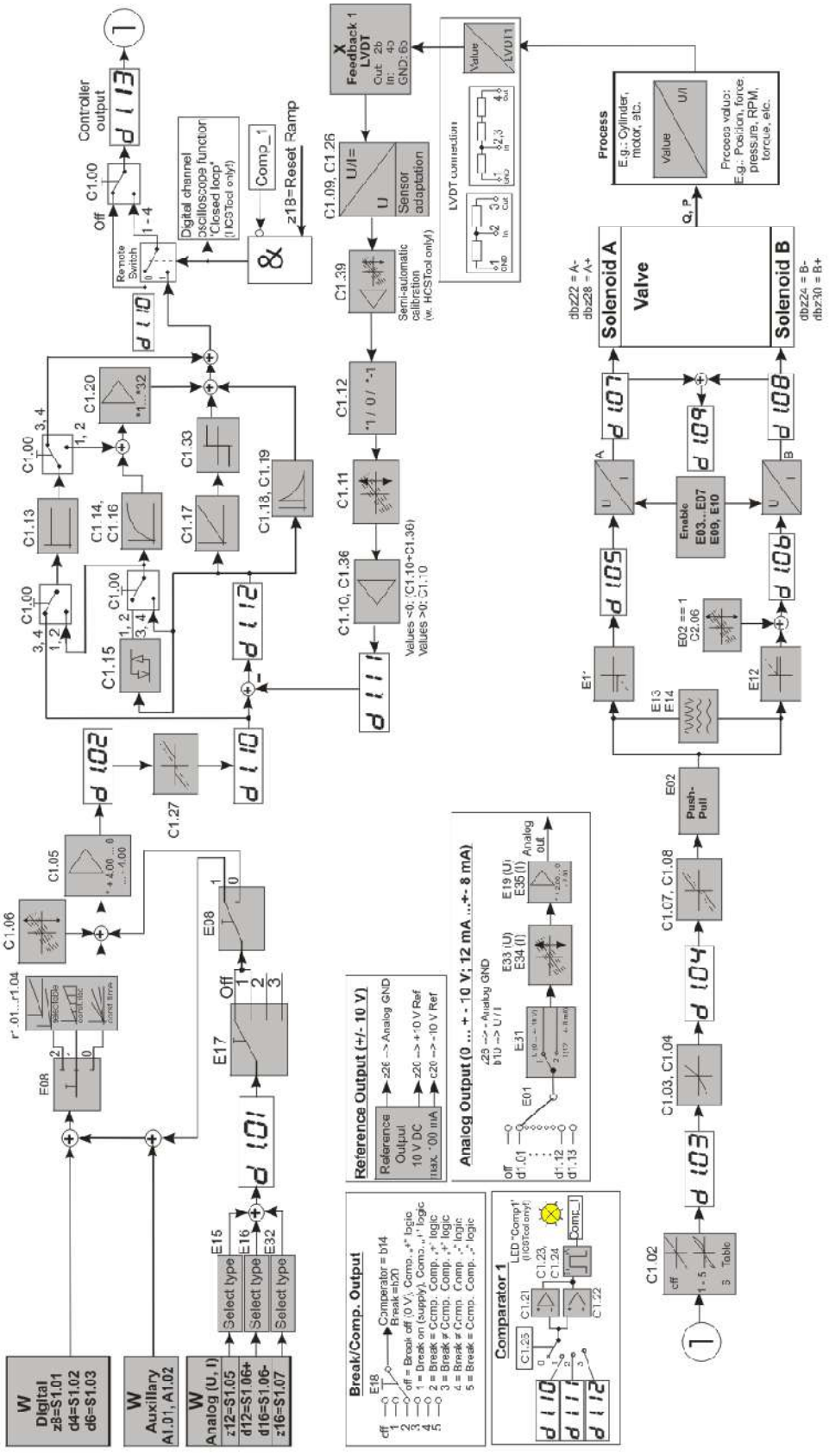
5.9.1 Operation Mode 03; …-SLVDT-1W

1 valve with 2 solenoids and LVDT spool position feedback



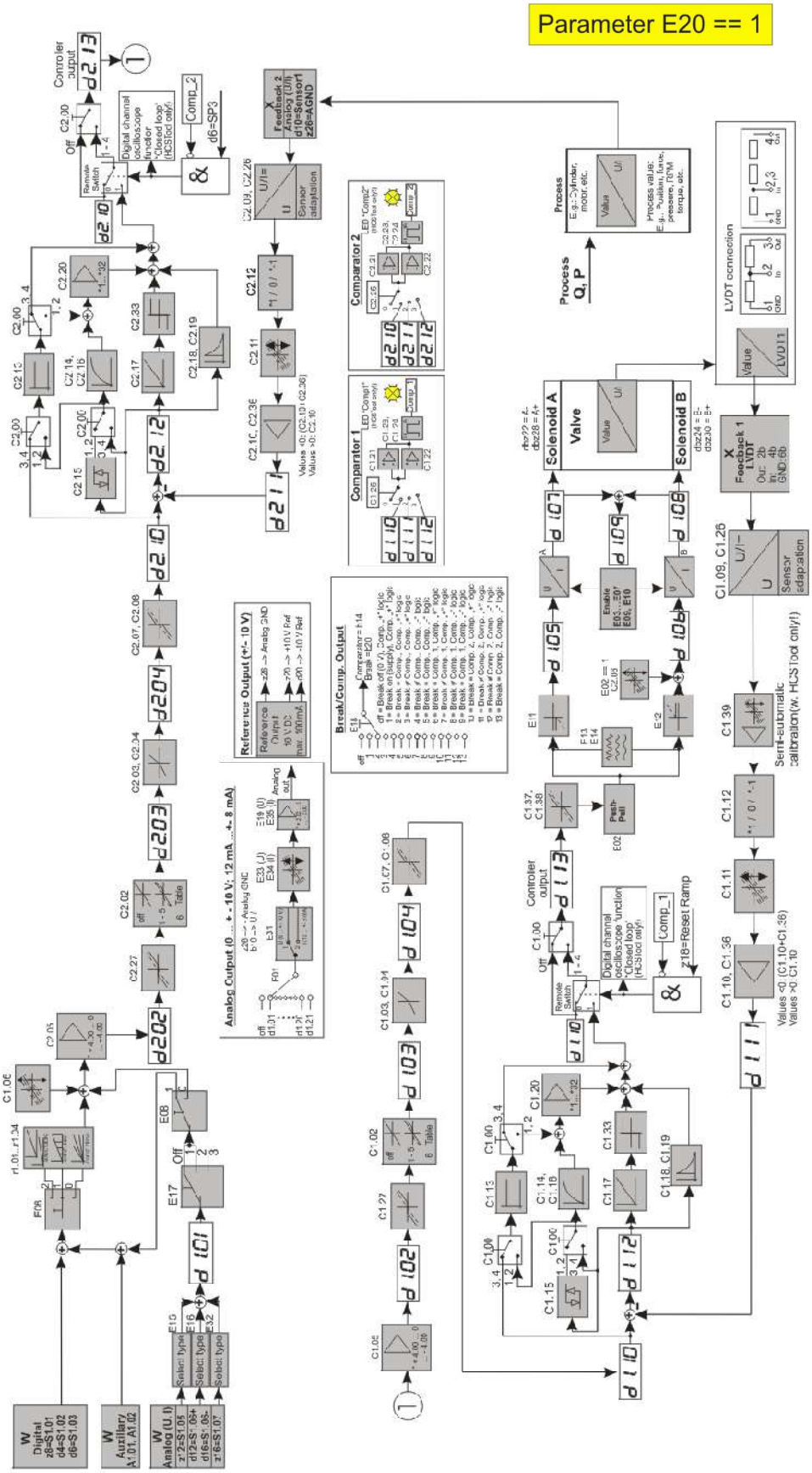
5.9.2 *Operation Mode 04; …-SLVDT-1W*

1 valve with 2 solenoids and LVDT process value feedback



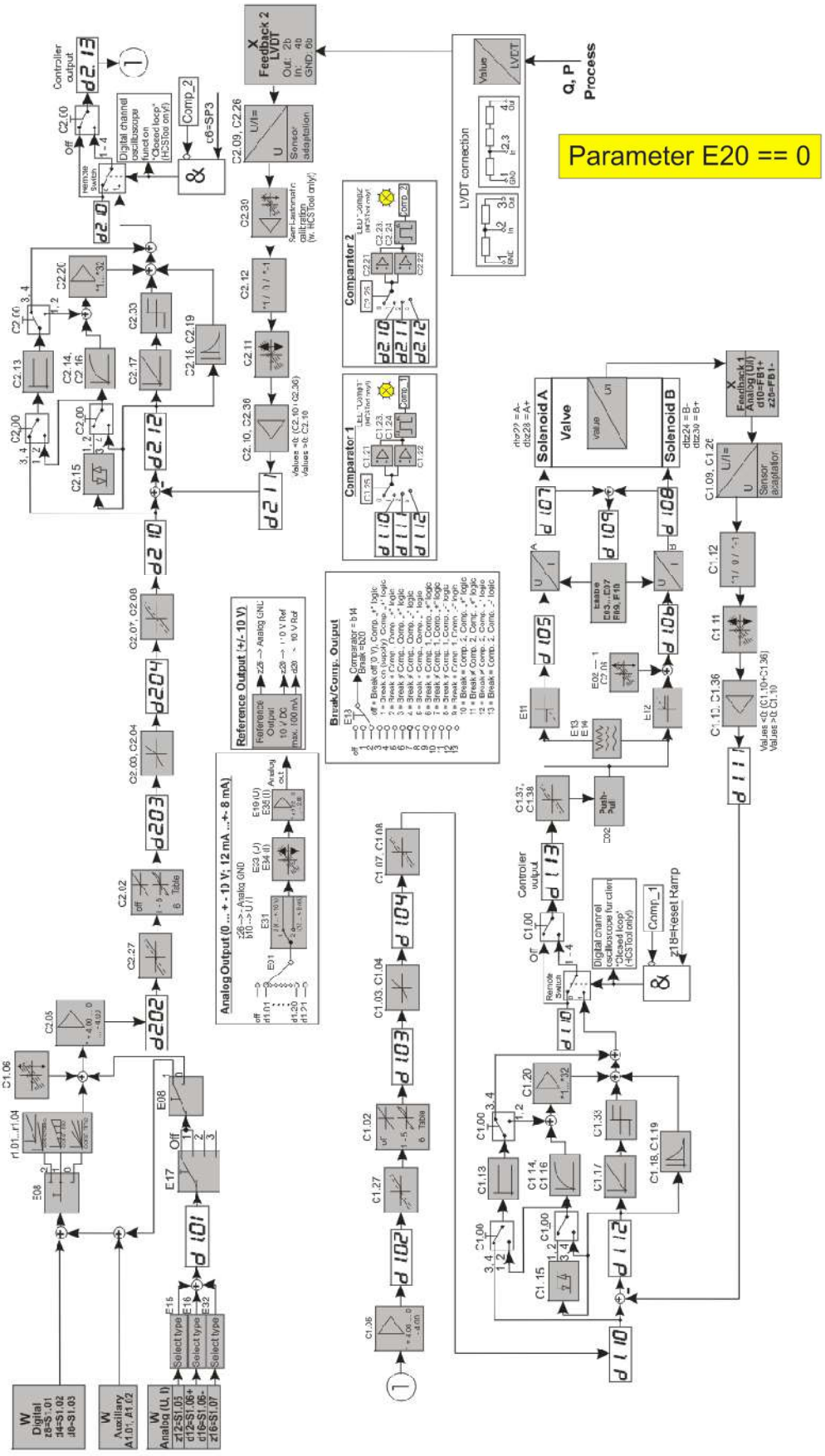
5.9.3 Operation Mode 06 …-SLVDT-1W, E20 == 1

1 valve with 2 solenoids LVDT spool position feedback and U/ I process value feedback



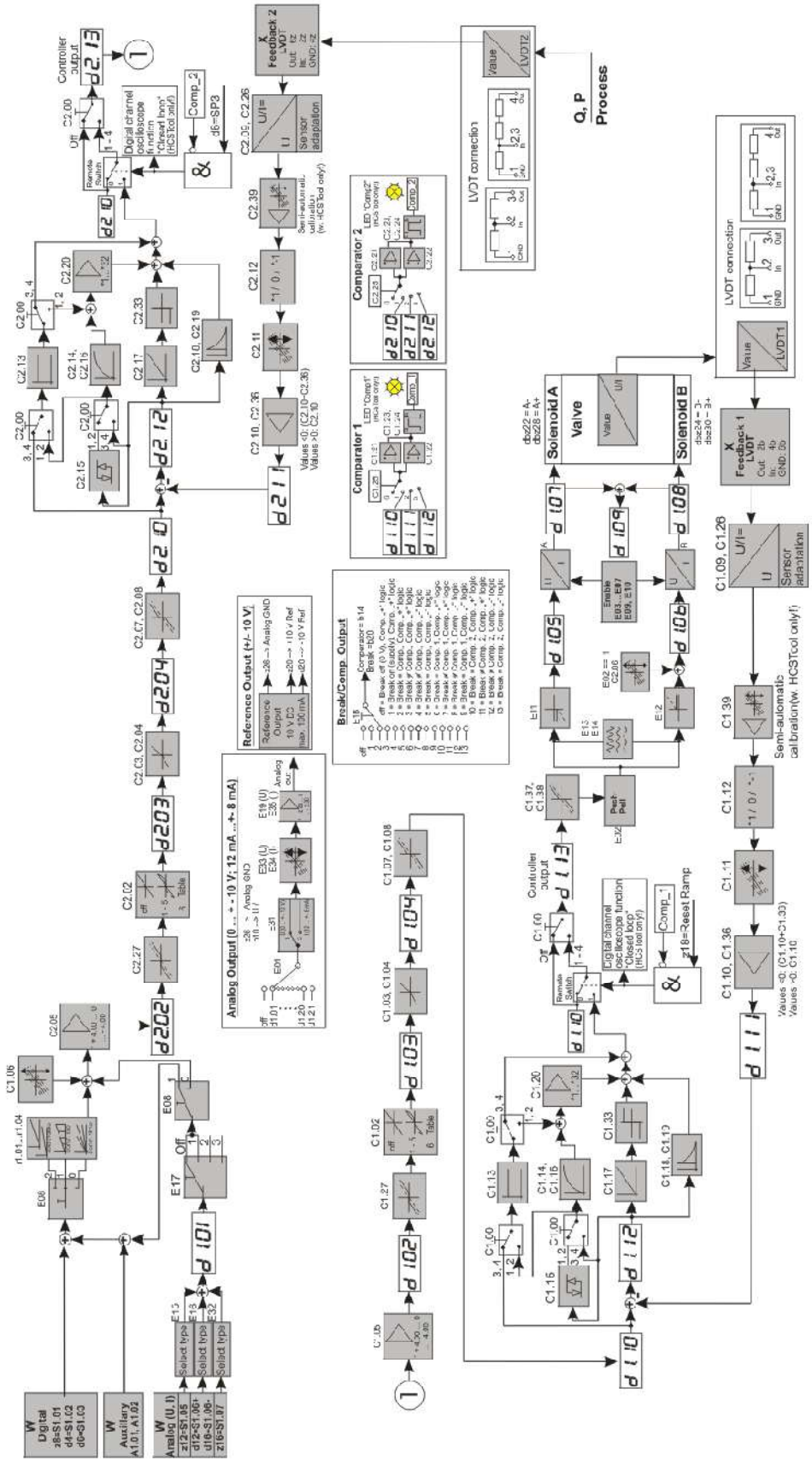
5.9.4 Operation Mode 06 …-SLVDT-1W, E20 == 0

1 valve with 2 solenoids U/ I spool position feedback and LVDT process value feedback



5.9.5 Operation Mode 06 …-SLVDT-2W

1 valve with 2 solenoids, LVDT spool position feedback and LVDT process value feedback



6 Calibration of LVDT sensor signal

Calibration of the LVDT sensor signal can be made directly at the application. If this is not possible then please use an alternative structure to simulate the assembly situation.

Hint

The controller and cable fracture detection has to be switched off before the calibration. In order to achieve this set parameters C1.00 = 0 and C1.26 = off.

During calibration the core inside the LVDT has to be placed in the positions relevant for the closed loop function. This means that the sensor must be manually adjusted to the maximum or minimum deflection. This determines the working range of the sensor. This can be easily achieved in the open loop function of the amplifier by utilizing the set point inputs S1.05, S1.06 or the offset parameter C1.06.

⚠ Danger

In this case the valve, axis or pump is working in open loop and an uncontrolled movement can happen. Make sure to avoid dangerous situations by taking the necessary precaution and safety measures!

6.1 Preparation

The calibration is performed by using the semi-automatic calibration function built into the HCSTool.
The latest HCSTool can be downloaded from this link:

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

⚠ 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.

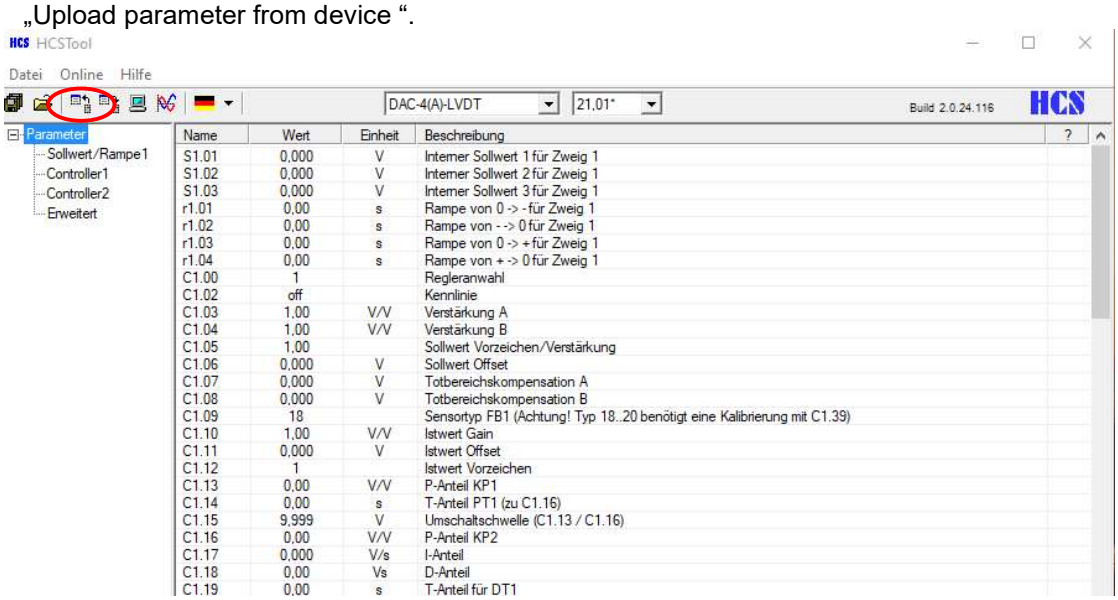
Please connect the DAC-4x(A) amplifier via USB-C connector at the front to a PC using USB interface cable.

Hint

For a proper function of the device the calibration of the LVDT sensor signals is mandatory. It is also possible to copy an existing calibration into the device.

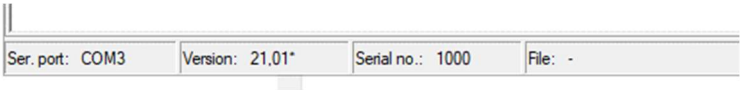
After installation of HCSTool

- Turn on the power of the DAC-4x(A) amplifier card
- Start the HCSTool on the PC.
- Read the actual parameter setting from the amplifier card by using the function: „Upload parameter from device “.



Picture 20: Upload parameter from device

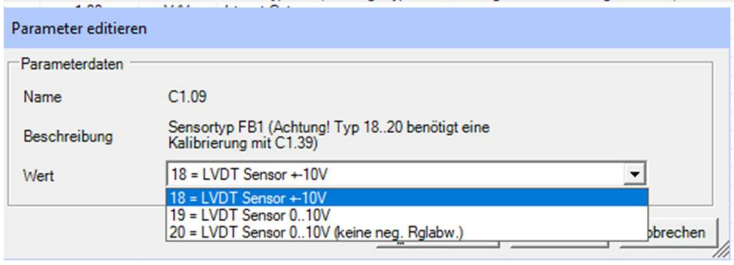
- The actual parameter setting is shown automatically after a successful upload. Also shown is the software version and serial number in the footer of the screen.



Picture 21: Footer

6.2 Sensor selection

The parameter C1.09 / C2.09 offers different LVDT sensor types for different functions to choose from. Depending on the application, the correct sensor selection must be defined before the adjustment.



Picture 22: LVDT sensor selectionl

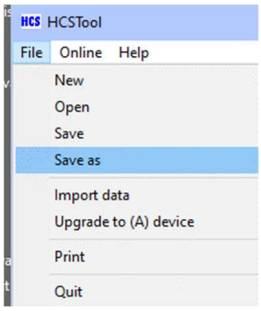
Sensor Type		
18	Sensor which generates a signal equivalent to the range of 0 … ± 10 V.	
	Step	In this case three key points must be covered:
	1	Key point is the position which reflects an input signal of - 10 V
	2	Key point is the position which reflects the 0-position (0 V)
	3	Key point is the position which reflects an input signal of + 10 V
19	Sensor which generates a signal equivalent to the range of 0 … 10 V	
	Step	In this case two key points must be covered:
	1	Key point is the position which reflects the 0-position (0 V)
	2	Key point is the position which reflects an input signal of + 10 V
20	is similar to type 19. Additionally, the controller output is limited to positive values (values ≥ 0 V).	

6.3 *Storing calibration values from device in a parameter-file*

If a sensor has already been calibrated in a similar application, these calibration data can be transferred to another amplifier card via a saved parameter file.

- The amplifier card with the successful adjustment of the LVDT sensor must be connected with the PC, start the HCSTool.
- The adjustment values from the LVDT sensor must first be uploaded in the HCSTool.
  Perform a parameter “upload from device”
  Call the function "Upload parameter from the device" inside of the HCSTool.

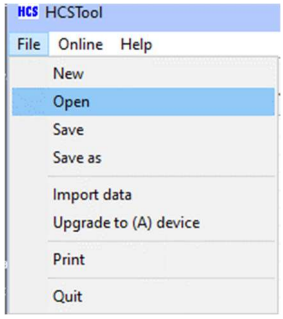
- Then the complete parameter set can be saved in a parameter file on the hard disk or USB stick.
  In the saved "dat-parameter-file” the calibration data is included.



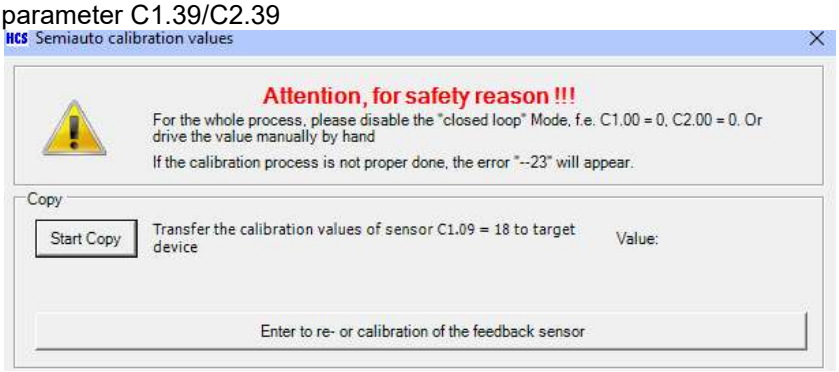
6.4 *Copying existing calibration values into a device*

If an existing parameter file contains calibration data that you want to transfer to the device with the uncalibrated sensor.

- Connect the device to the PC via USB port.
- Either you set the correct software version in the HCSTool or you use the “Upload from device function instead. This will automatically set the correct SW version. The data can only be transferred if the correct SW version is set in the HCSTool.
- Load the saved "dat-parameter-file” into the HCSTool, via the "open" function.



- Open the parameter C1.39/C2.39



- With the “Start Copy” button the calibration data of the stored “dat-parameter-file” will be transferred into the connected device.

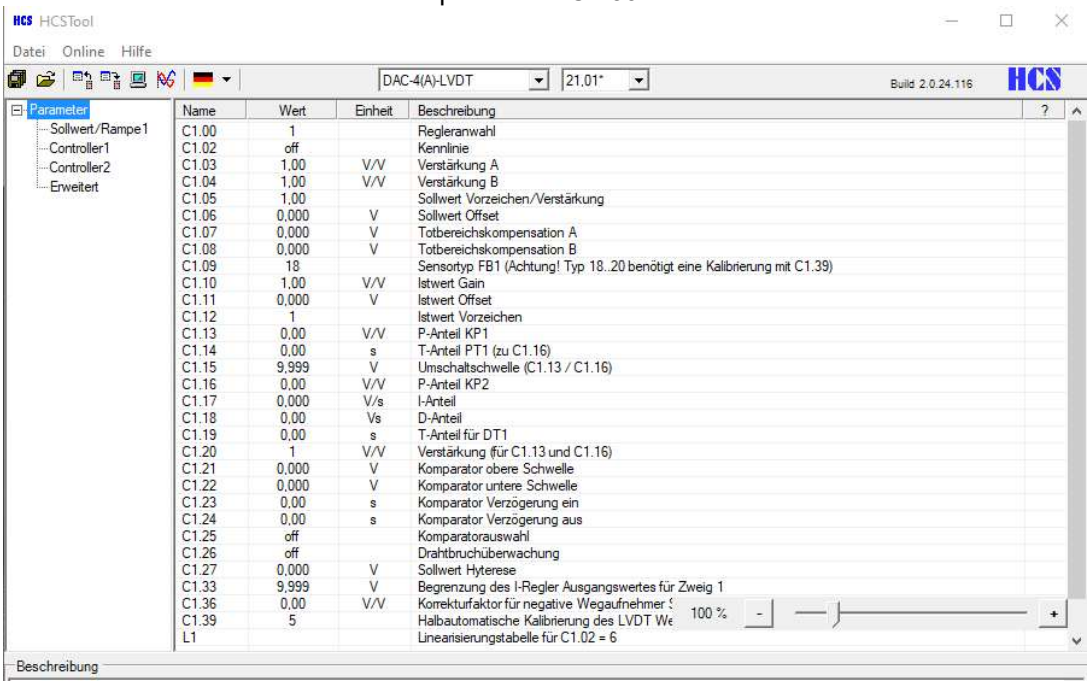
6.5 Calibration, example for LVDT channel 1

6.5.1 Sensor type selection and preparation

Danger

In this case the valve, axis or pump is working in open loop and an uncontrolled movement can happen. Make sure to avoid dangerous situations by taking the necessary precaution and safety measures!

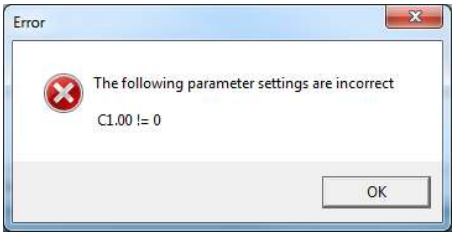
- To initiate calibration double click on parameter C1.39



Picture 23: Initiate calibration

- The parameters
  - C1.00/C2.00 = off (open loop)
  - C1.26/C2.26 = off (cable fracture detection deactivated)

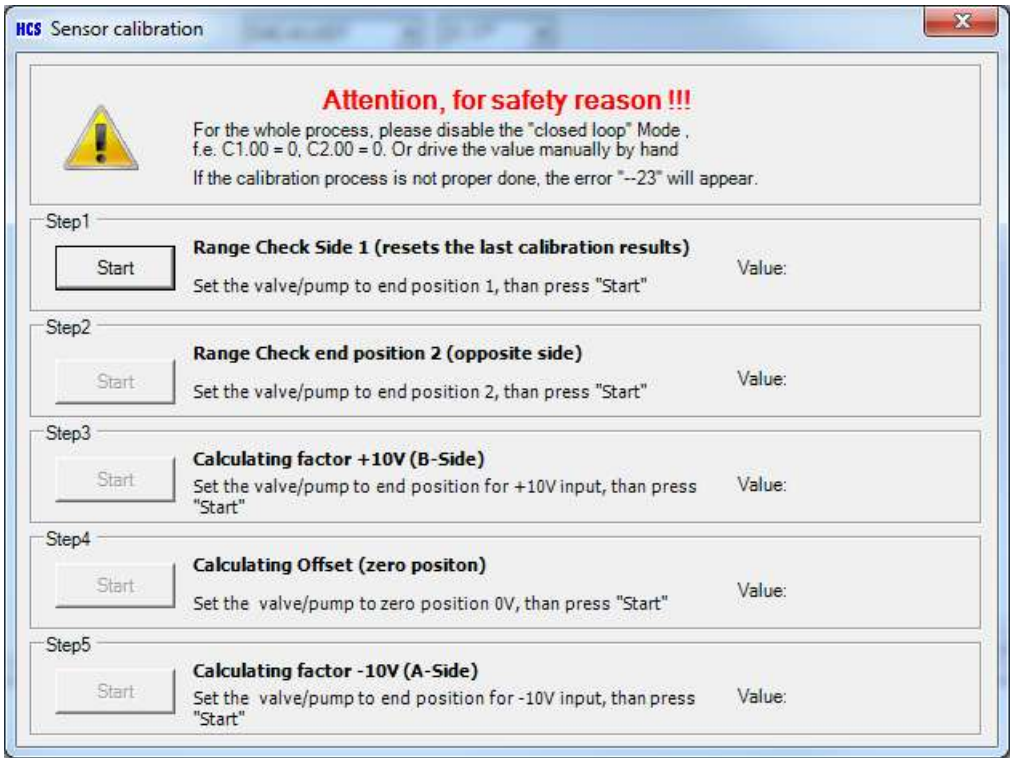
  Must be selected otherwise an error message will appear asking for correct setting of these parameters



Picture 24: Error message; e.g. parameter C1.00 is not set to „0“ (off)

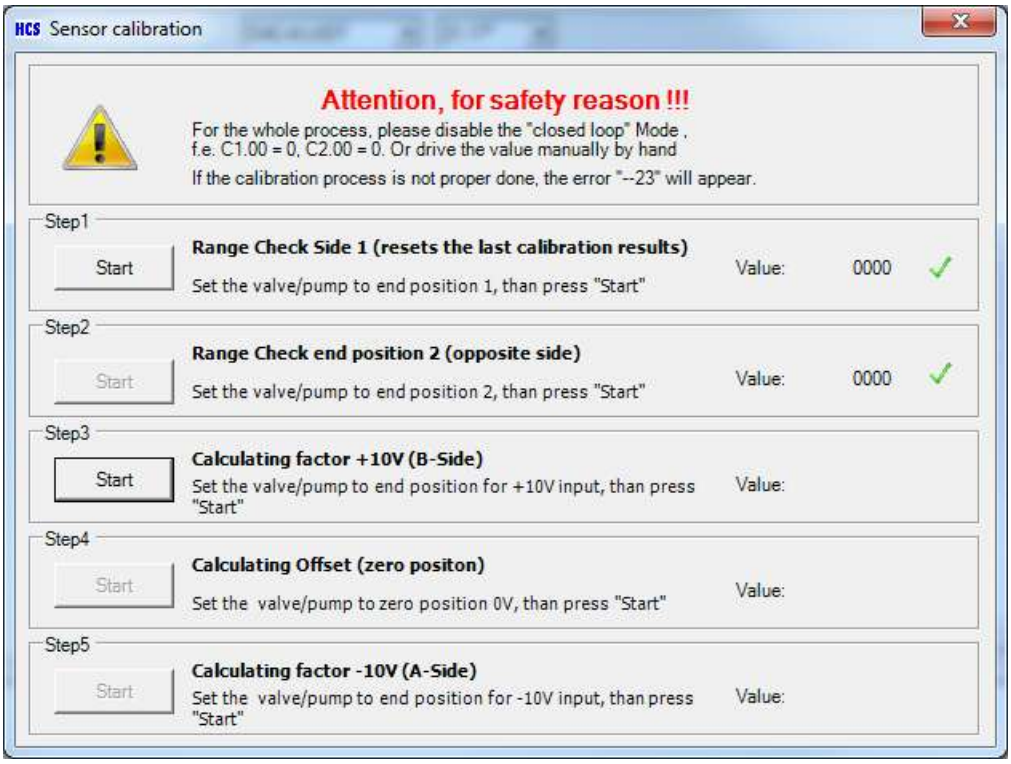
6.5.2 *Example: calibration sensor types 18 (± 10 V), step by step*

Step1 and step 2 requires going to the end positions of the sensor. E.g. Set point S1.06,S1.05 or the offset parameter C1.06 can be utilized in order to do so (open loop situation!). Which position is used first does not matter. Is the according position reached then hit the “Start” key



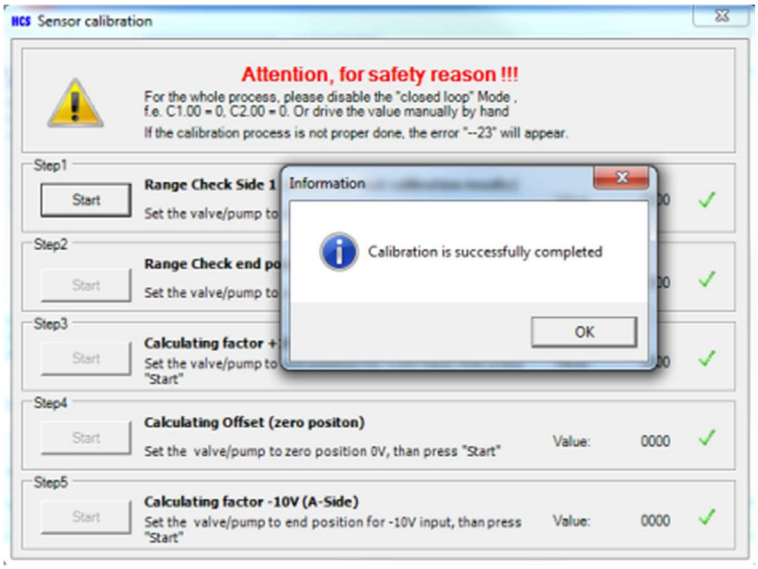
Picture 25: Calibration function; the single steps

After successful range check the steps are highlighted as „passed“ (green check mark)



Picture 26: Range check successful

Now the key points must be hit – based on the set point logic:
Step3: Put the sensor in the representing set point + 10 V, then hit the Start-key for acceptance.
Step4: Put the sensor in the representing 0-position for set point 0 V, then hit the Start-key for acceptance.
Step5: Put the sensor in the representing set point - 10 V, then hit the Start-key for acceptance.



Picture 27: Successful calibration

After successful adjustment, all steps are marked as "good" (green check mark) and the information window appears

Hint

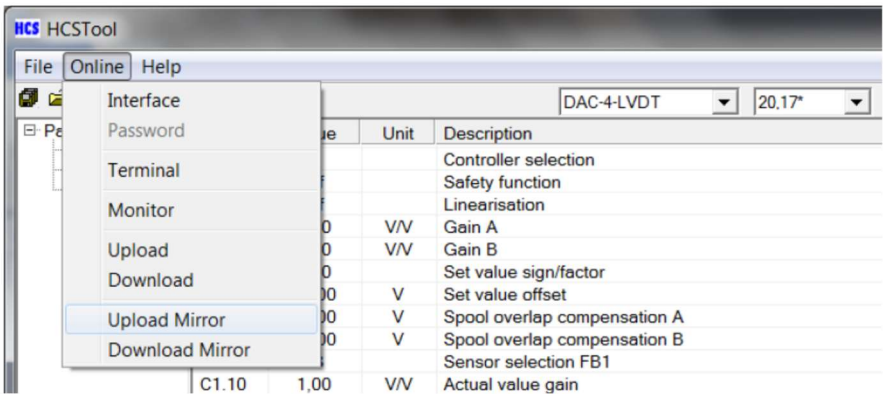
The sensor types 19, 20 are treated equally. Here Step 5, the adjustment of the negative set point, is eliminated.

6.6 Cable fracture detection

Cable fracture detection can only work properly if the used range is within the total range of the sensor.
Cable fracture detection is activated by means of parameter C1.26/C2.26.

6.7 Peculiarities with „Mirror“ function in HCSTool of DAC-4x(A) for LVDT applications

The DAC-4 promotes a so called “Mirror” function in order to save a parameter setting as default.
With “*Download Mirror*” or “*Upload Mirror*” this function can be utilized (see chapter 3 page 3.3 of the DAC-4 manual).

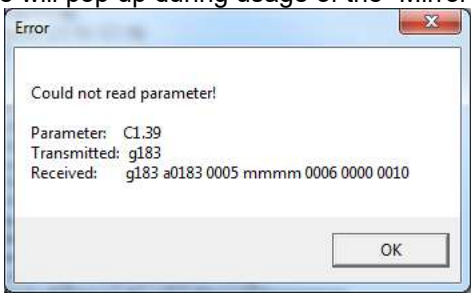


Picture 28: HCSTool screen / “Upload Mirror” or “Download Mirror”

The following parameters are not included in the “Mirror” function:

- C1.39
- C2.39 (only accessible if two LVDT sensors are used)
- Calibration parameters

All other parameters are still stored or read from the “Mirror” memory area. In order to make the user aware of this fact the following error message will pop up during usage of the “Mirror” function:



Picture 29: HCSTool screen error message for “Upload Mirror””

Hint

A regular “Upload” or “Download” command in HCSTool – either for single parameters or for a complete parameter list - grants full access to all parameters and calibration values.
Access is only limited for the “Mirror” function itself!

Function to recall default settings by means of DAC-4 keypad:

Step	Action	Result
1	Press all 4 cursor keys at the same time	Recall code is displayed -HHH
2	Recall function succesfully performed	Display VErS UEr5
3	Press key “UP” to display parameter d1.01	Display d1.01 d 1.0 1

Picture 30: “Recall default values” by means of DAC-4 Keypad

Hint

When using the “Recall default values” function no LVDT calibration values will be utilized. During the calibration process, the calibration data currently stored in the device is deleted in step “Step 1”.
This limitation can be overcome by creating a parameter file and then use the function “Start Copy” to write existing calibration values into the DAC-4x(A).

7 Functions

7.1 Output stages

- PWM output stages are used to reduce power losses at higher current output and designed for constant currents of 3.5 A.
- The pulse frequency is up to 50 kHz
- The output stages are equipped with over-energization and quick de-energization to increase dynamic response
- Parameter <E03> sets the nominal solenoid current. There are different standard settings available Further, there is a variable reduction possible with the parameter <E10>.
- With Parameter <E02>, the output can be defined as push-pull output. See next Chapter.

7.1.1 Push – pull / Short circuit, over current and wire break detection <E02>

E02

Push-Pull

<E02>	Description
off	Push-Pull function off. Normal operation mode.
1	Push-Pull function is activated. Only applicable for specially designed valves.
4	Push-Pull function off. Wire break detection to the solenoid is activated.
5	Push-Pull function is activated. Wire break detection to the solenoid is activated.

Table 9: <E02> selection

Independent of the setting of <E02>, the short circuits and overload protection between the outputs is always activated.
If the push-pull function is activated (<E02> = 1 or 5), 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.

Error message in case of short circuits, overloads or open circuits is either “- - 3” or “- - 8”.

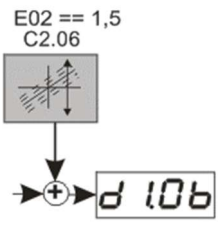
□ For further information, see the relevant chapter in the manual:
“DAC-4x(A) Manual E Rx_x YYYYMMDD”.

7.1.2 Adjust Parameter <C2.06> for single solenoid valve

If a single solenoid valve is used, it makes sense to set parameter E02 to 1 or 5. The magnet should be connected to output stage “Solenoid-B”., terminals [30bdz] and [24bdz].

Picture 31: Example of a single solenoid valve

To adjust the center position of the valve, parameter C2.06 can then be used.



7.1.3 Adjustment of the actual value signal Fb1

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

Selections 10, 11 and 12 at <C1.09> are for pressure control loops using pressure control valves. In this instance, the control output is limited to the positive range and therefore controlling only current output on stage “Solenoid-B”.

Selections 1 to 9 under <C1.09> apply to valves that use sensors with analog output signals such as voltage or current, or for applications that can generate negative signals as a feedback signal. With these choices, the controller output current can be output either through stage “Solenoid-B” or through stage “Solenoid-A”. Depending on whether the difference between the actual value and the setpoint is positive or negative.

To ensure utmost safety and best possible reproduction in a user-friendly way, all settings and adjustments are done digitally, supported by the hardware. Through 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 quite obvious.

Detailed adjustment description:

⚠ CAUTION

Activate the “enable” signal.
If <C1.09> = 10, 11 or 12, <d1.11> will not show any negative values

Step	Adjustment
1. Zero-point adjustment / general case	
1.1	place the output signal of the sensor in its zero position
1.2	set HCSTool monitor function to <d1.11>
1.3	save the inverted <d1.11< value in parameter <C1.11>
1.4	check <d1.11> again, repeat step 1.2 and 1.3 if necessary
2. Zero-point adjustment / valves with spool position feedback	
2.1	set initial current by <E11> = <E12> = 200 mA (centering the valve)
2.2	deactivate controller <C1.00> = 0
2.3	switch on enable and leave solenoid plug connected
2.4	repeat steps 1.2 to 1.4 according to “1. Zero-point adjustment / general case”
Amplifier adjustment	
2.5	set the system to achieve a maximum actual value
2.6	check <d1.11> display
2.7	adjust amplifying with <C1.10<
2.8	check <d1.11> result
2.9	repeat steps 2.7 and 2.8 if necessary

Table 10: Feedback signal adjustment

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.

8 Inputs, outputs and messages

8.1 Status LED´s

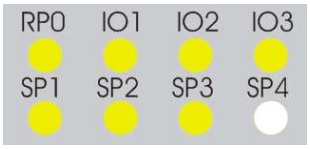
Power LED, device is powered by external supply or USB interface.

Error LED, lights up when an error occurs.

Enable LED, lights up when the signal at terminal [8d] is applied.

8.2 Digital inputs

All inputs are electrically isolated through opto-coupler.
If no electrical isolation is required the following terminals must be bridged:
[2d] to [26d] and [32z] to [32bd].
The status is displayed with the LED **«**Dout_1**»** (only available in the monitor function of HCSTool.



«RP0**»** lights up, when signal at terminal [18z] is applied.
«IO1**»«**IO2**»«**IO3**»** signal at terminal [2b], [4b], [6b] is applied.
«SP1**»«**SP2**»«**SP3**»** digital set value signal at terminal [8z], [4d], [6d] is applied. (In this hardware version the input SP4 is reserved for the second LVDT)

In this DAC-4x(A) hardware version the inputs SP4, the direction sign+/- of the digital set value, are reserved for the second LVDT. For the selection of a digital set value no extra selection of the sign is needed. The parameter S1.01…S1.03 can be defined with bipolar values.

□ For further information, see the relevant chapter in the manual:
"DAC-4x(A) Manual E Rx_x YYYYMMDD".

8.2.1 Enable

After the enable signal has been applied to terminal [18z], the LED **«**EN**»** lights up in yellow. If a time delay had been set in parameter E9, LED **«**EN**»** flashes yellow for the period of the delay. Once the time delay elapses, the flashing signal becomes a continuous signal and the output stages are enabled.
Without the enable signal applied, the output stages are locked on the hardware side.
The setpoint inputs are also ignored without an active enable signal.

8.2.2 Reset ramp (ramp = 0)

A high signal at the reset ramp input = 0 [18z] deactivates the ramp function generator immediately and the set points are ineffective. This is shown with the LED **«**RP0**»**. Once the signal is switched off, the ramp function generator starts again from zero. The pre-set time constant of the parameters r1.01 to r1.04 or r2.01to r2.04 is then used.

8.2.3 Programmable set points,

3 LEDs indicate the selected set points (SP1 for S1.01; SP2 for S1.02; SP3 for S1.03;)
An additional direction setting for the digital setpoints is not available. The digital set points are defined bipolar.
The LED's **«+»** and **«-»** are used to show the polarity signs of all measured values and parameters.

8.3 Digital outputs

Output error [14d], comparator [14b] and break [20b] are electrically isolated by optocouplers. The outputs are short circuit protected, except for the break output.
If no electrical isolation is required the following terminals must be bridged:
[2d] to [26d] and [32z] to [32bd].
All fault messages as well as the status of the comparator can be monitored with the software **HCSTool**.

8.3.1 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

□ For further information, see the relevant chapter in the manual:
"DAC-4x(A) Manual E Rx_x YYYYMMDD".

8.3.2 Fault (error)

The output is short circuit protected and can drive noninductive loads until 50 mA.
If an internal error is detected, e.g., an overcurrent or wire break, the signal at the "Error" output terminal [14d] is set to 0 V. The «ER» LED lights up red. This will remain until the cause of the error is resolved and the error is reset by disabling/enabling the card. For possible errors refer to

See □ Chapter "8.8 Display and error messages", page 48

8.3.3 Break output

The output Break is also isolated from the main supply. The output is able to directly activate and deactivate an inductive load of 1 A / 24 V.
E.g., this allows to directly control a valve.
The break Output is designed as open drain and available at terminal [20b], the associated ground signal is at terminal [2d].
Care must be taken to ensure that the supply voltage supplied via terminal [32z] can supply the connected load.

The output itself is not short circuit protected!

8.4 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 1:1 proportional to the measured value (half the set point voltage). At the socket "FB1" the analog actual value of the feedback (d1.11) can be measured. The reading is proportional to the actual value signal and also has the relation of 1:1.
At the monitor socket "MON", all display parameters are accessible in the form of an analog voltage being between 0 ±10 V.

8.5 Analog inputs

All analog inputs S1.05, S1.06, S1.07, Fb1, Fb2 can be used either as voltage or current inputs. If the input is defined as a current input, the measuring resistor of 255 ohms is automatically activated. If cable break monitoring is also active, undercurrent is also monitored. The corresponding error is triggered when the current falls below approx. 2 mA. The input is also protected against overload. When the input current exceeds the limit of approximately 23 mA, the input will automatically shut down to protect the hardware. In addition, an error is triggered and the corresponding error message is generated.

8.6 Analog outputs

Two analog outputs are available. One "AOUT" at the terminal [10b] another one at the test jack "MON". The analog output at [10b] can be a voltage or current output defined by parameter.

□ For further information, see the relevant chapter in the manual:
"DAC-4x(A) Manual E Rx_x YYYYMMDD".

8.7 Reference ±10V output

Integrated reference voltage supply of + 10 V terminal [20z] and -10V terminal [20d] (10 mA max.), to supply set point potentiometer or actual value transductor. The output is independent from the enable signal of the card.

8.8 Display and error messages

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
23	Calibration error (semi calibration error without success)
26	Communication error with the LVDT daughter card.
27	Communication error with the LVDT daughter card.
28	Wire break detected at the LVDT sensor (FB1)
29	Wire break detected at the LVDT sensor (FB2)

Table 11: List of error messages

Figure 32 : Example of Error message at the 7-segment display

9 Detailed electrical data

(For applications outside these parameters, please consult us!)

Supply voltage nom. 24V=		Min 12 V= -10 % Max 24V= +20 % Residual ripple < 10 %
Power consumption.	VA VA VA	4, solenoid not energized 43, one solenoid energized with 3.5 A 82, both solenoids energized with 3.5 A
Solenoid output		Rectangular voltage, pulse-modulated, with over-energization and quick de-energization Output stages are locked on the hardware side
	Iout	I_{max} = 4.5 A
	PWM frequency	22 kHz
	Cycle time current controller	45 µs
Analog input		U_{max} = +28 V U_{min} = -15V
	Voltage is selected	Typ. R_{in} = 200 kΩ Differential input S6 Typ. R_{in} = 333 kΩ Input S5, S7 Typ. R_{in} = 5 MΩ Input Fb1, Fb2
	Current is selected	Typ. R_{in} = 255 Ω All inputs
	over current protection	Typ. > 23 mA
Digital input		U_{max} = +28 V
	Supply 10 V	Typ. I_{in} = 0.8 mA
	Supply 24 V	Typ. I_{in} = 2.2 mA
	Low level	U_{in} < 3 V
	High level	U_{in} > 6 V
Digital Output	Error, Comparator	
	Supply 24 V	Protected at I_{outmax} typ. 40 mA Typ. U_{out} > 18 V @I_{out} 2 mA Typ. U_{out} > 15 V @I_{out} 10 mA,
	Supply 12 V	Protected at I_{outmax} typ. 20 mA Typ. U_{out} > 8 V @I_{out} 2 mA Typ. U_{out} > 5 V @I_{out} 10 mA,
	Break	
	Supply 24 V	I_{outmax} < 1 A
	Supply 12 V	I_{outmax} < 1 A
Analog output	Voltage is selected	-10 V … ±10V, tol. ±0.020 V The voltage output is locked on the hardware side
	Current is selected	4 mA … +20 mA, tol. ±0.020 mA
Reference Output		+ 10 V, tol. ±0.1 V - 10 V, tol. ±0.1 V max. load 10 mA
Control loop	Cycle time	100 µs For all PIDT1 or Dff controller

Table 12: List of error messages

10 USB-C interface

10.1 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 also 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.

10.2 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)

10.3 Downloading HCSTool

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

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

10.4 Using HCSTool

Figure 33 : 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)-03 with software version V1.12).

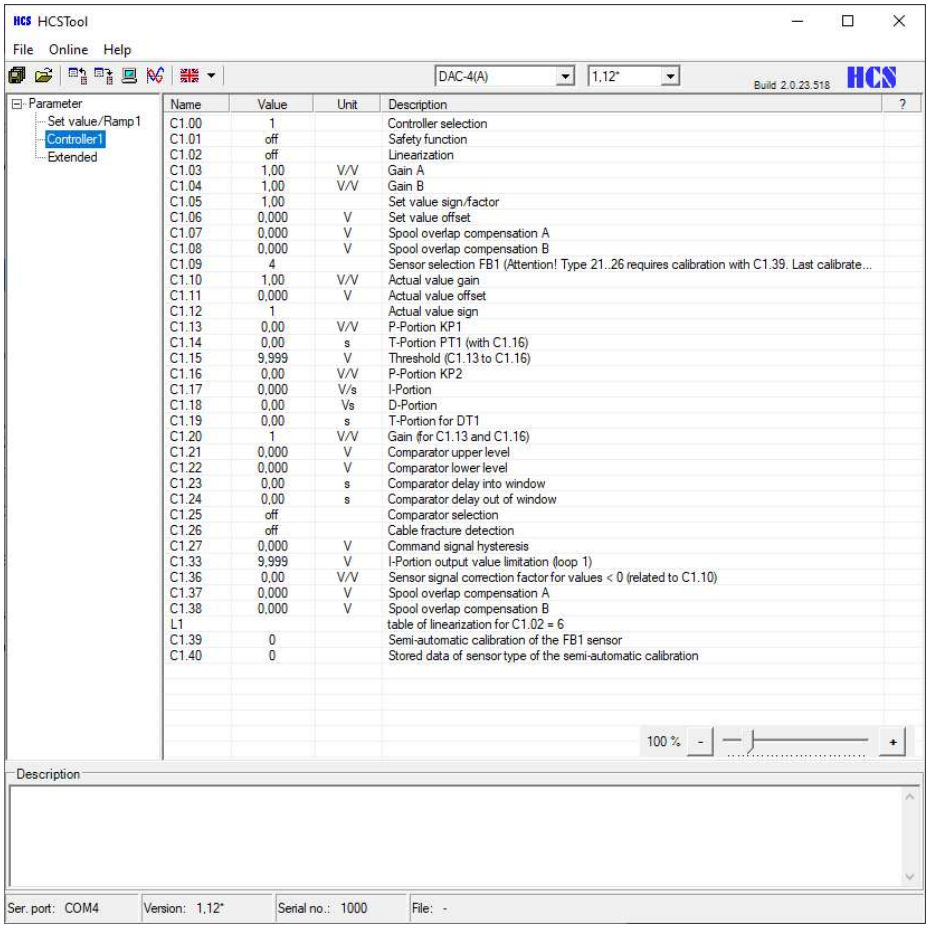


Figure 34 : HCSTool working area screen

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 C1.05:

Figure 35 : HCSTool Parameter editing

In order 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.

11 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

15.01.2024
Details of signatory: Dipl.-Ing. (FH) Peter Deuschle (General Manager)

Figure 36 : Declaration of conformity

- End -