Manual for

DAP-22

Universal Plug-On and Stand-Alone Digital Amplifier

Applicable for SW Versions V1.00 * or higher

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Revision History

Revision	Date	Description
Pre (01)	02.07.2020	First preliminary release
Pre (01)	01.12.2020	Review – changes, corrections and additional information included
R01	24.02.2021	Integrated details for parameters. First release after finalization
R01	12.07.2022	New definition of LED signalizing
R01	16.08.2022	List of figures/tables removed

Table of Content

1 Abbreviations

Abbreviation	Description
DAP	**D**igital **A**mplifier **P**lug-on
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 DAP-2
PC	**P**ersonal **C**omputer
µC	**M**icro **C**ontroller; CPU used inside the unit to control all functions
PG11	Thread size for cable gland
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
Clr	Clear; command used to clear errors
FS	**F**ull **S**cale

Table 1: Abbreviations

2 Terms and Definitions

Term	Description
Plug-on	Module which is directly placed on top of a valve solenoid
HCSTool	Software tool provided by HCS in order to adjust and parametrize DAP-2 units
CANopen	Bus interface for digital communication
Micro USB 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 plug-on amplifier “DAP-2”.

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 plug-on amplifier units!

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.

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

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.
It is applicable for “DAP-2” plug-on amplifiers with software version V1.00 or higher.

3.2.1 Copyright

3.2.2 Reservation of changes and validity

NOTICE

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

3.2.3 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 plug-on amplifier DAP-2 or the equipment in which it is installed.

3.2.4 Warranty and liability

NOTICE

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.

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.

3.2.5 Warning signs and symbols

⚠ 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 inevitably 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:

Identifier	Description
●/ -	listings
□	references to another chapter, page, table or figure in this manual
blue text	a hyperlink within the PDF file
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

3.3 Correct product use

The digital plug-on amplifiers “DAP-2” are used for the following applications:

- Controlling of proportional valves (pressure, directional control and flow valves); without) feedback
- To convert set point signals into a current signal to control one proportional solenoid 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 DAP-2 is given.

3.4 Non-intended product use

The digital plug-on amplifiers “DAP-2” 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 plug-on amplifier 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 solenoid connection.

3.5 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.

3.5.1 Inquiries and ordering

To order the product, the complete order code is requested

See □ Chapter "13 HCS Sales Partners and Distributors", page 28

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

See □ Chapter "13 HCS Sales Partners and Distributors", page 28

3.5.2 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 "13 HCS Sales Partners and Distributors", page 28

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 "13 HCS Sales Partners and Distributors", page 28

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 "13 HCS Sales Partners and Distributors", page 28

3.5.3 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.
If it should be necessary to clean the amplifier, we recommend sending it back to the manufacturer or any distributor and partner:

See □ Chapter "13 HCS Sales Partners and Distributors", page 28

⚠ CAUTION

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

3.5.4 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 plug-on amplifier is ready for use.

3.6 Introduction to product

The digital plug-on amplifier “DAP-2” 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 combined with other leading edge components The system features are essentially determined by the software and provide reserve capacity for further developments and adaptations.
The following features distinguish the “DAP-2” series products:

- Fully digital plug-on amplifier with the advantage of
  - no on-board potentiometer
  - no jumpers settings required
  - digital setting and display of all parameters via USB by means of PC and usage of HCSTool
  - user safety when programming
  - Very easy and simple to reproduce parameter adjustments
- flexible and reliable system:
  - use of a modern 16 Bit µC
  - high power reserve
  - high reliability and safety through the use of a hardware watch-dog and reset
  - variable settings for all kinds of solenoid systems and wide current range providing highest possible flexibility
  - built-in error self-resetting (depending on parameter setting and clearing of occurred errors)
- functional use of the interface:
  - change of selected parameters “on-the-fly” without interference or interruptions of the working cycle
  - static analyzation of system performance through selection of display parameters with PC and HCSTool
  - dynamic analyzation of system performance through selection of oscilloscope function with PC and HCSTool
  - CANopen bus interface optionally available

3.7 General Applications

The digital plug-on amplifier “DAP-2” is used for (all with single coil and without feedback = open loop)

- proportional directional valves direct and pilot operated
- proportional flow control valves
- proportional pressure reducing valves
- proportional pressure regulating valves
- cartridge valves

4 Overview, description, technical data

4.1 Technical features

The system features of the digital plug-on amplifier “DAP-2” are the following:

- One analogue input each for set point (command signal; S1.06) selectable by parameter. Possible input signal range (differential inputs):
  - 0 + 10V or 5 V ± 5 V or 5 V ± 4,5 V
  - 0 ... 20 mA or 4 ... 20 mA
    selection of cable fracture detection for current input and selection of set point type by means of parameter E15. Resolution of analogue input: 12 bit
- Function indication through multi color LED
- USB 2.0 interface with Micro USB connector
- CANopen interface optional on request.

The correct product connection is shown in the connection diagrams
See □ Chapter "5.4 Connection diagram", page 15

4.2 Technical data

Parameters	Range, characteristics
Supply voltage	12 VDC – 10 %.. 24 VDC + 20 %, residual ripple < 10 % Supply current 10 mA @ 24 VDC (estimated; solenoid deactivated)
Solenoid system selection	0.8 A / 1.1A / 1.3 A / 1.6 A / 2.4 A / 2.7 A / 3.5 A
Power input	Max. 22 VA
Applicable fuse (quick)	2.5 A
Operating ambient temperature	- 40 °C to + 75 °C for solenoid currents up to 2.7 A and supply voltage full range - 40 °C to + 60 °C for solenoid currents up to 3.5 A and supply voltage ≥ 24 V
Humidity (relative air humidity)	max. 95 % non-condensing
Max. elevation	2,000 m (mamsl)
Storage temperature	- 45 °C … 85 ° C
Protection class	IP65
Cable inlet	PG11 cable gland
Connection Access by removing lid!	5 / 7 screw terminals (7 terminals for CANopen version) Insulator: PA 66; color green; Flammability rating: UL94-V0 Metal housing: brass (CuZn); Terminal screw: steel zinc plated "-" slot type Contacts: brass; Current rating: 10 A; Contact resistance: 20 mOhm max UL certified (E315414) and VDE certified (40024437) Solid wire: 26 - 16 AWG / 0.129 - 1.31 mm², Stranded wire: 26 - 16 AWG / 0.129 - 1.31 mm² Torque: 3.5 lb/In - 0.4 Nm; Wire stripe length: 5 - 6 mm Screw: M2.5; Pitch: 5.0 mm; Refer also to: https://www.we-online.de/katalog/de/TBL_5_00_213_HORIZONTAL_ENTRY_MODULAR_69121371000X/?sq=691213710003#691213710003
Recommended cables	
For versions without CANopen	4 strand 0.5 mm² (max length 20 m) shielded. Lapp cable “ÖLFLEX® CLASSIC 115 CY” article number: 1136754 *1
For versions with CANopen	7 strand 0.5 mm² (max length 20 m) shielded. Lapp cable “ÖLFLEX® CLASSIC 115 CY” article number: 1136757 *1
EMC	
EMC in accordance with	EN 61000-6-2: 2001 / EN 50011:1998
Housing	
Dimensions	Approx. 104.0 x 44.5 x 59.0 mm (w x h x d) with PG11 cable gland Approx. 78.0 x 44.5 x 59.0 mm (w x h x d) without PG11 cable gland
Material	Main housing: PA66-FR in accordance with UL94V0, Lid for housing: die casted ADC12 aluminum alloy
Mounting	Housing without ventilation for direct mounting on solenoids with connector form “A” as per EN 175301-803-A / ISO 4400 (ex DIN43650/A), quadratical form Please use attached sealing between the solenoid and the plug-on amplifier
Gage glass for access and indication	Gage glass with G1/4 thread for indication of status by LED Removable for access to USB 2.0 interface

Parameters	Range, characteristics
Input signal	
Analogue set value (command input)	Selection by means of parameter: 1 differential input, 12 Bit resolution, 0 … + 10 V or 5 V ± 5 V or 5 V ± 4.5 V or 0 / 4…20 mA @ 100 Ohm (cable fracture detection selectable where applicable)
Output signal	
Solenoid current	1 output stage for up to 3.5 A; with over-energization
Interface	USB 2.0 interface with Micro USB connector
Recommended interface cable	Digitus; USB 2.0 Anschlussleitung, USB Stecker Typ A, USB Stecker Typ A, 1.8 m
Bus interface	CANopen
Operation	By means of USB 2.0 and PC with HCSTool Multi color status LED for indication of power and status
Frequencies and cycle times	
PWM Frequency / Cycle time	22 kHz / current controller and analog signal scan time approx. 0.045 msec

Table 4: Technical data

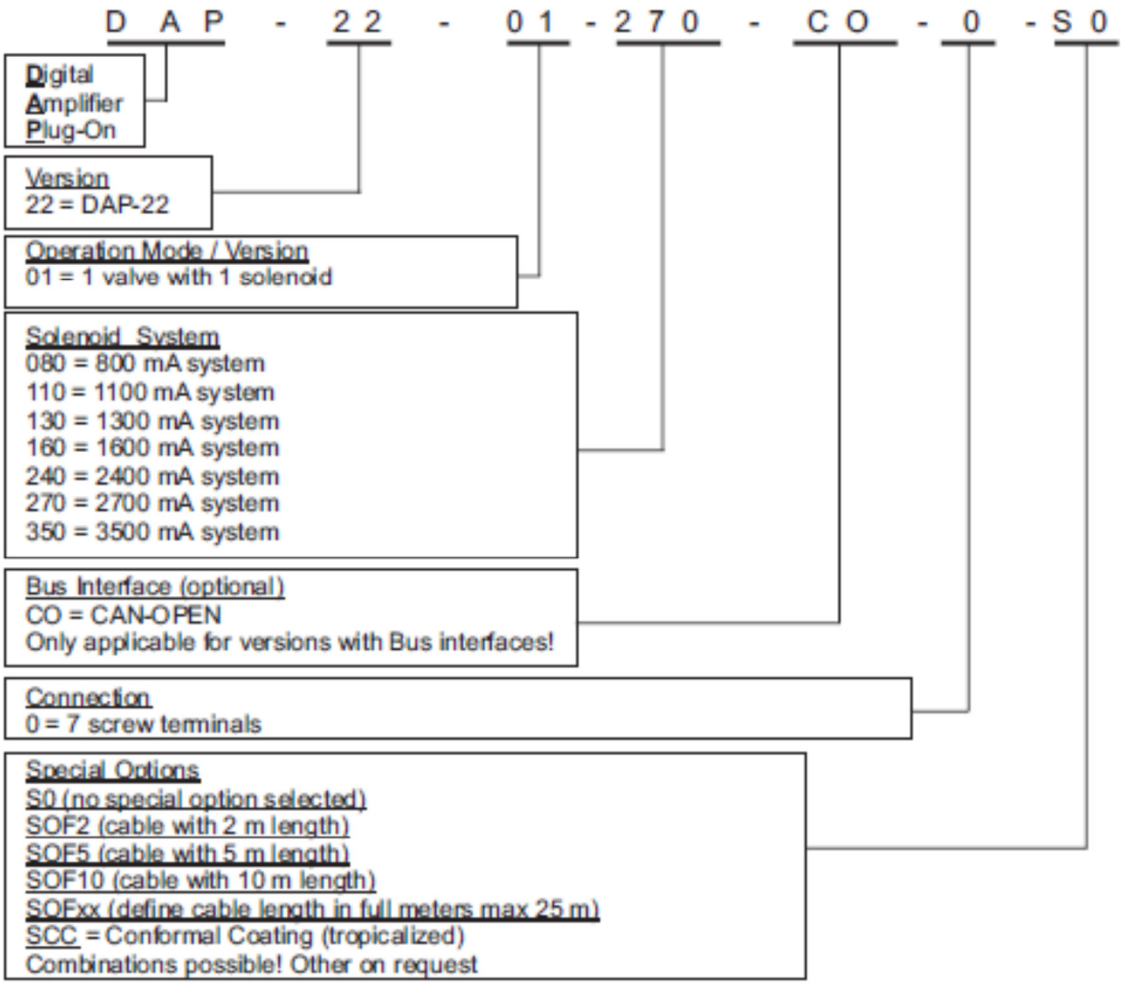
*1:
Lapp Kabel:
U.I. Lapp GmbH
Schulze-Delitzsch-Straße 25
D-70565 Stuttgart

Download-Link:

https://www.lappkabel.de/produkte/online-kataloge-shop/anschluss-und-steuerleitungen/vielseitige-anwendungen/pvc-mantel-und-nummerierte-adern/oelflex-classic-115-cy.html?tx_dgpsolr[q]=1136754

4.3 Model code

The following model code is applicable to all plug-on amplifier “DAP-2”:



Ordering code examples:

Version with CANopen interface for 1.6 A solenoid:

DAP-22-01-160-CO-0-S0

Version without bus interface for 0.8 A solenoid with 18 m cable and conformal coating:

DAP-22-01-160-0-SOF18-CC

Remark for cable versions

When selecting cable option the following cable versions are automatically asigned to the version:

For DAP-22 versions without CANopen interface --> 4 strand 0.5 mm² (max length 25 m) shielded.
Lapp cable “ÖLFLEX® CLASSIC 115 CY”. Lapp article number: 1136754

For DAP-22 versions with CANopen interface --> 7 strand 0.5 mm² (max length 25 m) shielded.
Lapp cable “ÖLFLEX® CLASSIC 115 CY”. Lapp article number: 1136757

4.4 Hardware-Block Diagram (version DAP-22-01-xxxx-S0)

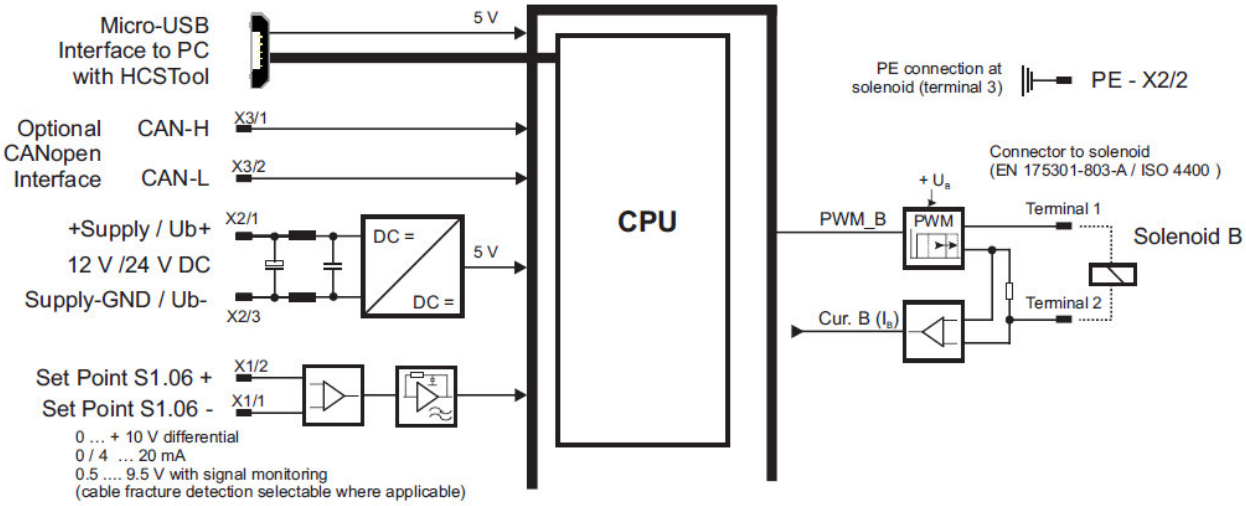


Figure 1 : Hardware block diagram

5 Connection

5.1 Exclusion of liability

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.

5.2 General recommendations

The supply voltage for the unit at terminals X2/3 = 0 V and X2/1 = +UB is 12 V to 24V DC – 10 % / + 20 %, residual ripple <10%.

Output stages are electronically protected against short circuit. The plug-on amplifier should be protected with a quick-acting fuse in the supply lines. The solenoids is connected by plugging on by means of connector form “A” as per EN 175301-803-A / ISO 4400 (ex DIN43650/A), quadratical form.

NOTICE

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 module is disconnected while the power supply is still on. Avoid such actions.

5.3 EMC

Devices of the DAP-22 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 minimised. 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 plug-on amplifier wiring system.
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

5.4 Connection diagram

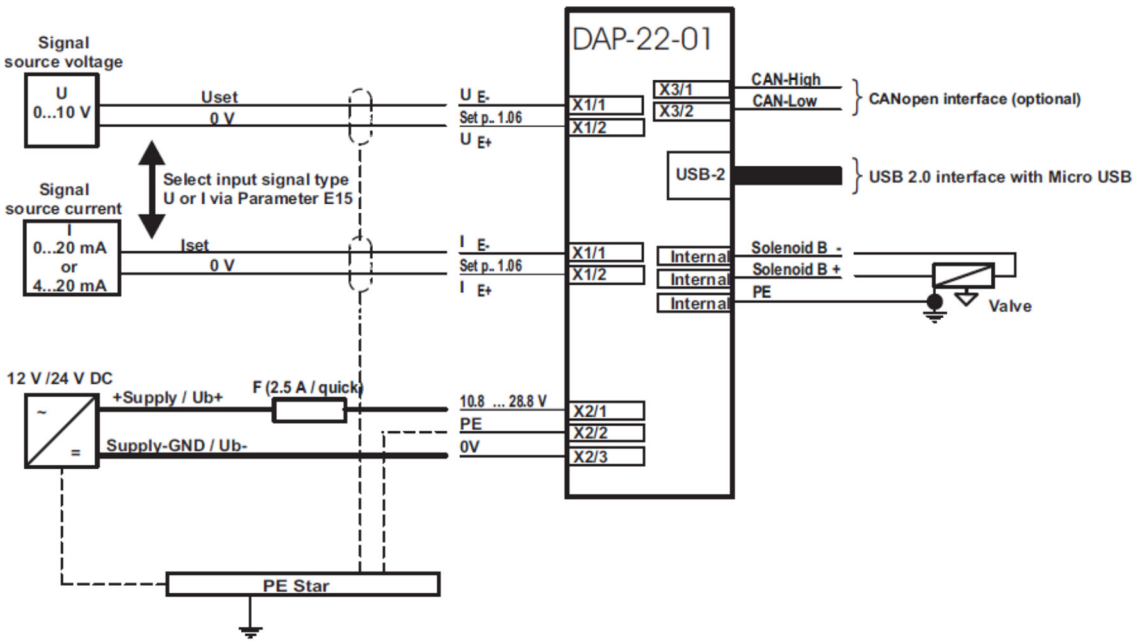
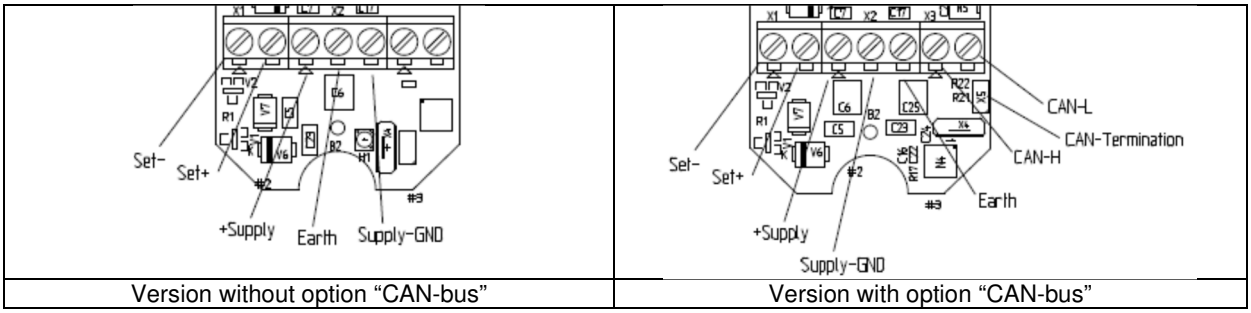


Figure 2 : Connection diagram

5.5 Connector position layout



Version without option “CAN-bus”	Version with option “CAN-bus”

Figure 3 : Connector position layout

5.6 Connection Terminals (X1, X2, X3)

X1		X2		X3	
Terminal	Signal	Terminal	Signal	Terminal	Signal
1	Set value S1.06- (Set-)	1	Ub+ (+Supply)	1	CAN-H
2	Set value S1.06+ (Set+)	2	= Earth, Cable shield	2	CAN-L
---	---	3	Ub- (Supply GND)	---	---

Table 5: Connection terminals

5.7 Top view onto unit

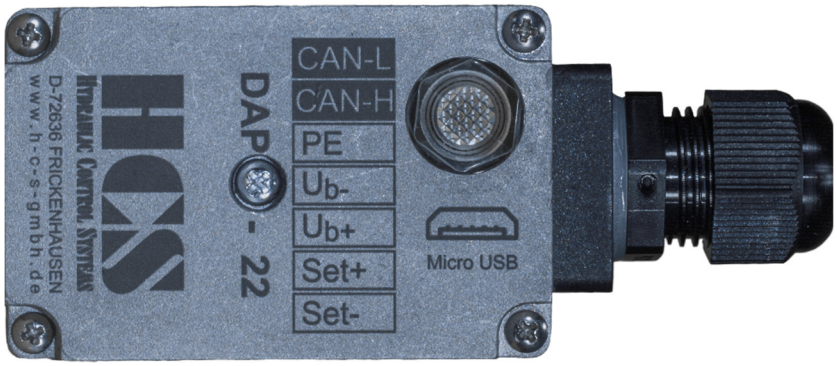


Figure 4 : Top view onto unit

6 Status LEDs

6.1 Status LEDs position

The interface and the plug-on amplifier states are indicated by multicolor LED (status display LEDs) inside the electronics housing visible through the gage glass.

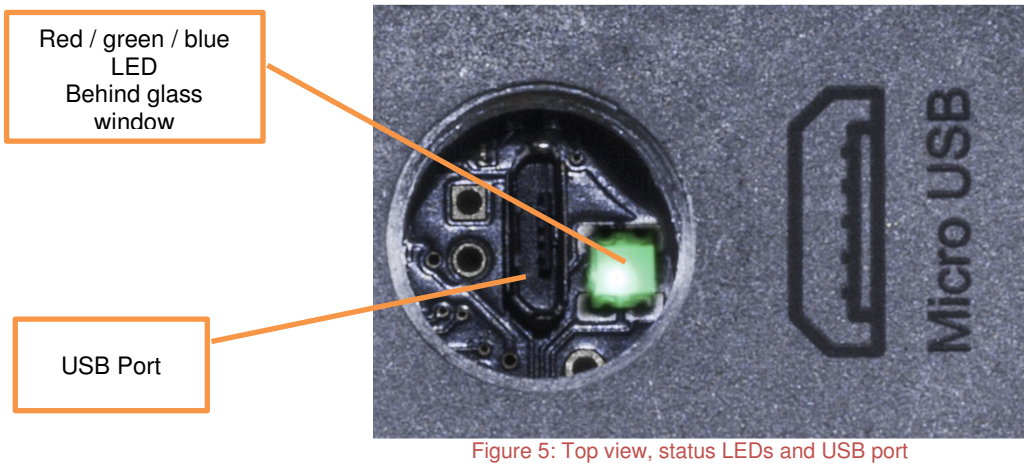


Figure 5: Top view, status LEDs and USB port

6.2 LED function definition

LED	Definition
ON	constantly ON
OFF	constantly OFF
Blinking	equal ON and OFF times with a frequency of 1.0 Hz: ON = 500 ms, OFF = 500 ms.
Change	Changing between green or blue (1s) and Red LED (250ms)

Table 6: LED function definition

6.3 LED status display

Blue LED	Green LED	Red LED	USB	Description
OFF	OFF	OFF	Inactive	No supply voltage is connected to the device. There is no USB connection, which means that there is no supply via the USB connection.
Blinking		OFF	Active	The device is connected to a supply voltage of < 8 V. The USB connection is ready for communication.
ON		OFF	Active	The device is connected to a supply voltage of > 8 V The USB connection is ready for communication
OFF	Blinking	OFF	Inactive	Output current is lower than the value defined in parameter E20 There is no USB connection active.
OFF	ON	OFF	Inactive	Output current is greater than the value defined in parameter E20 There is no USB connection active.
OFF	OFF	ON	Active/ Inactive	An error has occurred. □ See □ Chapture "Internal errors", Seite 26
Change	OFF	Change	Active	An error occurred but was reset automatically Only occurs if the error can be reset and an error is no longer pending
OFF	Change	Change	Inactive	

Table 7: LED status Display

7 Quick Setup – DAP-2

This chapter describes how to setup the DAP-2 amplifier.

7.1 Setup HCSTool

HCSTool software is executed on WINDOWS based PC's.

HCSTool can be downloaded from www.h-c-s-gmbh.de/download.
The required driver for a HCS USB interface is included and will be installed as well.

7.2 Connecting the USB interface

Connect the PC and the DAP with a micro USB cable.

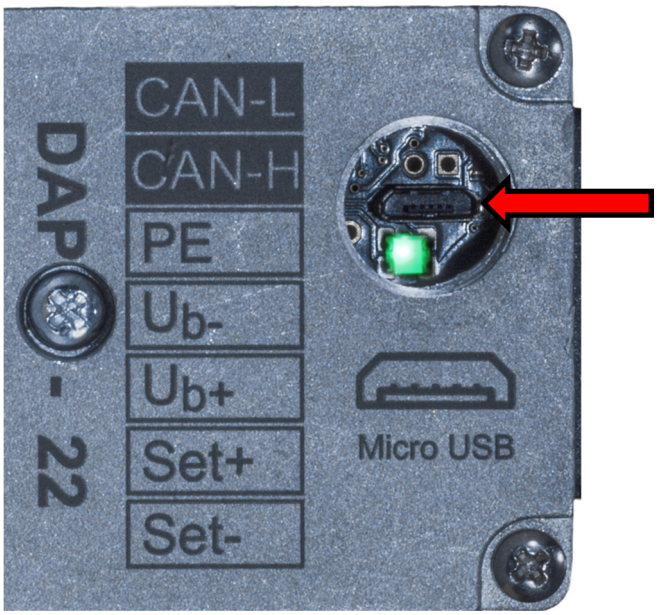


Figure 6: Micro USB interface

- Parameterization „on the desk" is possible.
  Just connect the USB and the supply via USB will be used to power the unit. In this situation the parameter setting can be performed without necessity to connect a separate power supply. Also the unit itself does not need to be opened for connection of power!
  The status of the power source can be monitored by means of HCSTool and its "Monitor" function. Upon selection of "d2.01" (Actual supply voltage) the "Monitor" function indicates approx. 3 V if USB only is connected.

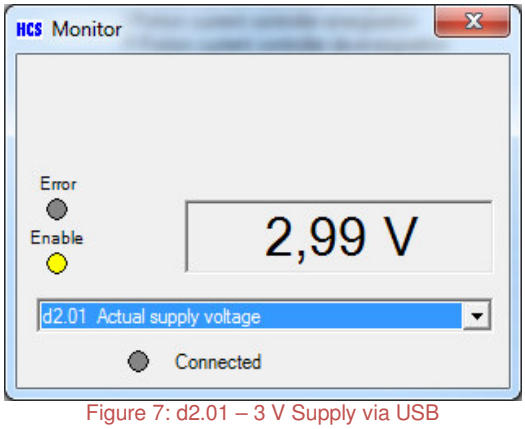


Figure 7: d2.01 – 3 V Supply via USB

- When the unit is supplied via the power supply input a connector “X2” then the main supply voltage can be seen at “d2.01”:

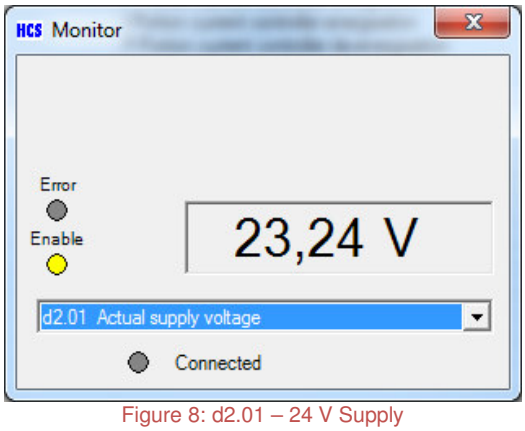


Figure 8: d2.01 – 24 V Supply

- Additionally the input signal at the analog input can be monitored as well!

By simply connecting the DAP-2 via USB 2.0 the following functions are available:
- Measuring the analog input signal
- Setting all parameters

7.3 Connecting the power supply

Without power supply outputting solenoid current is not possible.

The correct product connection is shown in the connection diagrams
See □ Chapter "5.4 Connection diagram", page 15

8 Parameter overview

8.1 Parameters for configuration

DAP-2 | 1.01* | Build 2.0.20.526

	Name	Value	Unit	Description
1	r1.03	0,00	s	Ramp from 0 -> +
	r1.04	0,00	s	Ramp from + -> 0
	C1.02	off		Linearisation
	C1.04	1,00	V/V	Gain solenoid
	C1.05	1,00		Set value sign
	C1.06	0,000	V	Set value offset
	C1.08	0,000	V	Spool overlap compensation
	C1.27	0,000		Command signal hysteresis
	L1			table of linearisation for C1.02 = 6
	E 00	1		Operation mode
	E 02	off		Monitoring of the solenoid outputs
	E 03	2,700	A	Solenoid selection
	E 04	500		P-Portion current controller energisation
	E 05	20		I-Portion current controller energisation
	E 06	500		P-Portion current controller de-energisation
	E 07	20		I-Portion current controller de-energisation
	E 08	1		Ramp selection
	E 10	1,00		Maximum output current adjustment
	E 12	0,000	V	Initial current
	E 13	0,000	V	Dither amplitude
	E 14	0	Hz	Dither frequency
	E 15	9		Selection of setpoint S1.06
	E 20	200	mA	Current level for LED display
	E 23	5,00	s	Automatic error reset time (deactivated at 0)
	E CLR	off		Reset Error

Figure 9: Parameters for configuration

9 Software block diagram (operation mode 1)

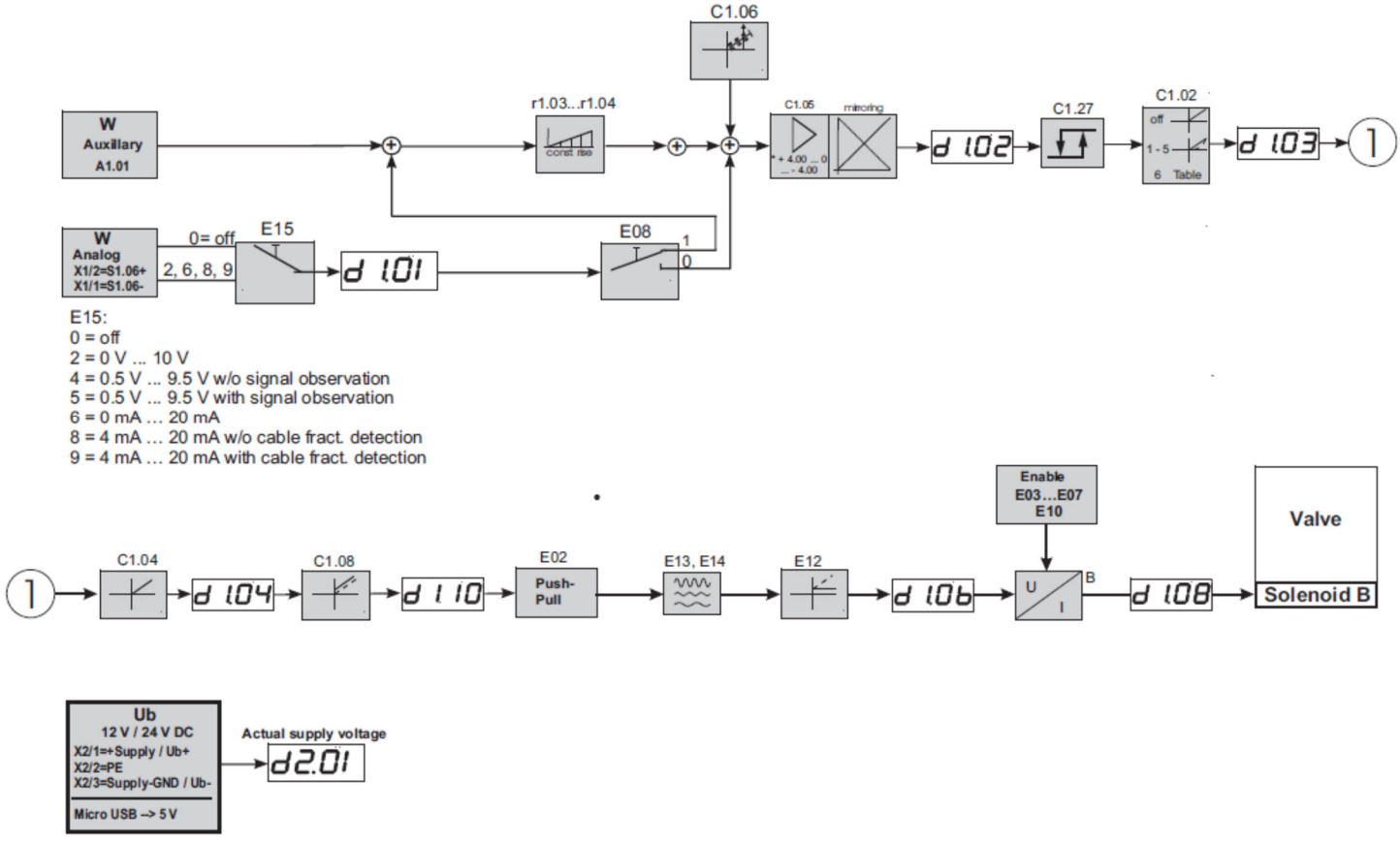


Figure 10: Software block diagram

10 Parameters

10.1 Parameter setting

Available parameters for version DAP-22-01-xxxx-S0:

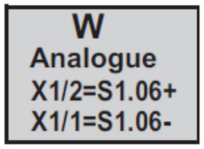
Display	ramps	Controller	Extended
"d1.xx"	**"r1.xx"**	**"C1.xx"**	**"Exx"**
d1.01	r1.03	C1.02	E00
d1.02	r1.04	C1.04	E02
d1.03		C1.05	E03
d1.04		C1.06	E04
d1.05		C1.08	E05
d1.06		C1.27	E06
d1.08		L1	E07
d1.10			E08
d2.01			E10
			E12
			E13
			E14
			E15
			E20
			E23
			E CLR

10.2 Description of software program

⚠ CAUTION

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

10.2.1 Analog set point (S1.06; E15)



- The set point S1.06 is designed for voltage and current signals (differential input). Signal range is:
  - 0 ... + 10 V
  - 0 ... 20 mA
  - 4 ... 20 mA
  - 0.5 V … 9.5 V with signal observation

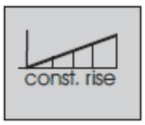
  Selection of cable fracture detection for current input and selection of set point type by means of parameter E15
  Resolution for the analog input: is 12 bit (4096 steps)
- If for S1.06 selection 0.5 V ….9.5 V is used than a signal observation is activated. If the input signal is below approx. 0.43 V or above 9.75 V then an error signal is triggered.
- If the current range is selected than a measuring resistance of 100 Ω is automatically activated
- In case of usage of current input signals the inputs are protected for overload. An error will be triggered at currents above approx. 25 mA. If cable fracture detection is selected than currents below approx. 2 mA will trigger an error. If the error is triggered then internally the output stages will be switched off and an error message via HCSTool can be observed. . □ See □ Chapter "11

Internal errors", page 26

- The set point is passed through the ramp function generator (ramp) if E08 = 1. If parameter E08 = 0, the analog set point bypasses the ramp function
- The input for S1.06 is designed as a differential input within the operating voltage range of ± 15 V
- The signal for set point S1.06 must be standardized to 0 … 10 V or 0 …. 20 mA max otherwise the A/D converter can be overloaded and cannot measure properly

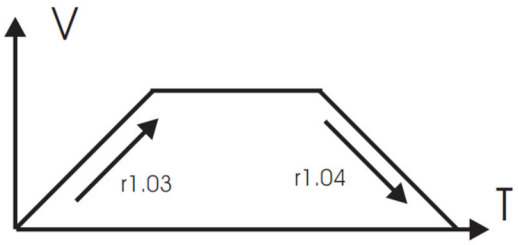
10.2.2 Ramp function (r1.03 to r1.04)

r1.03...r1.04



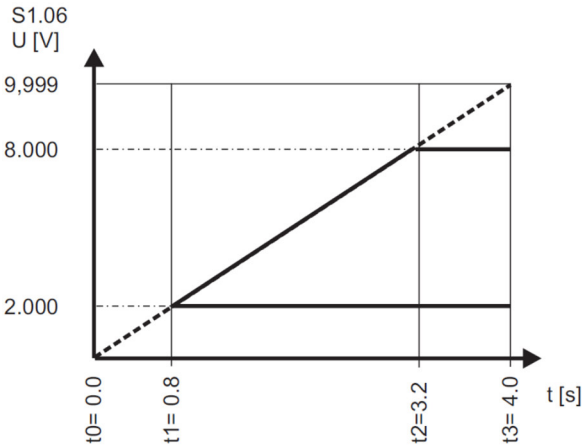
Times from 0 to 39.5 s can be set. The resolution is 0.01s.
The ramp characteristic is assigned as follows:

Ramp #	reaction
r1.03	ramp from 0 to positive values
r1.04	ramp from positive values to 0

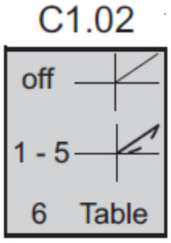


E08 = 0 ramp function deactivated
E08 = 1 effects S1.06 with constant rise rate

Example:
E08 = 1, ramp with constant rise rate
Changing at t1 from S1.06 = 2.000 V to S1.06 = 8.000 V at “t2” with r1.03 = 4.00 sec

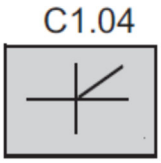


10.2.3 Linearization curve (C1.02)



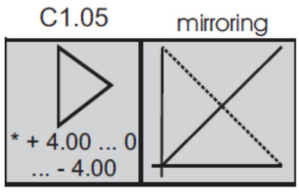
There are five characteristic curves available for the linearization of the valves characteristics:
Curve #1: general linearization for NC curve
Curve #2: linearization for proportional directional valves with flow characteristic > 10 l/min (NG6)
Curve #3: linearization for proportional directional valves 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
Curve #6: individual adjustable linearization (defined by means of parameter L1)

10.2.4 Gain for solenoid (C1.04)



The amplification can be programmed with parameter C1.04.

10.2.5 Gain and mirroring (C1.05)

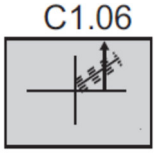


The mirroring function is used change the “direction” of the output signal. When negative values are applied then the output function is mirrored. This means for the full 100 % command signal the output is “0” and for “0” command signal the output is 100 % (of nominal value) for C1.05 = -1.00.

With values < | 1 | the signal will be attenuated and for values > | 1 | it will be amplified.

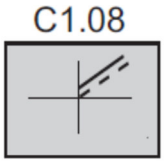
So this parameter also can be used to adapt the input signal range if necessary.

10.2.6 Offset for set point (C1.06; C2.06)



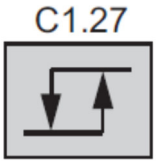
A drift of the drive or the hydraulic system can be corrected with the offset parameter C1.06.
The offset can be regarded as an additional set point. This allows a very fine change of the system behavior.

10.2.7 Spool overlap compensation (C1.08)



This parameter compensates a possible spool overlap. The compensation works as an additional set point that is activated as soon as set point is ≠ 0. Overlap of valves 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.
This pre-set value is directly applied as a current acting on the solenoid. The programming is standardized in volt.
10 V = maximum set current.

10.2.8 Command signal hysteresis (C1.27)

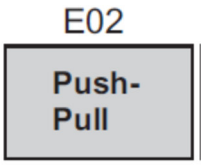


This parameter is used in order to create a “artificial” dead band for the command input around “0”. When set than the command input will be ignored up to the adjusted values and then will start with “0” from that point on. It can be used in to avoid a too sensitive reaction when starting from “0” and having applied a dead band compensation defined by C1.08 (e.g. when using joy-stick as signal source).

10.2.9 Operation mode (E00)

Operation mode for DAP-2 is always set to “1” which is the operation mode for open loop applications.

10.2.10 Monitoring of solenoid output, over current and open loop detection (E02)



E 02	Description
off	Wire break monitoring deactivated
4	The difference to E02 = off is that here the short circuit, overload and open loop protection is activated and also short circuits and overloads between the outputs and GND or power supply lines is detected.

Table 8: E02 Selection

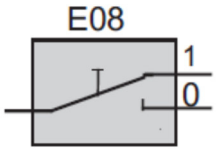
⚠ CAUTION

If short circuit and/or overload can occur also between the outputs and either GND or supply and if this can cause any risk or damage than E02 =4 must be activated. This setting also must be activated in cases of possible open circuits causing critical conditions in the application.

For E02 = 4 an error will only be detected if the difference between the desired current and the actual output current of plug-on amplifier is > 250 mA and at the same time active for a duration of approximately > 100 ms. Only in this case the output stage will be shut off automatically. This function cannot detect over-current.

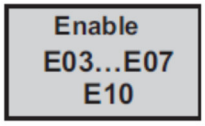
It is always recommended to have a fuse (quick reacting, 3.15 A) in the + power supply line to the DAP.
Error message in case of short circuits, overloads or open circuits is either “- - 3” or “- - 8”.

10.2.11 Type of ramp (E08)



This parameter defines if the ramp function is used.
E08 = 0: the ramp is by-passed and no ramp is active
E08 = 1: constant rise rate

10.2.12 Output stage parameters (E03 - E07, E10)



Each solenoid is activated by a PWM output stage that has over-energization and high-speed de-energization. The solenoid current 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 hence defines the nominal range of current for a given set point at 10 V.
Parameter E10 allows a fine and variable adjustment of the solenoid current and this allows adjusting the already set maximum current. Independently of all the settings, the minimum current is limited to 600 mA in any case.

10.2.13 Evaluation of the current controller parameters

Case 1: actual current is below the desired value (calculated is the required energization [err]):

e(t) >0: → $t_{pwm(t)} = kp_{err} \cdot e(t) + ki_{err} \cdot \int e(t)\,dt$

After transfer of the integral into discrete time interval (internally calculated with T_{ab}):

$$ki_{err} \cdot \int e(t)\,dt == \frac{Ki_{err} \cdot e(n)}{T_{ab}} + \frac{Ki_{err} \cdot e(n-1)}{T_{ab}} + \frac{Ki_{err} \cdot e(n-2)}{T_{ab}} \ldots\ldots \frac{Ki_{err} \cdot e(0)}{T_{ab}}$$

$$ki_{err} \cdot \int e(t)\,dt == \frac{Ki_{err} \cdot e(n)}{T_{ab}} + \sum_{t=0}^{t=n-1} \frac{Ki_{err} \cdot e(t)}{T_{ab}}$$

k_{perr} = E04; k_{ierr} = E05 * T_{ab}

Case 2: actual current is above the desired value (calculated is the required de-energization [ent]):

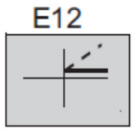
Calculation is the same as in case 1 but with different parameters and instead of k_{perr} and k_{ierr} the values k_{pent} and k_{ient} are used:

k_{pent} = E06; k_{ient} = E07 * T_{ab}

Abbreviations:

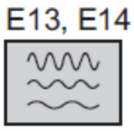
e(t) = error signal (deviation between current command and actual measured current)
t_{pwm} = time at which solenoid receives energy from the source (output stage)
T_{ab} = 45 µs; cylce time current controller (internal reference time)

10.2.14 Initial current (E12)



Initial current is used to keep the armature of the magnet always in touch with the spool. This places the spool solidly at the solenoid and prevents the spool being hit by the armature. The initial magnetizing can also improve the dynamic behavior of solenoids.
The programming is done in Volt: the programmable maximum current is 10 V.

10.2.15 Dither signal (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). A dither signal can reduce the hysteresis of the valve as well as of the drive itself and such may improve the reaction of the system. This will have a positive effect on the precision and repeatability and such on the performance.
In general, low frequency signals are more effective, but they can result in noticeable disturbances (noise, oscillations, vibrations). Values less than 100 Hz are for systems with a low characteristic frequency, higher values are used for systems with a high characteristic frequency. Dither amplitudes are usually set in 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 command input to output current.

NOTICE

Relationship for dither amplitude adjusted in parameters E13 to output current:
1.000 V = 20 % peak to peak value of max. rated current set by E03.

10.2.16 Selection of Set Point S1.06 (E15)

The parameter is used in order to select the type of analogue set point. Either a voltage input (0 … 10 V) or a current input can be selected. If current input is selected than the measuring resistance (100 Ω) is activated.
The following selection for the input is possible:
off = S1.06 is de-activated
2 = S1.06 is activated as voltage input; range: 0 … 10 V
4 = S1.06 is activated as voltage input; range: 0.5 V … 9.5 V w/o signal observation
5 = S1.06 is activated as voltage input; range: 0.5 V … 9.5 V with signal observation
6 = S1.06 is activated as current input; range: 0 … 20 mA, w/o cable fracture detection
8 = S1.06 is activated as current input; range: 4 … 20 mA, w/o cable fracture detection
9 = S1.06 is activated as current input; range: 4 … 20 mA, with cable fracture detection

E15	Signal within Range	System reaction	Signal level	System reaction	Signal level	System reaction
5	0.5 V … 9.5 V	Fully operational	< 0.35 V	Error 6	> 9.65 V	Error 16
9	4 … 20 mA	Fully operational	< 2 mA	Error 6	> 22 mA	Error 16

Table 9: E15 Signal ranges and reactions

10.2.17 Current Level for LED (E20)

This parameter is used to adjust the intensity of the LED. With higher current levels adjusted the LED becomes brighter.

10.2.18 Automatic Error Reset Time (E23)

This parameter can be used to activate a automated error reset. For any value > 0 the error will be reset automatically by the unit. If cause for error is persistent than the error status will persist as well and the error cannot be reset.

If the time is set to “0” than the error can only be reset by means of HCSTool and here usage of parameter

10.2.19 Reset Error (E CLR)

Parameter is used in order to clear errors if E23 “Automatic Error Reset” is not activated.

10.2.20 Display parameters (d1.01 – d1.04, d1.06, d1.08, d1.10, d2.01)

Example:

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

Values are displayed either in volt or milliampere (d1.08).

d-Parameter	Description
d1.01	Sum analog set values
d1.02	Sum all set values after ramp function
d1.03	Set value after linearization
d1.04	Set value after gain adjustment
d1.06	Signal to solenoid
d1.08	Solenoid current
d1.10	Desired value
d2.01	Actual supply voltage

Table 10: Available display parameters

11 Internal errors

If an error occurs, the internal “enable” is withdrawn and the plug-on amplifier goes into error mode. The output current to the solenoid is interrupted.

An error that has occurred can be reset using the following methods:
Power down reset (off/on). External supply as well as USB connection must be interrupted.
Parameter “E Clr”
Triggering an automatic reset by specifying the time in parameter E 23

Depending on the set-up a self-resetting behavior for error situations can be selected. In this case an error will be cleared automatically after the cause for the error has been removed without further action at the unit. The error itself will be internally stored for diagnosis purposes. This functionality leads to a higher availability and easier handling in the field.

After eliminating the cause of the error and resetting the error, the full function of the amplifier is active again.

An automatically cleared error remains stored in the background until the error is permanently deleted (supply or Clr). This enables a subsequent determination of the cause of the error.
Such an automatically cleared error is indicated by briefly flashing the red error LED. The error.
The code of the error that has occurred and has been automatically cleared can be determined using the monitor function in the HCSTool.
The error code of the last error that occurred is displayed every 4 seconds for 2 seconds.

11.1 Table of Errors:

#	Explanation
3	Short circuit at solenoid output
6	Analog current input is < 2 mA or voltage input < 0.35 V
8	Open circuit detection for solenoid output. With a command signal > „0“ and non-matching current
16	Analog current input is > 22 mA or voltage input > 9.65 V. Input will be switched off for protection purposes for I > 22 mA!

Table 11: Errors

11.2 Display of Errors via HCSTool

The monitoring window of HCSTool display the actual and sored error number.
A automatically reset error will be displayed for 2 seconds for every 4 seconds.

12 USB Interface Connection

As soon as an active USB connection is detected then the blue LED will be lit (flashing or constant).

12.1 Parameterization

The complete adjustment and parametrization can be maintained via the USB connection in conjunction with HCSTool. For this purpose no other power supply is needed!

12.2 Diagnosis of Command Input

The analog input signal can be directly monitored if just an active USB connection is present. For this purpose the main power supply at “X2” is not necessary.

13 HCS Sales Partners and Distributors

A list of all our active sales partners and distributors can be found on our home page.
Please follow the link for easy access:

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

14 Declaration of Conformity

EC Declaration of Conformity in accordance with EMC Directive 2004/108/EG

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 changes to the product without our written agreement.

Product:	DAP –Digital plug-on amplifier
Intended use:	Automation systems (industrial and mobile)
Model:	DAP-2
Rated voltage:	24 V DC; SELV
Rated power:	max. 25 W
Protection class:	III
Protection degree:	IP67
Relevant EC Directive:	EMC Directive 2004/108/EG
Applicable EU Standards:	EN 61000-6-2: 2005 EN 61000-4-2, EN 61000-4-3, EN 61000-4-4, EN 61000-4-5, EN 61000-4-6, EN 61000-4-16 EN 61000-6-3:2007 + A1:2011 EN 61000-6-4:2007 + A1:2011

Date/manufacturer's signature

01.01.2021
Details of signatory: Dipl.-Ing. (FH) Peter Deuschle (General Manager)

15 Notes:

End