Application Note

Power Supply Stepper

How to choose the correct current rating of the power supplies used for motor controllers

CMMO-ST,
CMMS-ST

100001

Title .... Power Supply Stepper
Version 1.30
Document no. 100001
Original ....en
Author .... ESSL

Last saved 19.05.2016

Legal Notice

Hardware, software, operating systems and drivers may only be used for the applications described and only in conjunction with components recommended by Festo AG & Co. KG.

Festo AG & Co. KG does not accept any liability for damages arising from the use of any incorrect or incomplete information contained in this documentation or any information missing there from.

Defects resulting from the improper handling of devices and modules are excluded from the warranty.

The data and information specified in this document should not be used for the implementation of safety functions relating to the protection of personnel and machinery.

No liability is accepted for claims for damages arising from a failure or functional defect. In other respects, the regulations with regard to liability from the terms and conditions of delivery, payment and use of software of Festo AG & Co. KG, which can be found at www.festo.com and can be supplied on request, shall apply.

All data contained in this document do not represent guaranteed specifications, particularly with regard to functionality, condition or quality, in the legal sense.

The information in this document serves only as basic information for the implementation of a specific, hypothetical application and is in no way intended as a substitute for the operating instructions of the respective manufacturers and the design and testing of the respective application by the user.

The operating instructions for Festo products can be found at www.festo.com.

Users of this document (application note) must verify that all functions described here also work correctly in the application. By reading this document and adhering to the specifications contained therein, users are also solely responsible for their own application.

Internet: http://www.festo.com
E-Mail: service_international@festo.com

Table of contents

1 Components/Software used

Type/Name	Version Software/Firmware	Date of manufacture
CMMS-ST	General	2014
CMMO-ST	General	2014

Table 1.1: Components/Software used

2 Application description

This application note gives you an overview, how to choose the correct current rating of the power supplies used for the motor controllers CMMO-ST or CMMS-ST.

Both motor controllers, CMMS-ST and CMMO-ST, provide separate connections for:

- Logic Supply, 24 V DC
- Power Stage Supply
  CMMO-ST: 24 V DC
  CMMS-ST: 24 V DC or 48 V DC (both are possible)

Both controllers use 24V DC for their internal logic supply, for the external I/O and for the motor brake.

> **Note**
> On CMMO-ST the motor brake current is part of the load circuit. This is important if two separate power supplies are used for control voltage and load Voltage.
> - CMMS-ST: The necessary current to drive the motor brake needs to be provided from the Logic Supply.
> - CMMO-ST: The necessary current to drive the motor brake needs to be provided from the Power Stage supply.

To determine the required power rating for the Power supplies for the logic supply and for the Power stage supply one need to calculate as follows:

Logic Power Supply:

1. Calculate the necessary logic Supply current for each CMMS-ST / CMMO-ST in the system (chapter 3)
2. Sum up the supply current for all CMMS-ST / CMMO-ST in the system
3. Provide at least 30% safety margin
4. Select the appropriate 24 V Logic power supply

Power Stage Power Supply:

1. Calculate the necessary Power Stage Supply current for each CMMS-ST / CMMO-ST in the system (chapter 5)
2. Sum up the supply current for all CMMS-ST / CMMO-ST in the system
3. Provide at least 30% safety margin
4. Select the appropriate 24 V or 48 V Power Stage supply

3 How to calculate Logic Supply Current of CMMS-ST and CMMO-ST

3.1 Logic Supply: Estimated current Consumption for CMMS-ST

Estimated current Consumption	**CMMS-ST**
CMMS-ST Controller logic consumption	approx. 0.3 A
External I/Os fully loaded	up to 0.4 A
Motor brake	max. 0.7 A
Sum:	1.4 A

Table 3.1:

Example Estimated Current from Logic Supply:
CMMS-ST + EMMS-ST-57-S-SB (motor with brake 0.3 A), outputs loaded with 0.1 A in total:

$$I_{Logic} = 0.3\ A + 0.1\ A\ + 0.3\ A = 0.7\ A$$

3.2 Logic Supply: Estimated current Consumption for CMMO-ST

Estimated current Consumption	**CMMO-ST**
CMMO-ST Controller logic consumption	approx. 0.3 A
External I/O	up to 1.1 A
Motor brake	Part of Power Stage supply
Sum:	1.4 A

Table 3.2:

Example Estimated Current from Logic Supply:
CMMO-ST + EMMS-ST-57-SS-SB (motor with brake 0.3 A), outputs loaded with 0.8 A in total:

$$I_{Logic} = 0.3\ A + 0.8\ A = 1.1\ A$$

(current for the brake is not part of the logic supply!)

4 List of supported motor types and motor brake current

4.1 24 VDC motor brake current EMMS-ST

Motor type	Brake	Brake current
EMMS-ST-28-L	24 VDC/8 W	approx. 0.3 A
EMMS-ST-42-S	24 VDC/8 W	approx. 0.3 A
EMMS-ST-57-S	24 VDC/8 W	approx. 0.3 A
EMMS-ST-57-M	24 VDC/10 W	approx. 0.42 A
EMMS-ST-87-S	24 VDC/11 W	approx. 0.46 A
EMMS-ST-87-M	24 VDC/11 W	approx. 0.46 A
EMMS-ST-87-L	24 VDC/11 W	approx. 0.46 A

Table 4.1:

4.2 24 VDC motor brake current EPCO motor

Motor type	Brake	Brake current
EMMS-ST-28-L	24 VDC/8 W	approx. 0.3 A
EMMS-ST-42-SS	24 VDC/8 W	approx. 0.3 A
EMMS-ST-57-SS	24 VDC/8 W	approx. 0.3 A

Table 4.2:

5 How to calculate Power Stage current using CMMS-ST and CMMO-ST

5.1 A little mathematics

The required current of the power supply depends on the motor current, cable length, motor speed, motor efficiency, temperature of the motor and more. Additional there must be considered a controller power loss from approx. 5%. Because it is nearly impossible to know all exact parameters of the system, there is a simplified calculation for stepper motor applications, based on the fact, that the output power of the power stage is limited in voltage and current.

In literature you will find a calculation factor (0.7 ... 0.8) between motor phase current and DC current in the intermediate circuit.

$$I_{Load,DC} = I_{Phase} * (0.7 \ldots 0.8)$$

Here comes an explanation, how this factor has to be calculated for the CMMS-ST and CMMO-ST, which are using pulse-width modulation (PWM) with an over modulation technique. The expected current in the intermediate circuit is calculated as follows:

Effective Output voltage at Motor output:

$$U_{Aeff} = \frac{U_{PS,DC}}{2} * \frac{1}{\sqrt{2}} * 1.2 \quad \text{(1.2=factor overmodulation)}$$

Effective Output current at motor output:

$$I_{Aeff} = I_{Phase}$$

Calculated maximum output power:

$$P_{load} = U_{Aeff} * I_{Aeff} * 2 * cos(\varphi) \text{ (Sum of Motor phases A and B)}$$

The output power plus the power losses in the power stage (factor 1.05) needs to be delivered from the power supply:

$$I_{PS,DC} = \frac{P_{load}}{U_{PS,DC}} * 1.05 = 2 * \frac{U_{PS,DC}}{2} * \frac{1}{\sqrt{2}} * 1.2 * I_{Phase} * cos(\varphi) * \frac{1}{U_{PS,DC}} * 1.05$$

With $cos(\varphi) \approx 0.9$ (which is already an optimistic high value) it results:

$$\boldsymbol{I_{PS,DC} = I_{Phase} * 0.80}$$

Use $I_{PS,DC} = I_{Phase} * 0.80$ to calculate the needed current for the power stage supply.

If using CMMS-ST / CMMO-ST in open loop mode, use the **rated current** for calculation.

If using CMMO-ST in closed loop mode, use the **rated current** for calculation.

If using CMMS-ST in closed loop mode you have to calculate with the **boost current**.

5.2 List of supported motor types and rated motor current in open loop and closed loop mode

CMMS-ST

Motor type	Rated current (open loop)	Boost current (closed loop)
EMMS-ST-28-L	1.4 A	1.8 A
EMMS-ST-42-S	1.8 A	2.2 A
EMMS-ST-57-S	5 A	5.4 A
EMMS-ST-57-M	5 A	5.4 A
EMMS-ST-87-S	8 A	8.4 A
EMMS-ST-87-M	8 A	8.4 A
EMMS-ST-87-L	8 A	8.4 A

Table 5.1:

If using CMMO-ST there are different rated current values. Controller has a limit of 5.7 A

Motor type	Rated current
EMMS-ST-28-L	1.4 A
EMMS-ST-42-S	1.8 A
EMMS-ST-42-SS (EPCO)	3.0 A
EMMS-ST-57-S	5.0 A
EMMS-ST-57-SS (EPCO)	4.2 A
EMMS-ST-57-M	5.0 A
EMMS-ST-87-S	5.7 A
EMMS-ST-87-M	5.7 A
EMMS-ST-87-L	5.7 A

Table 5.2:

If you use CMMO-ST, please add the current needed for the motor brake.

5.3 Power Stage Supply: Estimated current Consumption for CMMS-ST

Example 1: CMMS-ST + EMMS-ST-42-S in closed loop

$$I_{Boost} = 2.2\ A$$

$$I_{PS,DC} = 0.8 * 2.2\ A \approx 1.8\ A$$

Example 2: CMMS-ST + EMMS-ST-87-L in open loop

$$I_{Rated} = 8.0\ A$$

$$I_{PS,DC} = 0.8 * 8.0\ A \approx 6.4\ A$$

5.4 Power Stage Supply: Estimated current Consumption for CMMO-ST

Example 1: CMMO-ST + EMMS-ST-57-SS in closed loop

$$I_{Rated} = 4.2\ A$$

$$I_{MotorBrake} = 0.3\ A$$

(Current for motor brake will be delivered from Power Stage Supply at CMMO-ST!)

$$I_{PS,DC} = 0.8 * 4.2\ A + 0.3\ A \approx 3.7\ A$$

Example 2: CMMO-ST + EMMS-ST-87-L in open loop

$$I_{Rated} = 5.7\ A$$

$$I_{PS,DC} = 0.8 * 5.7\ A \approx 4.6\ A$$

6 Real application – measured currents and proof of calculation

6.1 CMMS-ST with Power Stage supply 48 V

6.1.1 Equipment

- CMMS-ST-C8-7-G2
- EMMS-ST-87-S-S-G2
- Power stage Supply 48 V DC
- Open loop

Calculated load current (see example 2, chapter 5.3) $I_{PS,DC}$ = 6.4 A

6.1.2 Measurement

Starting with motor running at constant speed.
Load torque increasing with constant slew rate over time
After approx. 5.5 s the load torque is higher than the peak torque of the stepper motor and the speed reversals.
The peak current at highest load, respectively highest output power reaches approx. 6.5 A

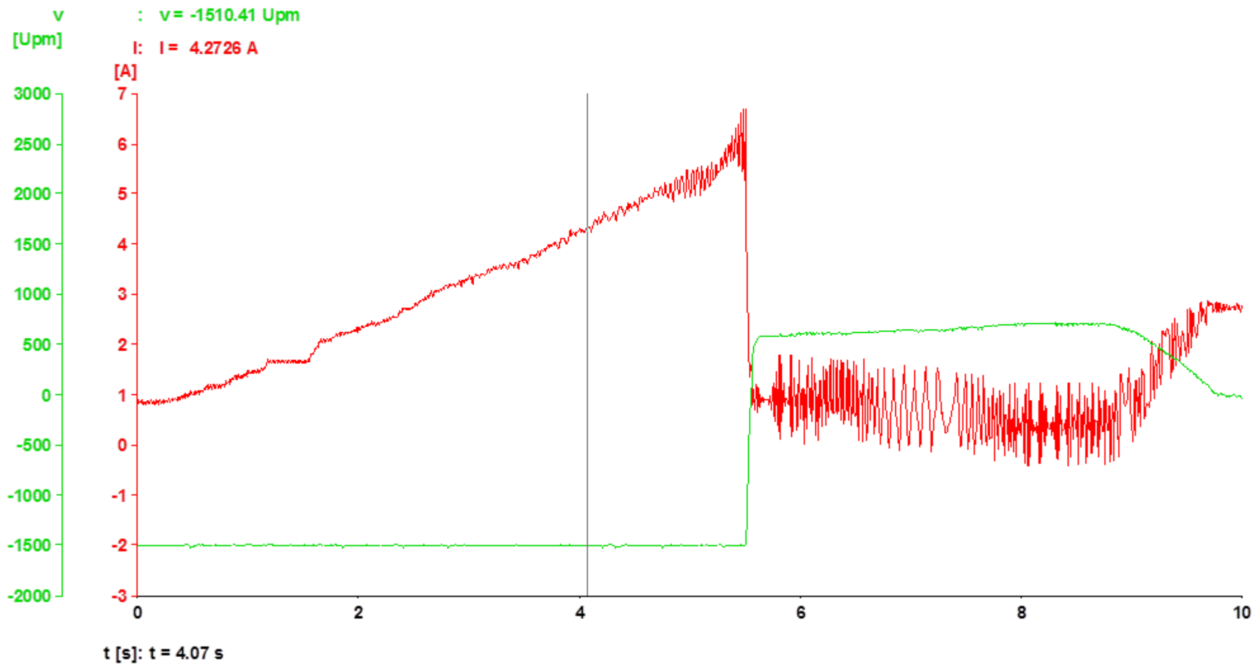

Fig. 6.1: Graph

6.2 CMMS-ST with Power Stage supply 24 V

6.2.1 Equipment

- CMMS-ST-C8-7-G2

- EMMS-ST-87-S-S-G2

- Power stage Supply 24 V DC

- Open loop

Calculated load current (see example 2, chapter 5.3) $I_{PS,DC}$ = 6.4 A

6.2.2 Measurement

Starting with motor running at constant speed.
Load torque increasing with constant slew rate over time
After approx. 5 s the load torque is higher than the peak torque of the stepper motor and the speed reversals
The peak current at highest load, respectively highest output power reaches approx. 6.3 A

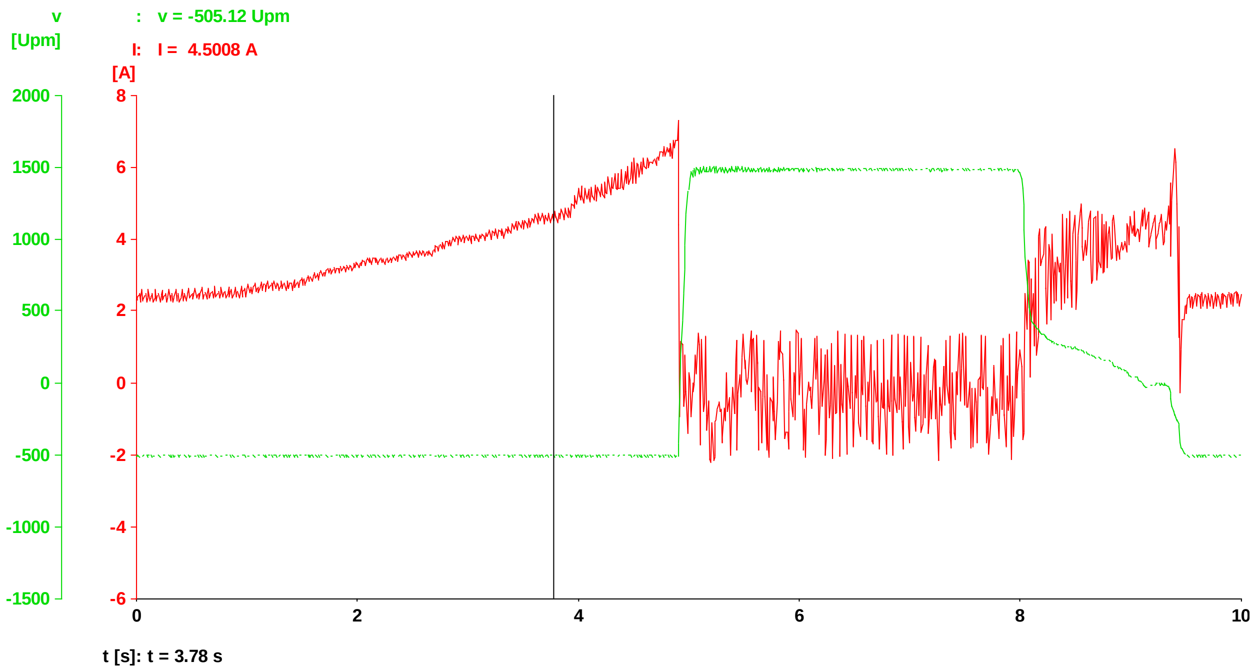

Fig. 6.2: Graph

6.3 CMMO-ST with Power Stage supply 24 V

6.3.1 Equipment

- CMMO-ST-C5-1-DIO

- Power stage Supply 24 V DC

- Open loop

Calculated load current (see example 2, chapter 5.4) $I_{PS,DC}$ = 4.6 A

6.3.2 Measurement

Starting with motor running at constant speed.
Load torque increasing with constant slew rate over time
After approx. 5.5 s the load torque is higher than the peak torque of the stepper motor and the speed reversals.
The peak current at highest load, respectively highest output power reaches approx. 4.6 A

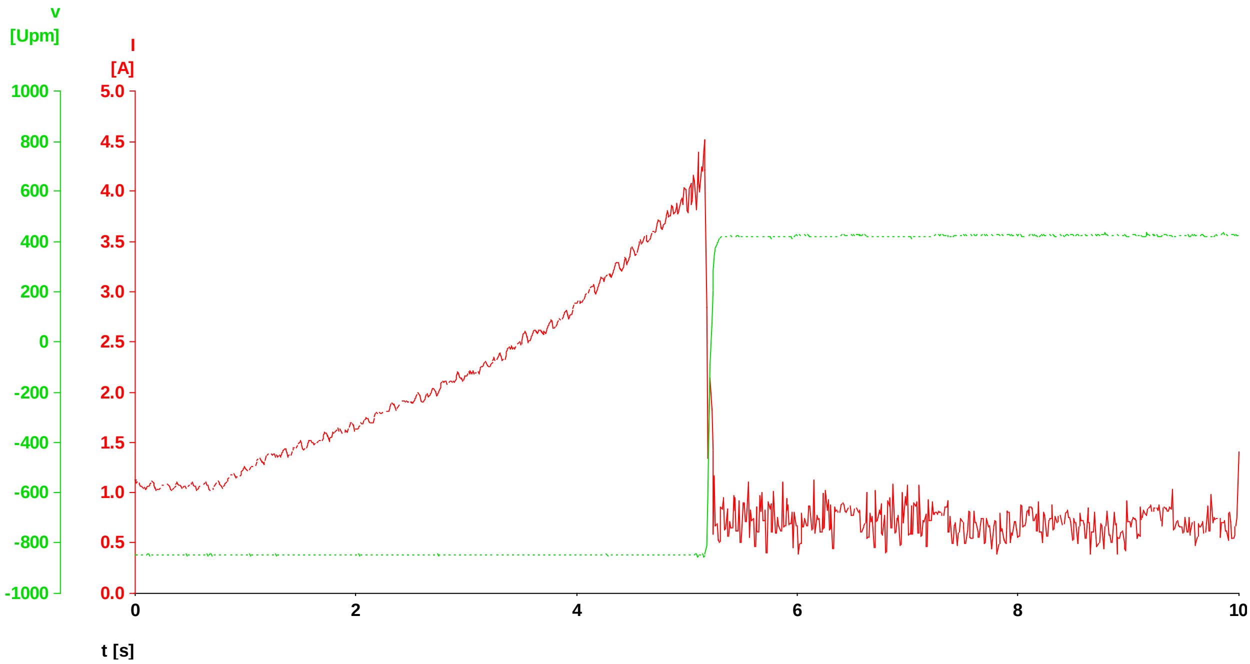

Fig. 6.3: Graph

7 Further hints / comments

7.1 Using CMMS-ST and CMMO-ST in open loop mode

If you are using CMMS-ST and CMMO-ST in open loop mode, you need to calculate with the full rated current of the motor.

7.2 Using CMMS-ST and CMMO-ST in closed loop mode

If you are using CMMS-ST and CMMO-ST in closed loop mode, the motor current will be determined by the load. The calculation in chapter 5 is a worst case calculation. Depending on the application, a smaller power supply might be sufficient, if the load current does not reach the rated current.

Maybe it is possible to reduce the setting of the rated current in your application, and then you should re-calculate according to chapter 5.

7.3 Initial sequence to find the right encoder angle offset for commutation

The Controllers have to find the right encoder offset angle each time the power stage is enabled.

CMMS-ST and CMMO-ST detect the encoder angle with the first "Controller enable" after power on. For this function the CMMS-ST uses the boost current. The CMMO-ST uses the rated current. Make sure the used power supply can provide the boost current*0.8 in case of CMMS-ST and rated current *0.8 in case of CMMO-ST.

7.4 Current peak at power stage enable

Each time you enable the power stage of the controller, a small current peak might occur. If this current peak triggers the overload circuit of your power supply do the following: If you are using several Controllers in one machine it is useful to enable the controllers one by one or in groups with a small time delay.

300ms for CMMS-ST

800ms for CMMO-ST.

7.4.1 Example CMMO–ST

Machine with 16 axes. The load current of one axis is 1 A, but the rated current is 4.2 A.

During the run is approximately 16 A load current necessary, but if all controllers get the "Controller enable" at the same time, the current can rise up to 16* 4.2 A* 0.8 =53.76 A

7.5 CMMS-ST with 24 VDC load voltage

Make sure you have the right settings if only one Power supply 24 VDC is used for control voltage and load voltage, because there may occur higher regenerative voltages during operation.
These voltages are limited via the internal brake chopper.
Therefore, it is absolutely necessary to parameterize the proper load voltage in the

FCT project. (page "configuration")

An incorrect setting may cause damage to the controller.

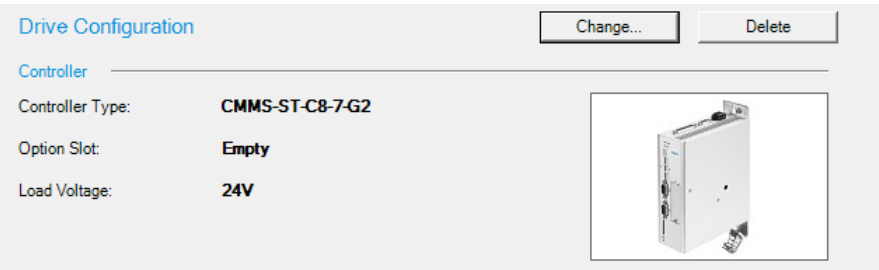

Fig. 7.1: Screenshot

7.6 Inrush current peaks

Because of capacities in the intermediate circuit and the logic cuircut there will be an inrush current peak during power on. This current peaks will occur by switching on the 24 VDC logic supply and by switching on the load voltage.

This current peaks will be limited by the used Festo power supply due to current limitation.

- Make sure your power supply has a current limitation and is short circuit proofed.
- Do not use any power supplys with fold back characteristic or immediate current shut of at peak current condition.
- Only use power supplies, which are capable to deliver the inrush currents without switching of.

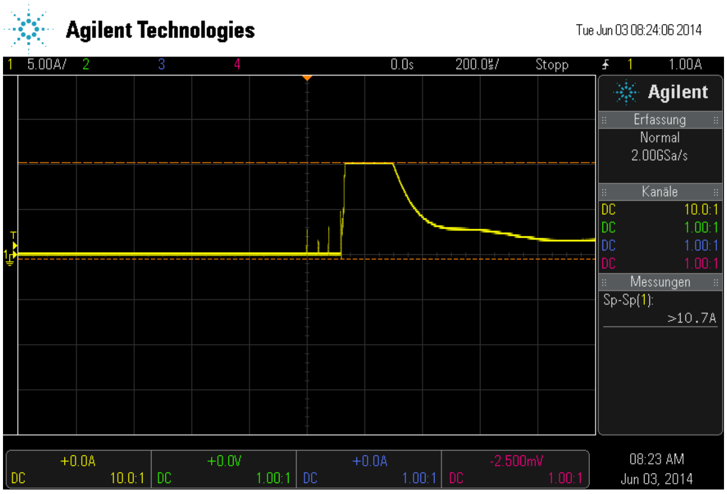

Fig. 7.2: Example: CMMS-ST logic 24 VDC power on with Festo 10 A power supply

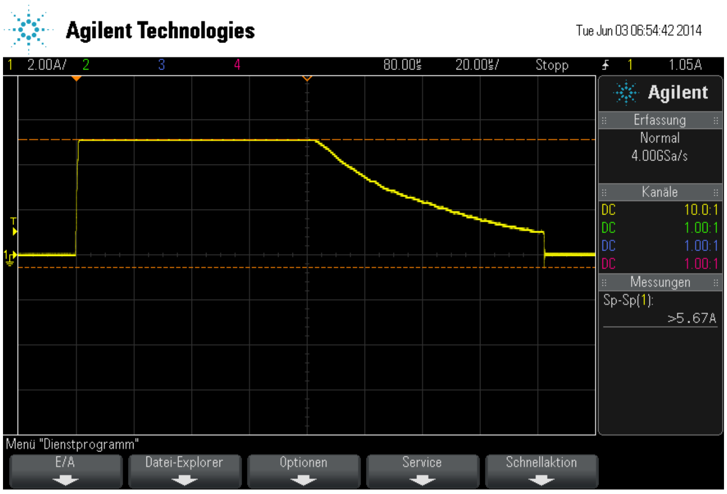

Fig. 7.3: Example: CMMO-ST logic 24 VDC power on with Festo 5 A power supply

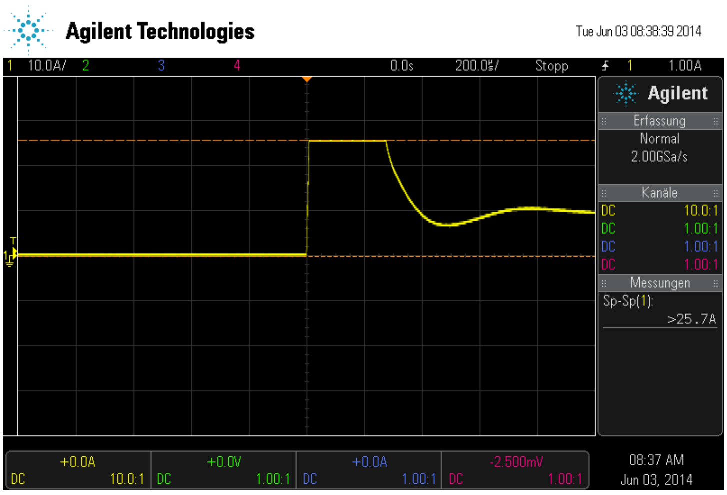

Fig. 7.4: Example: CMMS-ST load voltage 48 VDC power on with Festo 10 A power supply

A Technical appendix

A.1 Technical data

A.1.1 General

⚠ **Warning**
Type and source of danger if personal damage.
Result if disregarded.
Action to avoid danger.

B Index