EN

AG 0101

Drive Optimisation

Guideline for PMSM - CFC Closed-Loop

NORD DRIVESYSTEMS

Documentation

Title:	AG 0101	
Order – No.:	6047602	
Series:	SK 200E, SK 500E	
FI series:	SK 200E, SK 210E, SK 220E, SK 230E, SK 205E, SK 215E, SK 225E, SK 235E, SK 520E, SK 530E, SK 535E,SK 540E, SK 545E	
FI types:	**SK 2xxE-111-123-A**	(1.1 kW, 1 ~ 220 - 240 V)
	SK 2xxE-111-323-A ... SK 2xxE-112-323-A	(1.1 - 5.5 kW, 3 ~ 220 - 240 V) [1]
	SK 2xxE-111-340-A ... SK 2xxE-551-340-A	(1.1 - 5.5 kW, 3 ~ 380 - 500 V)
	SK 5xxE-111-323- ... SK 5xxE-221-323-	(1.1 - 2.2 kW, 1/3 ~ 230 V)
	SK 5xxE-301-323- ... SK 5xxE-551-323-	(3.0 – 5.5 kW, 3 ~ 230 V)
	SK 5xxE-111-340- ... SK 5xxE-551-340-	(1.1 – 5.5 kW, 3 ~ 400 V)

[1)] Size 4 (5.5) only in the versions SK 2x0E

Version list

Title, Date	Order number	Version	Remarks
AG 0101, August 2016	6047602 / 3216	1.0	First edition, based on the manuals BU 0200 GB / 1216, BU 0210 GB / 2509, BU 0500 GB / 0715, BU 0505 GB / 0715, BU 0510 GB / 3911

Table 1: Version list AG 0101

Publisher

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General information

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Completeness and correctness

This application description is not binding and does not claim to be complete with regard to the structure and parameterisation of components.

Every care has been taken to ensure that the contents of this application description are correct. However, in case of deviations between the application description and other documentation (e.g. Manuals) the content of the other documentation has priority.

NOTICE	**Application**

This application example is only valid in combination with the operating instructions of the respective frequency inverters and technology options. This is an essential prerequisite for the availability of all the relevant information required for the safe commissioning of the frequency inverter.

Exclusion of liability

This application document is an aid for the installation and parameterisation of an application with NORD products. The description is based on an example for a specific application and can be used as orientation for comparable applications.

As this is an example, Getriebebau NORD GmbH & Co. KG does not accept any liability for injury or material damages and does not grant any warranty, either explicitly or implicitly with regard to the information contained in this application description.

Information about this guide

This application guide is primarily intended for planners as well as commissioning and service personnel, who are familiar with the use and function of electronic drive technology (motors and frequency inverters) from Getriebebau NORD. The guide is a recommendation for the step-by-step commissioning and parameterisation of the individual controller and function settings as well as the procedure for optimisation of the drive unit or controller.

The information and recommendations relate to currently available drive units and control components or controller settings, preferably standard products from Getriebebau NORD. The guide refers to current drive technology software and hardware versions, which were valid at the time of publication of this guide. Optimisation procedures must be carried out in observance of the current manuals and drive technology data sheets. The versions of the manuals and technical data sheets may differ.

Information and explanations for the use of this application guide are given below.

Structure symbols

Individual section areas and application steps are provided with the following structure symbols in order to provide "familiar" users with graphical or quicker orientation:

Identification	Meaning
Step 1	The **Step** (1, 2, etc.) serves to provide "familiar" users with a quicker overview for the use of the guide. In places, the steps can also be used as cross-references, or as hyperlinks, see 🕮 1.3 "Overview (schematic procedure)".
Information	The **Information** indicates that the following is only stated as information for the corresponding area of the section and provides the user with detailed or helpful additional information.
Instructions	The **Instructions** indicate that in the following, the user is required to take action, e.g. for parameterisation, testing or optimisation.
Information & instructions	**Information** & **Instructions** indicate that in the following, helpful additional information as well as the requirement for action by the user is described.

Fig. 1: List of structure symbols

Cross-references and hyperlinks

For quicker and easier use of the guide, cross-references are prefixed with a symbol 🕮. With a mouse click on the cross-reference - see 🕮 9.1 "Manuals" the user can directly access the appropriate section, information or the relevant document.

In addition, hyperlinks (e.g.M7000 Electric Motors) are used, with which the user can directly access the relevant manual, data sheet, contact partner, etc. on the Getriebebau NORD homepage..

User symbols

By means of certain hand symbols, etc. the user is presented with important indications of additional information, curves and the objective of the optimisation of the controller.

☝	Observance and indication of important additional information
☞	Definition and objective of the optimisation to be made
👍	Partial success for an optimised curve for optimisation of controllers
✓	Objective of an optimum curve for the optimisation of the controller

Fig. 2: List of user symbols

Symbols

🕮	Indication of further information
🔄	Automatic parameter change
→	Change to
✋	manual parameterisation
👓	Check the display
*	Footnotes / deviations, e.g. device types
[V]	Unit of the parameter value
[-01]	Array No.
{1}	Function No. / Value
{1 = Off}	Description of function, the function number corresponds to the name of the function

Fig. 3: List of symbols

Parameters

The indication of individual parameters has been selected so that parameters which are shown in "**bold**" type, e.g. **Motor list P200** indicate their relevance within a section. If the parameter is not written in "bold" type, e.g. Weak field limit P320, this is only subordinate information, or is not explained further.

Due to certain configurations, the parameters are subject to certain conditions. The relevant / used explanation symbols are listed below:

Parameter No. [-Array]		Name [Unit]		Factory setting	Setting related to parameter set (P1, ... , P4)	
MOTOR DATA/ CHARACTERISTIC CURVE PARAMETERS					**NORD motor** ⑦	**Third party motor** ⑧
P240 ①	(P) ②	EMF voltage PMSM [V] ④		⑥ 0	**0 → 341**	**0 → 296**
P241	[-01] ③	Inductance PMSM (d axis) [mH]	⑤	20	**20 → 22.6**	⑨ **20 → 24.3**
P241	[-02]	Inductance PMSM (q axis) [mH]		20	**20 → 45.9**	**20 → 24.3**

① Parameter number

② Parameters (P) depend on parameter sets, see 🕮 Parameter P100, Supervisor parameters (S) depend on the setting, see 🕮 Parameter P003

③ Array value and description of the array parameter

④ Parameter text: Name / meaning of NORD CON display text

⑤ Parameter unit

⑥ Default value (factory setting) of parameter

⑦ Parameter setting for NORD motors

⑧ Parameter setting for third party motors

⑨ Usage symbols, see 🕮 Symbols

Fig. 4: List of parameter indications

Names of parameters and functions

In the following, for example, a parameter is described with its name, number and with the corresponding selected function (number and name):

Motor list ① **P200** ② with selection of the function {**109** ③ = **3.0 kW 400 V 100T2/4** ④}

① Parameter name

② Parameter number

③ Function number

④ Description of function / Name of function or NORD CON display text

Fig. 5: Overview of names of parameters and functions

Overview for experienced user

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1 Introduction

This guide explains the step-by-step procedure for optimisation of the individual control functions, as well as the parameterisation which is to be carried out in the particular frequency inverters.

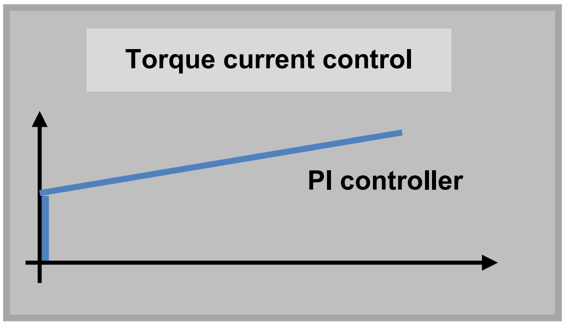
Only **CFC closed-loop mode** is considered, which has the following advantages compared with operation in VFC open-loop mode:

- High torques – Rigidity
- Full torque at speed "zero"
- High speed precision
- Short control times possible

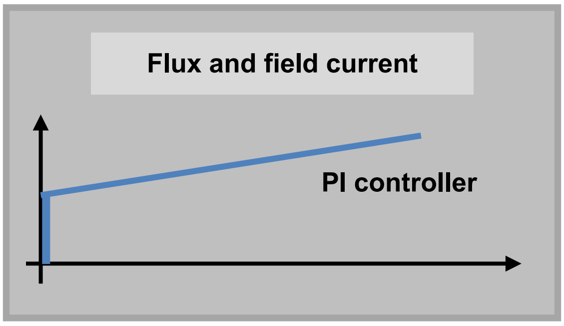
CFC closed-loop mode, also known as servo mode, is an operating mode with speed feedback.

Several different control functions are implemented in decentralised SK 2xxE frequency inverters as well as in type SK 5xxE control cabinet versions.

This provides the possibility of individually optimising the functional and application-specific requirements of the application which is to be implemented by means of the 4 available controllers.

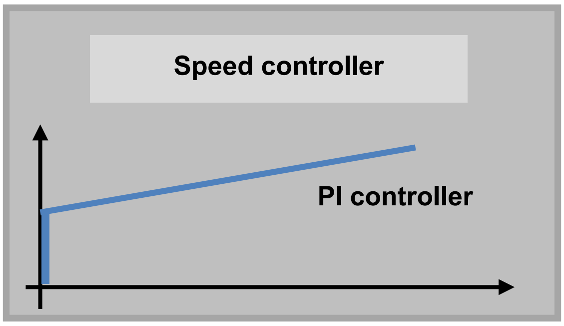


Parameters: P312, P313, P314



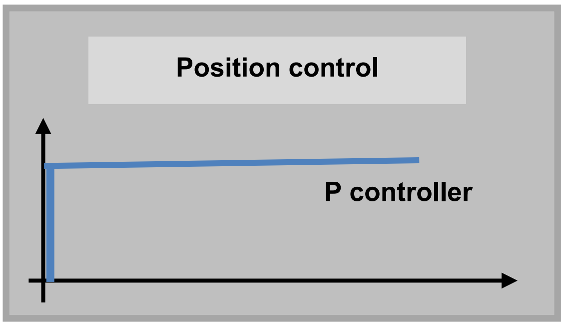
Parameters: P315, P316, P317

Fig. 6: Current controller



Parameters: P310, P311, P112

Fig. 7: Speed controller



Parameter: P611

Fig. 8: Position control

This guide for the optimisation of drive units uses the example of a decentralised **SK 200E-401-340-A** frequency inverter in combination with a **3.0 kW** NORD IE4 synchronous motor (IPMSM, i.e. **I**nterior **P**ermanent **M**agnet **S**ynchronous **M**otor) with **NORD CON** oscilloscope recordings.

A guide is available to assist in planning and commissioning, which was specially produced for IE4 synchronous motors from Getriebebau NORD. Further details are described in the Technical Information TI 80_0010, see 🕮 9.3 "TIs - Guidelines"

The correct connection of the components to the control and power terminals, as well as further information about the functions used can be obtained from the relevant manuals, see 🕮 9.1 "Manuals".

If the different names (e.g. connection terminals, parameter structure) are taken into account, this guide can also be used analogously for other performance levels of the decentralised **SK 2xxE** and **≥ SK 520E** control cabinet frequency inverter types.

1.1 Introduction to controller optimisation

A controller uses the principle of continuous:

Measuring – Comparison – Provide

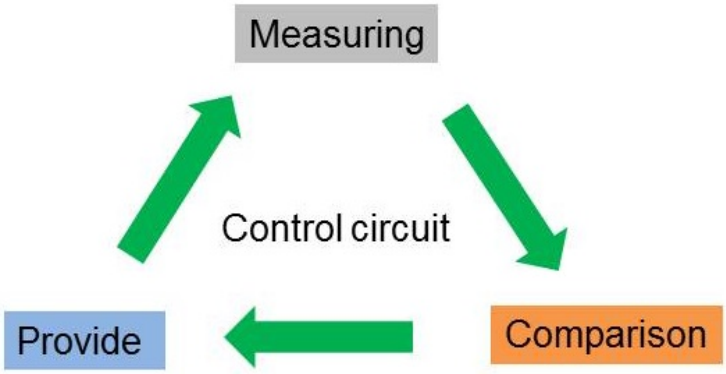


Fig. 9: Control loop

The **value to be controlled** is measured with sensors (e.g. incremental encoders). The value to be controlled is compared with the **setpoint**. The difference is the **deviation**. From the deviation, the value for the adjustment is determined with consideration of the dynamic characteristics of the **control route**.

A control loop is used to bring a specified physical value, the so-called control value, to a required value (setpoint) and to maintain this value, regardless of any disturbances which may occur. To carry out the control task, the momentary value of the control value - the **actual value** - is measured and continuously compared with the setpoint. In case of deviation, adjustment must be made in a suitable manner and a response made as soon as possible. Control technology is used to technically perform this task. This is essentially based on the mathematical description and modelling of the control loop system. Stated simply, the main components of the control loop are the **controller** and the **control route**.

From the deviation, the controller determines the corrective measures required in consideration of the dynamic characteristics of the control route and makes the adjustment accordingly. The control route is the part of the control loop which is controlled by the controller.

(Source: see www.rn-wissen.de**)**

Information **Optimisation information**

For optimal optimisation of the individual controllers, the following operating conditions should be taken into account in the optimisation procedure.

- Current control in static operation without load
- Speed and position control in dynamic operation under load

Application-specific conditions must also be taken into account for the optimisation.

1.2 Field-orientated control

To begin with, some information about the motor model or **field oriented control**, also known as current vector control, in the frequency inverter.

With a field-oriented **PMSM- model** (**P**ermanent **M**agnet **S**ynchronous **M**otor) the 3-phase currents and voltages are stated as space vectors, which consist of the components "**d**" and "**q**".

The following diagram shows the orientation of the d component of the rotating coordinate system for the field of the **PMSM** rotor in the space vector or the **vector diagram**.

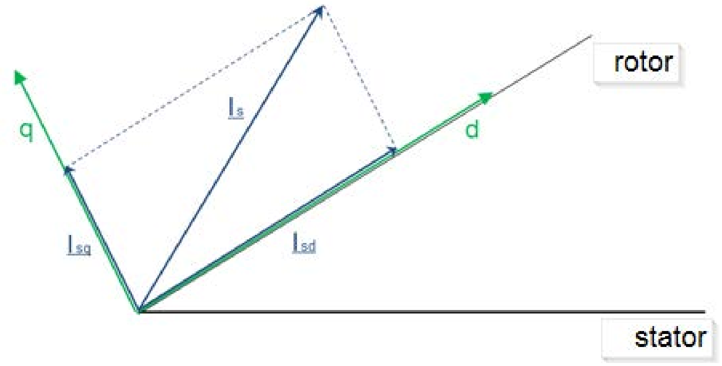


Fig. 10: Current vector diagram

I_s:	Line motor current (≈ Nominal current)	*[A]*
I_{sd}:	Weak field current (set by control to 0 ≈ No-load current)	*[A]*
I_{sq}:	Torque-forming current (torque current (≈ rotor current)	*[A]*

The **current components** I_{sd} (field weakening current / ≈ Actual **field current** P721) and I_{sq} (torque-forming current, ≈ Act. **Torque current** P720) are normal to each other. I_s is the total line current (≈ Actual **current** P719).

The following simplified relationships result in association with this:

$$I_s = \sqrt{(I_{sd}^{\ 2} + I_{sq}^{\ 2})}$$

CFC Closed-Loop mode: In the basic speed range, up to the rated frequency $I_{sd} = I_0$ = no load current.

I_s:	*Line motor current (P203 / ≈ P719)*	*[A]*
I_{sd}:	*Field weakening current (P209 / ≈ P721) to be set to "0"*	*[A]*
I_{sq}:	*Torque-forming current or rotor current (≈ P720)*	*[A]*

1.2.1 Torque calculation

The **torque M** is calculated with the following formula:

$$M \approx \Phi \cdot I_{sq}$$

M:	*Torque*	*[Nm]*
Φ:	*Magnetic flux*	*[Wb]*
I_{sq}:	*Torque-forming current or rotor current (≈ P720)*	*[A]*

In other words, if I_{sq} increases, the **torque M** must also increase.

1.3 Overview (schematic procedure)

Step	Description of procedure / Optimisation procedure	🕮 Documentation / Section Further information
"Step 1"	**Hardware** Selection, setup and connection – Installation and connection work – Power and control terminals – DIP switches – Motor connection (check Y / ▲) – Synchronous motors (PMSM, IPMSM, SPMSM) – Frequency inverter ↔ Assignment of asynchronous motor – Encoder resolution – Selection of encoder system (IG / AG) – Selection of encoder type: Data for incremental and / or absolute encoders, universal encoders	🕮 Manual BU 0200 🕮 Manual BU 0500 🕮 Manual BU 0505 🕮 2 "Hardware"
"Step 2"	**Basic commissioning / Motor data** Parameterisation according to motor list, type plate and data sheet – NORD CON parameterisation – Modification of operating displays – Adjustment of the maximum frequency (P105) – Selection of motor manufacturer or motor data – Motor list, motor type plate or data sheet (contact the motor manufacturer if necessary) – 🕮 Motor data / Characteristic curve parameter (P2xx) – NORD- motor or third party motor parameter identification (P220) (identification R_S or identification motor) – Stator resistance (P208), check display – Voltage constant k_e, Stator inductances L_d / L_q – EMF voltage PMSM (P240) – PMSM inductance (P241) [-01] & [-02] – Reluctance angle IPMSM (P243) – Peak current PMSM (P244) – Mass inertia PMSM (P246), 🕮 Mass inertia – Optimisation of specific motor data for third party motors	🕮 NORD CON – Manual BU 0000 🕮 Manual BU 0200 🕮 Manual BU 0500 🕮 Manual BU 0505 3.3 "Motor data"

↓

"Step 3"	**Incremental encoder (IG)** Parameterisation, connection and commissioning	
	– Incremental encoder data – 🕮 Control parameter (P3xx) – Incremental encoder (P301) – Encoder with zero track – Sync. 0-pulse (P335) – Control terminals (P420 [-01] ... [-03]) – Connection, see 🕮 Technical Data Sheet – Function test of IG rotary encoder – Speed feedback / Servo mode (P300)	🕮 Manual BU 0200 🕮 Manual BU 0500 🕮 Manual BU 0505 3.5 "Incremental encoder (IG)"
	Absolute encoder (AG) Parameterisation, connection and commissioning	
	– CANopen combined absolute encoder with incremental encoder – Absolute encoder data – 🕮 Additional parameter (P5xx) and positioning parameter (P6xx) – Encoder resolutions (P605) – Set CANopen parameters (P514 & P515) – Connection, see 🕮 Technical Data Sheet – Function test for CANopen AG encoders	🕮 Manual BU 0210 🕮 Manual BU 0510 3.6 "Absolute encoder (AG)"
	Procedure for determining the start position of the rotor Selection and parameterisation of rotor position identification	
	– PMSM control method (P330) – Encoder offset PMSM (P334) – Sync. 0-pulse encoder (P335), 🕮 Incremental encoder	**Fehler! Verweisquelle konnte nicht gefunden werden. "Fehler! Verweisquelle konnte nicht gefunden werden."**

"Step 4"	**Current control** Torque current controller (P312, P313, P314) Field current controller (P315, P316, P317)	
	– Adjust no load current (P209) – NORD CON Remote control – NORD CON Oscilloscope trigger, scan time, channel settings, etc. – Torque current controller P (P312) – Torque current controller I (P313) – Field current controller P (P315) – Field current controller I (P316)	4 "Current control"

"Step 5"	**Speed control** Speed controller (P310, P311) – Acceleration time (P102) – Jog frequency (P113) – NORD CON Remote control – NORD CON Oscilloscope trigger, scan time, channel settings, etc. – Speed Ctrl P (P310) – Speed Ctrl I (P311)	5 "Speed control"
↓		
"Step 6"	**Position control / Positioning** Position controller (P611) – Activate position controller (P600) – Travel sensor system (P604 [01] & [02] & [03]) – Setpoint specification & setpoint mode (P610) – Positioning parameters (P607 to P609 & P612) – Positions (P613 [01] to [63]) – NORD CON Control – NORD CON device overview trigger, scan time, channel settings, etc. – Position controller P (P611)	🕮 Manual BU 0210 🕮 Manual BU 0510 6 "Position control"
↓		
"Step 7"	**Reluctance torque** Reluctance angle IPMSM (P243) – Only for **IPMSM** type **third party motors** – NORD CON Remote control – NORD CON device overview as necessary – NORD CON Oscilloscope trigger, scan time, channel settings, etc. – Operate the motor under normal operating conditions / at the operating point under the nominal load – Optimise the reluctance angle IPMSM (P243)	🕮 Manual BU 0200 🕮 Manual BU 0500 🕮 Manual BU 0505 7 "Reluctance torque"

Table 2: Flow chart for procedure

⚠ DANGER!	Danger to life

The **correctness of each individual commissioning step must be checked** with a function test. Suitable **precautions** must be taken to prevent damage to the system or danger to persons if the system behaves incorrectly (e.g. brake control for lifting equipment, mechanical coupling of parallel drives, etc.)

2 Hardware

Step 1

Information

The factory settings of all frequency inverters supplied by Getriebebau NORD are pre-programmed with the default setting for standard applications with 4 pole asynchronous motors (ASM) with the same voltage and power.

In addition, the motor data for all **IE4 synchronous motors** (IPMSM) produced by NORD for the power range from **1.1 kW** to **5.5 kW** are saved in the frequency inverter. For use with permanently excited synchronous motors from other manufacturers, the data from the type plate or data sheet of the motor must be entered.

In principle, the frequency inverters are operable in this configuration and can be further configured according to the requirements of the application,. This includes settings such as the encoder system, ramp times and interfaces and possibly the bus system configuration.

Configuration can be carried out to a limited extent with the integrated DIP switches (see 🕮 9.1 "Manuals").

Information **Configuration via DIP switch**

Mixing of DIP switch configuration and (software) parametrisation should be avoided. DIP switch settings for the frequency inverter have priority over parameter settings.

2.1 System components

For this guide, a 4 kW frequency inverter / 3 kW motor combination was used for the test setup.

Number	Designation	Nominal ratings
1	Frequency inverter SK200E	SK 200E-401-340-A
1	SK 200E connection unit	SK TI4-2-200-3
1	3.0 kW or 4.0 kW, synchronous motor (IPMSM),IE4, 4-pole	SK 100 T2/4 BRE40 TF IG+AG
1	CANopen absolute encoder with incremental track / AG4	Resolution 8192/4096 pulses
1	External brake resistor, 400 Ω, 100 W	SK BRE4-1-400-100

Table 3: System components

With these system components, examples of the individual optimisations of the controllers are illustrated in the following sections on the basis of NORD CON oscilloscope images.

Information **Version status**

Due to software updates, the parameters described in this guide may differ from those in the firmware version for the frequency inverter which is used. Because of this, care should be taken that both the current **NORD CON version** and the **software version** of the latest **firmware version** (see 🕮 **Software version parameter P707**) correspond to that of the frequency inverter.

IE4 synchronous motors produced by Getriebebau NORD have only been implemented as of **NORD CON** Version **V2.3**.

2.2 Synchronous motors (PMSM / IPMSM)

Synchronous motors **PMSM (P**ermanent **M**agnet **S**ynchronous **M**otor), like Getriebebau NORD IE4 synchronous motors **IPMSM** (**I**nterior **P**ermanent **M**agnet **S**ynchronous **M**otor) are energy-saving drives, which may **only** be operated with **frequency inverters**!

At present, Getriebebau NORD supplies synchronous motors with efficiency class **IE4** in the **power range** from **1.1 kW** to **5.5 kW**.

NOTICE	**Mains operation**

Synchronous motors and IE4 motors produced by Getriebebau NORD **must not** be operated directly from the **mains**! A **safety label** on the drive unit explicitly warns the user of this.

Failure to comply with this may cause damage to the synchronous motor due to impermissible currents in the components.

The specific NORD synchronous motors are equipped with permanent magnets which are located in the rotor package. These are inserted in recesses and are known as so-called IPMSMs. Due to their high efficiency, they offer the advantage of energy saving, especially for applications with long operating times (S1 operation).

None of the **IE4 synchronous motors** from Getriebebau NORD are **servo motors**.
Due to the control response times and the electrical time constants, their dynamic behaviour is definitely comparable with motors (ASM) with efficiency class IE1 and IE2.
Motors specific to NORD (i.e. so-called NORD motors) with efficiency class IE4 **do not have any slip**. They are designed for various nominal speeds or operating points:

1. 2100 rpm at 70 Hz, 400 V in Y or 230 V in ▲
2. 3000 rpm at 100 Hz, 400 V in ▲

Information	**Third party motors**

Synchronous motors or **brands** from other **manufacturers** (i.e. so-called third party motors) can be operated by frequency inverters manufactured by Getriebebau NORD.

However, in general **all frequency inverter – synchronous motor combinations** should be checked in advance by **Getriebebau NORD**!

2.3 Frequency inverter - motor assignment

Synchronous motors (PMSM) and IE4 synchronous motors (IPMSM) from Getriebebau NORD can be operated with either decentralised SK 2xxE frequency inverters or the control cabinet versions SK 5xxE with all performance levels.

As with asynchronous motors, the selected allocation of the **frequency inverter** to the **synchronous motor** (PMSM / IPMSM) is primarily made according to the **power** and the **current**.

Frequency inverter power	≥	*Nominal motor power*
Nominal frequency inverter current	≥	*Nominal motor current*

NOTICE **Drive unit load**

The assignment of synchronous motors to the particular frequency inverters applies for operation up to the nominal speed.

Higher **speeds** and **overloads** require special planning or **consultation** with **Getriebebau NORD**.

Failure to comply with this may cause damage to the motor or the gear unit due to impermissible loads on the components.

Information **Third party motors**

In principle, IE4 synchronous motors from Getriebebau NORD can be operated with frequency inverters from other manufacturers. However, the customer is responsible for the success of commissioning. Also, the performance of the motor, or the achievement of efficiencies which correspond to the IE4 classification depends on the frequency inverter and its function and settings.

2.4 Encoder resolution selection

For the correct selection of the **rotary encoder** with regard to the maximum **resolution**, the maximum limiting frequency should be taken into account using the following rule-of-thumb:

$$\frac{f_{\max} \times 60}{n_{\max}} = \textit{Encoder resolution}$$

$$\frac{205000\ [Hz] \times 60\ [s]}{n_{max}\ [\mathrm{rpm}]} \geq \textit{Encoder resolution}\ \text{"[Pulse number}_{\max}\text{]"}$$

$$\frac{205000\ [Hz] \times 60\ [s]}{1500\ [rpm]} = 8200$$ 8200 ≥ 8192 Pulses Encoder resolution ($n_{max} = 1500\ rpm$)

$$\frac{205000\ [Hz] \times 60\ [s]}{3000\ [rpm]} = 4100$$ 4100 ≥ 4096 Pulses Encoder resolution ($n_{max} = 3000\ rpm$)

f_{max}:	*maximum limiting frequency for digital inputs*	*[Hz]*
n_{max}:	*maximum speed of motor*	*[rpm]*

All standard encoders defined by Getriebebau NORD, i.e. the recommended encoder systems and types enable "safe" operation within a very wide adjustment range (e.g. 0 to 100 Hz). I.e. the minimum Pulse number$_{min}$ has already been taken into account with regard to encoder resolution.

2.5 Selection of the incremental encoder (IG)

The correct selection, parameterisation and connection of an **HTL- incremental encoder** (**IG**) to a decentralised **SK 2xxE** frequency inverter as well as a **TTL incremental encoder** or **sine wave encoder** (e.g. **SIN/COS encoder**) to an **SK 53xE** or **SK 54xE** control cabinet frequency inverter are described in greater detail in previous or further sections.

Various encoders with a cable length of 1.5 m are defined as **standard incremental encoders** by Getriebebau NORD:

Fig. 11: Standard incremental encoders

NORD data			Power supply	Incremental encoder resolution	
FI type	**Part no. Supplier**	**Designation**	**Voltage / DC**	**Type**	**Increments**
SK 2xxE	19551021 Fritz Kübler GmbH	IG 42 10-30 V HTL 4096 D12 5820 1,5 m	10 … 30 V	HTL / Push-pull	4096 pulses
SK 53xE SK 54xE	19551022 Fritz Kübler GmbH	IG 41 10-30 V TTL 4096 D12 5820 1,5 m	10 … 30 V	TTL / RS422	4096 pulses

Table 4: Standard incremental encoders

Taking into account the **maximum limiting frequency** for the selection of the encoder, the **highest possible resolution** should be selected and if possible, an encoder system with a **power supply** of **10 … 30 V** should be used.

Technical data for the incremental encoder, e.g. the relevant resolution, interface, etc. can be obtained from catalogue 🕮 M7000 Electric Motors and Section 🕮 9.3.1 "TIs – Incremental encoder (IG)".

Detailed information for the connection of:

- **HTL incremental encoder** to **SK 2xxE**
- **TTL incremental encoder** to ≥ **SK 53xE**
- **SIN/COS encoder** to **SK 54xE**

can be obtained from the relevant manuals 🕮 BU 0200, BU 0500 und BU 0505.

Information regarding the **POSICON** function is provided in the supplementary manuals BU 0210 and BU 0510, see Section 🕮 9.1 "Manuals".

Information — Testing the encoder function

After completion of connection and basic commissioning the **correct function** of the incremental encoder should always be **checked**. Detailed **information** and **warnings for the testing** and **activation** of the encoder are provided in Section 🕮 3.5.3 "Function test of rotary encoders (IG)".

For **activation** of the **speed feedback** (**CFC closed loop** mode) under the tab "**Control parameters**" the parameter **Servo mode P300** must be set to Function {**1** = **On (CFC closed-loop)**}.

2.6 Selection of absolute encoders

The correct selection, parameterisation and connection of a **CANopen absolute encoder** to a decentralised **SK 2xxE** or **≥ SK 53xE** control cabinet frequency inverter are different. In addition, for position control, further types of absolute encoder can be connected to **SK 54xE** control cabinet frequency inverters. Other encoder systems such as SSI, BISS, Endat and Hiperface encoders can be connected to its universal interface or terminal bar X14.

Several **multiturn CANopen** encoders are defined as **standard combined absolute encoders** by Getriebebau NORD:

Fig. 12: Standard CANopen encoders

NORD data			Absolute encoder resolution		Incremental encoder resolution	
FI type	**Part no. Supplier**	**Type Designation**	**Single turn**	**Multiturn**	**Type**	**Increments**
SK 2xxE	19551886 Fritz Kübler GmbH	AG4 AG&IG CANOPEN 8192-4096/2048 HTL D12BUSH	13 Bit / 8192 pulses	12 Bit / 4096 pulses	HTL	2048 pulses
	19556994 Baumer IVO GmbH & Co. KG	AG6 AG&IG IVO CANOPEN 8192-65K/2048 HTL D=12	13 Bit / 8192 pulses	16 Bit / 65536 pulses	HTL / Push-pull	2048 pulses
SK 53xE SK 54xE	19551881 Fritz Kübler GmbH	AG1 AG&IG CANOPEN 8192-4096/2048 TTL D12BUSH	13 Bit / 8192 pulses	12 Bit / 4096 pulses	TTL / RS422	2048 pulses
	19556995 Baumer IVO GmbH & Co. KG	AG3 AG&IG IVO CANOPEN 8192-65K/2048 TTL D=12	13 Bit / 8192 pulses	16 Bit / 65536 pulses	TTL / RS422	2048 pulses

Table 5: Standard absolute encoders

Taking into account the **maximum limiting frequency** for the selection of the encoder, the **highest possible resolution** should be selected and if possible, an encoder system with a **power supply** of **10 … 30 V** should be used.

Technical data for the incremental encoder, e.g. the relevant type, interface, etc. can be obtained from catalogue 🕮 M7000 Electric Motors and Section 🕮 9.3.2 "TIs - CANopen absolute encoder (AG)".

Detailed information for the connection and parameterisation of standard combination absolute encoders with a CANopen interface can be obtained from the supplementary manuals BU 0210 und BU 0510, see Section 🕮 9.1 "Manuals".

NOTICE	**Installation of rotary encoders**

It is **essential** that the **combination absolute encoder** (single and multiturn with integral incremental track) is mounted on the **end of the motor shaft**.

Other types of absolute encoder (e.g. Type AG1 / Part no. 19551881 / Kübler Type 8.5888.0421.2102. S010.K014) must **not necessarily** be mounted on the end of the motor shaft.

In this case, the speed ratio in the frequency inverter must be parameterised with the aid of the Ratio P607 and the Reduction Ratio P608. Otherwise, **inaccuracy** of the **speed** (incremental track) and / or the **position control** may result.

For an absolute encoder, the encoder system must be parameterised in the Parameter **Travel measurement system P604**, and the corresponding **resolutions** / **pulse numbers** and the encoder type (**Single** or **Multiturn**) must be parameterised in the parameter **Absolute encoder P605**.

For detailed information, please refer to the relevant manual for the frequency inverter, see 🕮 9.1 "Manuals" or Section 🕮 3.6.1 "Parameterisation of CANopen encoders (absolute encoders)".

Information	**Activating the position control**

For **positioning / position control** (**CFC Closed Loop** mode) the position control must be activated with the parameter **Position control P600** or the required function (selection of ramp type) must be parameterised in the tab **"Positioning parameters".** For further details of activation of the position control, see 🕮 6.4.2 "Activating the position control".

3 Basic Commissioning

Step 2

Information

If the frequency inverter is not in the state as delivered, a reset of all parameters should generally be carried out via the parameter **Factory Setting P523** before basic commissioning is carried out. This parameter can be found under the tab "**Additional Parameters**".

All parameters which are not explicitly mentioned in this guide should therefore be left in the factory or default setting. For more detailed information, please refer to the relevant manual for the frequency inverter, see 🕮 9.1 "Manuals".

Information — Parameterisation

Other **application-specific settings**, e.g. Deceleration time P103 (Brake reaction time P107 and Brake delay off P114) are **not** described in this guide and must be **adjusted independently** by the user! For optimisation of the controller only the **Acceleration time P102**, for the speed control, and the **Deceleration time P103**, need to be adjusted.

Several other parameters **must** be changed for the optimisation of the particular controller, in order to obtain informative oscilloscope recordings.

After completion of the individual **controller optimisations** these **parameters** must be **re-adjusted** according to the particular requirements of the application.

NOTICE — Function restrictions

The following frequency inverter functions for the parameters are only available to users to a **limited extent** or not at all for synchronous motor applications:

- **Shut-down mode P108**
  Function {**3** = **Instant d.c. braking**}
  Function {**5** = **Combi. braking**}

- **Flying start P520**
  Function {**1** - **4** = **All functions**} *

* Only available as of software version ≥ **2.1 R0** for **SK 2xxE**, ≥ **3.1 R0** for **SK 5xxE** or ≥ **2.3 R0** for **SK 54xE**

An incorrect parameterisation of this function is not used for the operation of the drive unit or is automatically not activated by the frequency inverter, even though it has been parameterised.

3.1 Operating display settings

Instructions

For optimisation of the relevant controller, the following two parameters must be checked or set in advance.

Parameter No. [-Array]	Name [Unit]	Factory setting	Setting related to parameter set (P1, ... , P4)
OPERATING DISPLAYS			
P001	Select of disp.value	0*	**0 → 2** (Setpoint frequency [Hz])
P003	Supervisor-Code	1 **	**1 → 3** (all parameters visible) only for SK 2xxE
		* 0 corresponds to the actual frequency [Hz]	
		** 1 corresponds to all parameters visible except P3xx / P6xx	

In general, optimisation of the speed and position controllers should be made in **dynamic** operation under **load conditions** with specification of a setpoint. Because of this, the **Select of disp.value P001** should be changed from the function {**0** = **Actual frequency**} to {**2** = **Setpoint frequency**}. The setpoint frequency is displayed in [**Hz**].

In contrast, optimisation of the current controller should be made in **static** operation without load and without specification of a setpoint.

Information **Supervisor-Code**

The tabs Control Parameters P3xx and **Positioning** P6xx are only enabled and therefore made visible for decentralised SK 2xxE frequency inverters by means of Supervisor-code P003 {3 = **all parameters visible**}. In the NORD CON display, all tabs are always visible.

For **control cabinet SK 5xxE frequency inverters** all tabs are enabled or displayed in the **factory setting** {**1** = **all parameters visible**}.

3.2 Further settings

For the operation of synchronous motors with nominal frequencies > 50 Hz, setting of the following parameters is mandatory.

Parameter No. [-Array]	Name [Unit]	Factory setting	Setting related to parameter set (P1, ... , P4)
BASIC PARAMETERS			
P105 (P)	Maximum frequency [Hz]	50.0	**50.0 → 70.0**

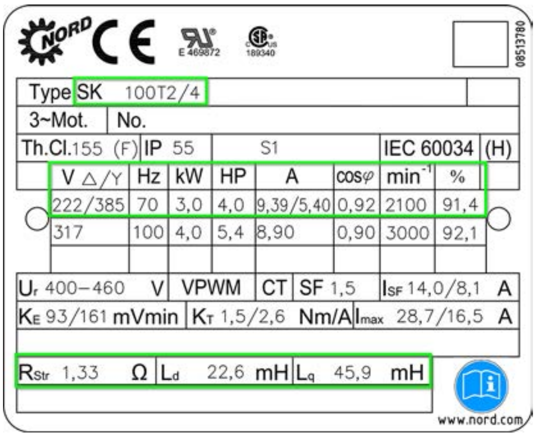
Due to the "changed" motor data of a synchronous motor or the higher **Nominal frequency P201**, a change must be made to the value in the parameter **Maximum frequency P105**.

Depending on the selected **operating mode** and the requirements of the application, the value of the **Maximum frequency P105** may also vary according to the specific application. The selected value should not be **larger** than the value for the **Nominal frequency P201** so that the motor is not operated in the weak field range.

3.3 Motor data

Information

In principle, the windings of a Getriebebau NORD IE4 **synchronous motor** (**IPMSM**) or PMSM and SPMSM drives from other manufacturers can be wired in 2 ways (**Y** / **▲**), depending on the mains voltage. Depending on the circuit, synchronous motors can be operated only using with a **frequency inverter** on different mains connections (including 230 V, 50 Hz and 400 V, 50 Hz) and therefore usually have several different **V/f characteristic curves**.



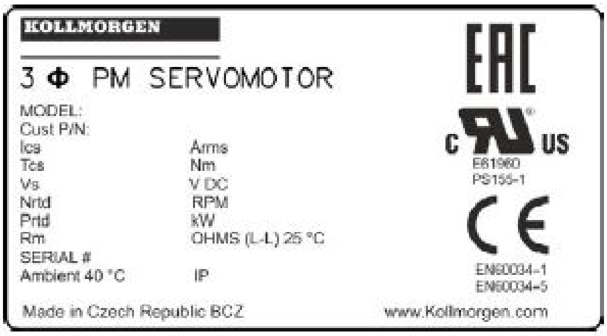
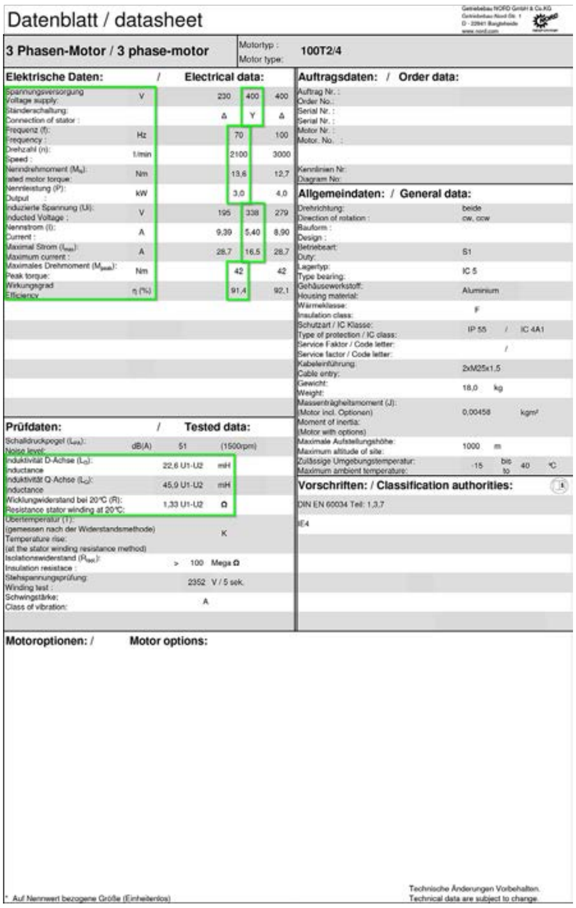


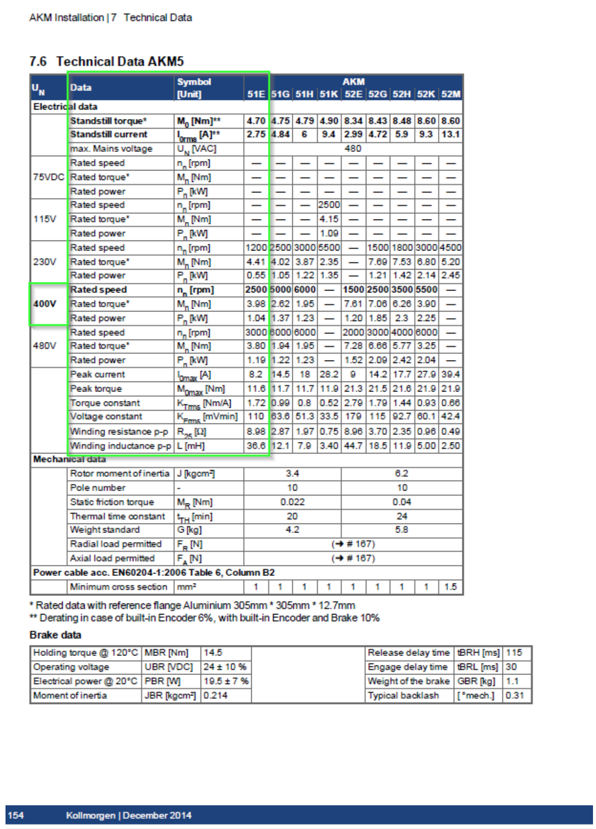
Fig. 13: Examples of motor type plates

Getriebebau NORD



Third party brand (Source: KOLLMORGEN *)

*AKM Operating Instructions, Edition 2014



AKM Installation | 7 Technical Data

7.6 Technical Data AKM5

U_N	Data	Symbol [Unit]	51E	51G	51H	51K	52E	52G	52H	52K	52M
Electrical data											
	Standstill torque*	**M_0 [Nm]****	**4.70**	**4.75**	**4.79**	**4.90**	**8.34**	**8.43**	**8.48**	**8.60**	**8.60**
	Standstill current	**I_{0rms} [A]****	**2.75**	**4.84**	**6**	**9.4**	**2.99**	**4.72**	**5.9**	**9.3**	**13.1**
	max. Mains voltage	U_N [VAC]	480								
75VDC	Rated speed	n_n [rpm]	—	—	—	—	—	—	—	—	—
	Rated torque*	M_n [Nm]	—	—	—	—	—	—	—	—	—
	Rated power	P_n [kW]	—	—	—	—	—	—	—	—	—
115V	Rated speed	n_n [rpm]	—	—	—	2500	—	—	—	—	—
	Rated torque*	M_n [Nm]	—	—	—	4.15	—	—	—	—	—
	Rated power	P_n [kW]	—	—	—	1.09	—	—	—	—	—
230V	Rated speed	n_n [rpm]	1200	2500	3000	5500	—	1500	1800	3000	4500
	Rated torque*	M_n [Nm]	4.41	4.02	3.87	2.35	—	7.69	7.53	6.80	5.20
	Rated power	P_n [kW]	0.55	1.05	1.22	1.35	—	1.21	1.42	2.14	2.45
400V	**Rated speed**	**n_n [rpm]**	**2500**	**5000**	**6000**	—	**1500**	**2500**	**3500**	**5500**	—
	Rated torque*	M_n [Nm]	3.98	2.62	1.95	—	7.61	7.06	6.26	3.90	—
	Rated power	P_n [kW]	1.04	1.37	1.23	—	1.20	1.85	2.3	2.25	—
480V	Rated speed	n_n [rpm]	3000	6000	6000	—	2000	3000	4000	6000	—
	Rated torque*	M_n [Nm]	3.80	1.94	1.95	—	7.28	6.66	5.77	3.25	—
	Rated power	P_n [kW]	1.19	1.22	1.23	—	1.52	2.09	2.42	2.04	—
	Peak current	I_{0max} [A]	8.2	14.5	18	28.2	9	14.2	17.7	27.9	39.4
	Peak torque	M_{0max} [Nm]	11.6	11.7	11.7	11.9	21.3	21.5	21.6	21.9	21.9
	Torque constant	K_{Trms} [Nm/A]	1.72	0.99	0.8	0.52	2.79	1.79	1.44	0.93	0.66
	Voltage constant	K_{Erms} [mVmin]	110	63.6	51.3	33.5	179	115	92.7	60.1	42.4
	Winding resistance p-p	R_{25} [Ω]	8.98	2.87	1.97	0.75	8.96	3.70	2.35	0.96	0.49
	Winding inductance p-p	L [mH]	36.6	12.1	7.9	3.40	44.7	18.5	11.9	5.00	2.50
Mechanical data											
	Rotor moment of inertia	J [kgcm²]	3.4				6.2				
	Pole number	-	10				10				
	Static friction torque	M_R [Nm]	0.022				0.04				
	Thermal time constant	t_{TH} [min]	20				24				
	Weight standard	G [kg]	4.2				5.8				
	Radial load permitted	F_R [N]	(➔ # 167)								
	Axial load permitted	F_A [N]	(➔ # 167)								
Power cable acc. EN60204-1:2006 Table 6, Column B2											
	Minimum cross section	mm²	1	1	1	1	1	1	1	1	1.5

* Rated data with reference flange Aluminium 305mm * 305mm * 12.7mm

** Derating in case of built-in Encoder 6%, with built-in Encoder and Brake 10%

Brake data

Holding torque @ 120°C	MBR [Nm]	14.5	Release delay time	tBRH [ms]	115
Operating voltage	UBR [VDC]	24 ± 10 %	Engage delay time	tBRL [ms]	30
Electrical power @ 20°C	PBR [W]	19.5 ± 7 %	Weight of the brake	GBR [kg]	1.1
Moment of inertia	JBR [kgcm²]	0.214	Typical backlash	[°mech.]	0.31

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Fig. 14: Examples of data sheets

The motor data are parameterised in the frequency inverter in the tab "**Motor data / Characteristic curve parameters**" in parameters **P201 - P209**. In contrast to asynchronous motors, for **synchronous motors further** specific **motor data** are relevant or must be parameterised. There are various methods of writing these motor-specific data for a synchronous motor in the parameters **P240 - P247**.

The selection of the input method depends on whether the motor is an IE4 synchronous motor from Getriebebau NORD or a synchronous motor from a different manufacturer.

The following two methods are available for the parameterisation of synchronous motors:

1. **NORD motors** (**IE4 synchronous motors** (**IPMSM**))
   - Selection using the parameter **Motor list P200** and the **function** {**109** = **3.0 kW 400 V 100T2/4**}, with **automatic** entry of the motor data in parameters (P201 - P209 and P240- P246)
   - Measurement of the stator resistance R_S using **Par.-identification P220** and selection of the **function** {**1** = **Identification R_s**}

2. **Third party motors** (synchronous motors (**SPMSM**) from other manufacturers)
   - Adopt the data from the **motor type plate** and / or the **data sheet**
   - **Manual** entry of the motor data in parameter (P201 - P207 and P240- P246)
   - Measurement of the stator resistance R_S using **Para. identification P220** and selection of the **function** {**1** = **Identification R_s**}
   - With subsequent **optimisation** of the motor data for the parameters (P240, P241, P246), see 3.4 "Optimisation of motor data"

If the motor data of the **synchronous motor** for the parameters **Stator resistance R_S**, **Stator inductance L_d** and **L_q** are not known, there is the further possibility of determining the data by means of **Motor identification**:

Parameter identification with parameter **Par.-identification P220** and selection of the **function** {**2** = **identification motor**}

- Only applies for **synchronous motors** from other manufacturers / **third party brands** if none of the motor data for the **third party motor** are known
- Only applies for **NORD motors** for (field test devices, special motors, etc.)
- Only the **Stator resistance R_S** in the parameter **Stator resistance P208** and the **Stator inductance L_d** in the parameter **Inductance P241** [**-01**] are determined.
- The **Stator inductance L_q** in the parameter **Inductance P241** [**-02**] is calculated from **L_d**
- Subsequent optimisation of the specific motor data

Instructions

3.3.1 Motor lists

If the motor is from **Getriebebau NORD** it can be selected using the parameter **Motor list P200** from a list of the available 4-pole **IE4 synchronous motors** (IPMSM). With the selection of the motor type, the corresponding parameters **P201 - P209** and **P240 - P246** are set **automatically** ⟲.

Information — NORD motor data

The motor data which are saved in the frequency inverter are **only** for **IE1 asynchronous motors** and **IE4 synchronous motors** manufactured by **Getriebebau NORD**. The values have been calculated from the specific data sheets for the motor or the details on the type plate.

The **Motor cos phi P206** is also stated or pre-set via the Motor list P200, **but** is **not relevant** for synchronous motors.

After entry of the motor data via the Motor list P200, the **No load current P209** is **only** always parameterised **automatically** to the value **"0"** ⟲ for **IE4 synchronous motors**.

Course of action

In the parameter **Motor list P200** the following functions are available for selection, e.g. for a Getriebebau NORD **SK100 T2/4** IE4 synchronous motor:

- Function {103} = 2.2 kW / 230 V ⇨ 230 V frequency inverter
  Motor connected in Y, nominal speed 1500 rpm
- Function {108} = 3.0 kW / 230 V ⇨ 230 V frequency inverter
  Motor connected in ▲, nominal speed 2100 rpm
- Function {109} = 3.0 kW / 400 V ⇨ 400 V frequency inverter
  Motor connected in Y, nominal speed 2100 rpm
- Function {113} = 4.0 kW / 400 V ⇨ 400 V frequency inverter
  Motor connected in ▲, nominal speed 3000 rpm

With the selection of **function** {**109 = 3.0 kW 400 V 100T2/4**} the following motor data / characteristic curve parameters the are only set **automatically** for **NORD motors** ⟲:

Parameter No. [-Array]		Name [Unit]	Factory setting	Setting – related to parameter set (P1, ... , P4)
MOTOR DATA/ CHARACTERISTIC CURVE PARAMETERS				**NORD motor**
P200	(P)	Motor list	0	✋ **0 → 109** (3.0 kW 400 V 100T2/4)
P201	(P)	Nominal frequency [Hz]	50.0*	⟲ **50.0 → 70.0**
P202	(P)	Nominal speed [rpm]	1445*	⟲ **1445 → 2100**
P203	(P)	Nominal current [A]	8.3*	⟲ **8.3 → 5.4**
P204	(P)	Nominal voltage [V]	400*	⟲ **400 → 385**
P205	(P)	Nominal power [kW]	4*	⟲ **4 → 3**
P206	(P)	Cos phi	0.8*	⟲ **0.8 → 0.92**
P207	(P)	Star Delta con.	1*	⟲ **1 → 0** (Star)
P208	(P)	Stator resistance [Ω]	3.44*	⟲ **3.44 → 1.44** (measured)
P209	(P)	No load current [A]	4.4*	⟲ **4.4→ 0** **
P220	(P)	Par.-identification	0	✋ **0 → 1** (Identification R_S)

Parameter No. [-Array]		Name [Unit]	Factory setting	Setting related to parameter set (P1, ... , P4)
MOTOR DATA/ CHARACTERISTIC CURVE PARAMETERS				**NORD motor**
P240	(P)	EMF voltage PMSM [V]	0	**↻ 0 → 341**
P241	[-01]	Inductance PMSM (d axis) [mH]	20	**↻ 20 → 22.6**
P241	[-02]	Inductance PMSM (q axis) [mH]	20	**↻ 20 → 45.9**
P243	(P)	Reluctance angle IPMSM [°]	0	**↻ 0 → 10**
P244	(P)	Peak current PMSM [A]	5 ***	**↻ 5 → 14**
P246	(P)	Mass Inertia PMSM [kg*cm²]	5	**↻ 5 → 45.8**
P247	(P)	Changeover frequency VFC PMSM [%]	25	✍ 25 (leave as set)

* dependent on FI power or parameters P200/P220

** ↻ To "**0**" for IE4 synchronous motors from Getriebebau NORD
☝ To "**0**" for synchronous motors from other manufacturers

*** Depending on the frequency inverter, SK 5xxE factory setting = 20

The **Stator resistance P208** should always be measured and set with the automatic stator resistance measurement and should then be checked, see **Par.-identification P220** and the **function** {**1 = Identification Rs**}.

Information — Stator resistance

The measured value or the value to be entered for the **Stator resistance P208** of a line (if this is available) should always be relative to an **ambient temperature** of approx. **20 °C**.

For IE4 synchronous motors manufactured by Getriebebau NORD, the value of the stator resistance is also stamped on the motor type plate.

The parameter **Mass inertia P246** describes the moment of inertia of the drive machine. The factory setting of **5 kg*cm²** is **sufficient for most applications**.
However, for highly dynamic applications, the mass inertia for the entire drive system should ideally be parameterised.
This results in an improvement of the dynamic characteristics. The values should be obtained from the technical data sheets or by an enquiry to the manufacturer.

Information & instructions

3.3.2 NORD – Motor type plates / Data sheet

The motor data can be obtained from the motor type plate, see 📖 3.3 "Motor data" and / or the manufacturer's data sheet. The manufacturer's motor data should be parameterised accordingly in the tab "**Motor data / Characteristic curve parameters".**

NORD motors

In **general** only the motor data for should be selected by means of the **motor type** via the parameter **Motor list P200**, e.g. function {**109** = **3.0 kW 400 V**}.

Datenblatt / datasheet

Getriebebau NORD GmbH & Co.KG
Getriebebau-Nord-Str. 1
D - 22941 Bargteheide
www.nord.com

3 Phasen-Motor / 3 phase-motor	Motortyp : Motor type:	100T2/4

Elektrische Daten: / Electrical data:

Spannungsversorgung Voltage supply:	V	230	400	400
Ständerschaltung: Connection of stator :		Δ	Y	Δ
Frequenz (f): Frequency :	Hz		70	100
Drehzahl (n): Speed :	1/min		2100	3000
Nenndrehmoment (M_N): rated motor torque:	Nm		13,6	12,7
Nennleistung (P): Output :	kW		3,0	4,0
Induzierte Spannung (Ui): Inducted Voltage :	V	195	338	279
Nennstrom (I): Current :	A	9,39	5,40	8,90
Maximal Strom (I_{max}): Maximum current :	A	28,7	16,5	28,7
Maximales Drehmoment (M_{peak}): Peak torque:	Nm		42	42
Wirkungsgrad Efficiency	η (%)		91,4	92,1

Auftragsdaten: / Order data:

Auftrag Nr. : Order No.:	
Serial Nr. : Serial Nr. :	
Motor Nr. : Motor. No. :	
Kennlinien Nr: Diagram No:	

Allgemeindaten: / General data:

Drehrichtung: Direction of rotation :	beide cw, ccw		
Bauform : Design :			
Betriebsart: Duty:	S1		
Lagertyp: Type bearing:	IC 5		
Gehäusewerkstoff: Housing material:	Aluminium		
Wärmeklasse: Insulation class:	F		
Schutzart / IC Klasse: Type of protection / IC class:	IP 55	/	IC 4A1
Service Faktor / Code letter: Service factor / Code letter:		/	
Kabeleinführung: Cable entry:	2xM25x1,5		
Gewicht: Weight:	18,0	kg	
Massenträgheitsmoment (J): (Motor incl. Optionen) Moment of inertia: (Motor with options)	0,00458	kgm²	
Maximale Aufstellungshöhe: Maximum altitude of site:	1000	m	
Zulässige Umgebungstemperatur: Maximum ambient temperature:	-15	bis to 40	°C

Prüfdaten: / Tested data:

Schalldruckpegel (L_{PA}): Noise level:	dB(A)	51	(1500rpm)
Induktivität D-Achse (L_D): Inductance	22,6 U1-U2	mH	
Induktivität Q-Achse (L_Q): Inductance	45,9 U1-U2	mH	
Wicklungwiderstand bei 20°C (R): Resistance stator winding at 20°C:	1,33 U1-U2	Ω	
Übertemperatur (T): (gemessen nach der Widerstandsmethode) Temperature rise: (at the stator winding resistance method)		K	
Isolationswiderstand (R_{isol}): Insulation resistace :	> 100	Mega Ω	
Stehspannungsprüfung: Winding test :	2352	V / 5 sek.	
Schwingstärke: Class of vibration:		A	

Vorschriften: / Classification authorities:

DIN EN 60034 Teil: 1,3,7

IE4

Motoroptionen: / Motor options:

* Auf Nennwert bezogene Größe (Einheitenlos)

Technische Änderungen Vorbehalten.
Technical data are subject to change.

Fig. 15: NORD motor data sheet SK 100T2/4 BRE40 FHL TF

If a **NORD motor is not** selected with the aid of the parameter **Motor list P200**, the motor data must be parameterised according to the type plate or from the data sheet.

The **No Load Current P209** must then always be explicitly parameterised **manually** ☟, to the value "**0**" by the user.

The specific motor values for the **Voltage constant k_e**, the **Stator resistance R_s** and the **Stator inductances L_d** and **L_q** are listed in the data sheet or stamped on the motor type plate. The parameter **Reluctance angle IPMSM P243** must be parameterised to the value **10°**. The values for the two parameters **Peak current PMSM P244** and **Mass inertia PMSM P246** must also be adjusted according to the data sheet or the details from the manufacturer.

3.3.3 Third party motor type plates / Data sheets

This **Section** only applies for **third party motors** or **synchronous motors from other manufacturers**.
For applications with a **NORD motor**, this **section can be completely ignored**!

For synchronous motors from other **manufacturers** or other **brands**, there is **only** the possibility of obtaining the motor data from the motor type plate or from the manufacturer's **data sheet**. The motor data must be entered or parameterised in the frequency inverter in the tab "**Motor data / Characteristic curve parameters**" with parameters **P201 - P209**. In contrast to asynchronous motors, for synchronous motors further specific motor data are relevant or must be parameterised. The additional motor data values for the specific manufacturer must be entered in the parameters **P240 - P246** by the user.

NOTICE **Motors from other manufacturers**

The selection or pre-setting of the motor data (P2xx) for third party motors must **not** be made via the parameter **Motor list P200**, e.g. with the function {109 = 3,0 kW, 400 V, 100T2/4}! Otherwise the calculation of the PMSM model will be based on "false" motor data values. As these are data for the synchronous motor which are specific to the particular manufacturer, the **manufacturer** of the drive should always be contacted in case of doubt.

The specific motor values for the **Voltage constant k_e**, the **Stator resistance R_s** and the **Stator inductances L_d** and **L_q** are listed in the data sheet or stamped on the motor type plate.

If in the case of a **third party motor** the **Nominal current P203** is not stated on the motor type plate or in the manufacturer's data sheet, this can be calculated according to the following formula:

$$I_N = \frac{M_N}{K_{Trms}} \triangleq P_{203} = \frac{M_N}{K_{Trms}}$$

I_N:	Nominal current [A]	
P_{203}:	*Nominal current [A]*	
M_N:	*Nominal torque*	*[Nm]*
K_{Trms}:	*Torque constant*	*[Nm/A]*

Information **Motor data for third party motors**

The **Motor cos phi P206** may also be stated by the manufacturer, **but** is **not relevant** for synchronous motors. From the entry of the **Nominal frequency P201** and the **Nominal speed P202** the number of pole pairs is determined automatically. For synchronous motors, there may be occasionally deviations. Please contact the Getriebebau NORD Service department.

The **No load current P209** for **synchronous motors** from other **manufacturers**, i.e. in general for all **third party motors**, must always be **manually** ☟ parameterised to the value "**0**" by the user.

The parameter **Reluctance angle IPMSM P243** must be set according to the manufacturer's details. The values for the two parameters **Peak current PMSM P244** and **Mass inertia PMSM P246** must also be adjusted according to the data sheet or the details from the manufacturer.

AKM Installation | 7 Technical Data

7.6 Technical Data AKM5

U_N	Data	Symbol [Unit]	AKM 51E	51G	51H	51K	52E	52G	52H	52K	52M
Electrical data											
	Standstill torque*	**M_0 [Nm]****	**4.70**	**4.75**	**4.79**	**4.90**	**8.34**	**8.43**	**8.48**	**8.60**	**8.60**
	Standstill current	**I_{0rms} [A]****	**2.75**	**4.84**	**6**	**9.4**	**2.99**	**4.72**	**5.9**	**9.3**	**13.1**
	max. Mains voltage	U_N [VAC]	480								
75VDC	Rated speed	n_n [rpm]	—	—	—	—	—	—	—	—	—
	Rated torque*	M_n [Nm]	—	—	—	—	—	—	—	—	—
	Rated power	P_n [kW]	—	—	—	—	—	—	—	—	—
115V	Rated speed	n_n [rpm]	—	—	—	2500	—	—	—	—	—
	Rated torque*	M_n [Nm]	—	—	—	4.15	—	—	—	—	—
	Rated power	P_n [kW]	—	—	—	1.09	—	—	—	—	—
230V	Rated speed	n_n [rpm]	1200	2500	3000	5500	—	1500	1800	3000	4500
	Rated torque*	M_n [Nm]	4.41	4.02	3.87	2.35	—	7.69	7.53	6.80	5.20
	Rated power	P_n [kW]	0.55	1.05	1.22	1.35	—	1.21	1.42	2.14	2.45
400V	**Rated speed**	**n_n [rpm]**	**2500**	**5000**	**6000**	**—**	**1500**	**2500**	**3500**	**5500**	**—**
	Rated torque*	M_n [Nm]	3.98	2.62	1.95	—	7.61	7.06	6.26	3.90	—
	Rated power	P_n [kW]	1.04	1.37	1.23	—	1.20	1.85	2.3	2.25	—
480V	Rated speed	n_n [rpm]	3000	5000	6000	—	2000	3000	4000	6000	—
	Rated torque*	M_n [Nm]	3.80	1.94	1.95	—	7.28	6.66	5.77	3.25	—
	Rated power	P_n [kW]	1.19	1.22	1.23	—	1.52	2.09	2.42	2.04	—
	Peak current	I_{0max} [A]	8.2	14.5	18	28.2	9	14.2	17.7	27.9	39.4
	Peak torque	M_{0max} [Nm]	11.6	11.7	11.7	11.9	21.3	21.5	21.6	21.9	21.9
	Torque constant	K_{Trms} [Nm/A]	1.72	0.99	0.8	0.52	2.79	1.79	1.44	0.93	0.66
	Voltage constant	K_{Erms} [mVmin]	110	63.6	51.3	33.5	179	115	92.7	60.1	42.4
	Winding resistance p-p	R_{25} [Ω]	8.98	2.87	1.97	0.75	8.96	3.70	2.35	0.96	0.49
	Winding inductance p-p	L [mH]	36.6	12.1	7.9	3.40	44.7	18.5	11.9	5.00	2.50
Mechanical data											
	Rotor moment of inertia	J [kgcm²]	3.4				6.2				
	Pole number	-	10				10				
	Static friction torque	M_R [Nm]	0.022				0.04				
	Thermal time constant	t_{TH} [min]	20				24				
	Weight standard	G [kg]	4.2				5.8				
	Radial load permitted	F_R [N]	(➜ # 179)								
	Axial load permitted	F_A [N]	(➜ # 179)								
Power cable acc. EN60204-1:2006 Table 6, Column B2											
	Minimum cross section	mm²	1	1	1	1	1	1	1	1	1.5

* Rated data with reference flange Aluminium 305mm * 305mm * 12.7mm
** Derating in case of built-in Encoder 6%, with built-in Encoder and Brake 10%

Brake data

Holding torque @ 120°C	MBR [Nm]	14.5	Release delay time	tBRH [ms]	115
Operating voltage	UBR [VDC]	24 ± 10 %	Engage delay time	tBRL [ms]	30
Electrical power @ 20°C	PBR [W]	19.5 ± 7 %	Weight of the brake	GBR [kg]	1.1
Moment of inertia	JBR [kgcm²]	0.214	Typical backlash	[°mech.]	0.31

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Fig. 16: Kollmorgen AKM5 third party motor data sheet

An **SK 540E-221-323-A** frequency inverter and a synchronous motor from the firm ***Kollmorgen***, with the designation ***AKM5*** were used for the test setup.

Parameter No. [-Array]		Name [Unit]	Factory setting	Setting related to parameter set (P1, ... , P4)
MOTOR DATA/ CHARACTERISTIC CURVE PARAMETERS				**Third party motor**
P201	(P)	Nominal frequency [Hz]	50.0*	**50.0 → 208.3**
P202	(P)	Nominal speed [rpm]	1440*	**1440 → 2500**
P203	(P)	Nominal current [A]	5.2*	**5.2 → 1.5**
P204	(P)	Nominal voltage [V]	400*	400 (leave as set)
P205	(P)	Nominal power [kW]	2.2*	**2.2 → 1.04**
P206	(P)	Cos phi	0.74*	0.74 (leave as set)
P207	(P)	Star Delta con.	0*	0 (leave as set)
P208	(P)	Stator resistance [Ω]	2.43*	**2.43 → 4.45** (measured)
P209	(P)	No load current [A]	3.8*	**3.8→ 0** **
P220	(P)	Par.-identification	0	**0 → 1** (Identification R_S)
P240	(P)	EMF voltage PMSM [V]	0	**0 → 275**
P241	[-01]	Inductance PMSM (d axis) [mH]	20	**20 → 8.5**
P241	[-02]	Inductance PMSM (q axis) [mH]	20	**20 → 18.3**
P243	(P)	Reluctance angle IPMSM [°]	0	0 (leave as set)
P244	(P)	Peak current PMSM [A]	20 ***	**20 → 8.2**
P246	(P)	Mass Inertia PMSM [kg*cm²]	5	**5 → 3.4**

* depending on FI power or parameters P200 / P220

** To "**0**" for synchronous motors from other manufacturers

*** Depending on the frequency inverter, SK 2xxE factory setting = 5

After entry of the motor data parameters, **optimisation** of the **other motor data** should only be carried out for third party motors.

The stator resistance should be measured with the **Identification motor**, see **Par.-identification P220** and the function {**1** = **Identification R_S**}. After this, **optimisation** of the other **motor data** should be carried out according to Section 3.4 "Optimisation of motor data".

The **Voltage constant k_e**, which states the value for the inductive reactance voltage of the synchronous motor is stated on the motor type plate and in the data sheet. The voltage constant k_e states the voltage induced by the field (from the rotor to the stator) relative to the speed of the motor.

EMF voltage PMSM P240

The **EMF voltage PMSM P240** is calculated according to the following formula, using the **Voltage constant k_e** :

$$EMF\ voltage\ PMSM = k_e * n_N \triangleq P_{240} = k_e * P_{202}$$

k_e:	*Voltage constant*	*[mV/min]*
n_N:	*Nominal speed*	*[rpm]*
P_{202}:	*Nominal motor speed*	*[rpm]*
P_{240}:	*EMF- voltage PMSM*	*[V]*

The calculated value for the **EMF voltage PMSM P240** and the values for the **stator inductances L_d** and **L_q** obtained from the data sheet or the motor type plate must be parameterised accordingly in the frequency inverter.

Inductance PMSM (P241)

[-01] for **d-axis** ≙ **Stator inductance L_d**
[-02] for **q-axis** ≙ **Stator inductance L_q**

For third party motors, the values for the two stator inductances L_d and L_q, in parameter **Inductance PMSM P241 [-01]** and **[-02]** can be determined by means of the parameter identification, see 🕮 **Par.-identification P220** by selecting the function {**2** = **identification motor**}.

As the **stator inductance** of the **d-axis** is not equal to that of the **q-axis**,

L_d ≠ L_q Inductance PMSM P241 [-01] ≠ Inductance PMSM P241 [-02]

for IE4 synchronous motors produced by Getriebebau NORD (NORD motors) and third party IPMSM motors, the **Reluctance torque** or the parameter **Reluctance angle IPMSM P243** must also be taken into account.

Reluctance angle IPMSM P243

The **Reluctance angle IPMSM P243**, states the additional **angle** which results from the anisotropy (dependence on direction) of the inductance in the **d-** and **q-axis**.

Information SPMSM drives

For applications with SPMSM (**S**urface **P**ermanent **M**agnet **S**ynchronous **M**otors), i.e. synchronous motors with surface magnets, the parameter **Reluctance angle IPMSM P243** must be set to "**0** " or left in the factory setting {**0°**}.

The motor-specific reluctance angle (**10°** for **IE4 synchronous motors** from Getriebebau NORD) should always be determined experimentally **under load conditions** for **third party motors**. For further details see Section 🕮 9.1 "Manuals". For IE4 synchronous motors from Getriebebau NORD the value of 10° is set **automatically** ↻, with the selection of the synchronous motor from the Motor list P200.

After completion of the basic commissioning of IPMSM drives from other manufacturers, the drive should be run under a **constant load** (**> 0.5 x M_N**) in **CFC Closed-Loop** mode (see 🕮 **Servo mode P301** with the **function** {**1** = **On** (**CFC Closed-Loop**)}).

For detailed information, please refer to the relevant manual for the frequency inverter, see 🕮 7 "Reluctance torque".

Peak current PMSM P244

The peak current of the drive system is entered in the parameter **Peak current PMSM P244**. This parameter serves as a type of motor protection and prevents demagnetisation of the drive. This value must be obtained from the manufacturer or from the motor type plate or data sheet.

Mass Inertia PMSM P246

The mass inertia of the drive system is entered in the parameter **Mass inertia PMSM P246**. The factory setting of **5 kg*cm^2** is sufficient for most applications. For highly dynamic applications, e.g. dynamic conveyor systems, the actual value should ideally be determined and entered.

The values for synchronous motors should be obtained from manufacturer's technical data or by an enquiry to the manufacturer. The portion of the external centrifugal mass (e.g. gear unit, machine) must be calculated or may alternatively be determined experimentally.

Correct setting of the parameter **Mass inertia PMSM P246** results in an improvement of the dynamic characteristics of the drive unit.

For detailed information, please refer to the relevant manual for the frequency inverter, see 🕮 9.1 "Manuals".

3.3.4 Motor identification

If the motor data for the **Stator resistance R_S** and the **Stator inductance L_d** and **L_q** are not known, e.g. neither the data sheet nor the motor type plate are available, there is the possibility of determining these motor data automatically by means of a motor identification.

However, to do this, the motor data for the parameters:

- **Nominal frequency P201**
- **Nominal speed P202** approx. values, as this depends on the number of pole pairs (2 / 4)
- **Nominal voltage P204**
- **Nominal power P205**
- **Star Delta con. P207**

must be known to the user and parameterised in the frequency inverter under the tab "**Motor data / Characteristic curve parameters**".

Nominal frequency P201

The nominal motor frequency is calculated from the **Nominal speed P202** according to the following formula:

$$f = \frac{n * p}{60} \triangleq P_{201} = \frac{P_{202} * p}{60}$$

f:	*Frequency*	*[Hz]*
n:	*Speed*	*[rpm]*
p:	*Number of pole pairs*	*[-]*
P_{201}:	*Nominal frequency / Frequency*	*[Hz]*
P_{202}:	*Nominal current*	*[rpm]*

The calculated value is entered in the parameter **Nominal frequency P201**.

Para. Identification P220

By means of the parameter **Par.-identification P220** there is the possibility of determining the **motor data** for the **Stator resistance R_S** and the **Stator inductance L_d** and **L_q automatically** ◌.

Information **Parameter identification SK 5xxE**

With **SK 5xxE** frequency inverters, for the **Par.-identification P220** the function {**2** = **Identification motor**} is **only** possible for frequency inverter / motor combinations **≤ 7.5 kW** (for 400 V) or. **≤ 4.0 kW** (for 230 V).

For **SK 5xxE** applications **≥ 11.0 kW** the **function** {**2** = **identification motor**} is **not approved**.

For decentralised **SK 2xxE** frequency inverters the **function** {**2** = **identification motor**} is possible for the entire power range.

The **Par.-identification P220** must be carried out **when the motor is cold** (**15 °C ≥ T_{Motor} ≤ 25 °C**) .

The following two functions can be selected:

- Function {1} **Identification R_S** :

  For the **Identification R_S** only the **Stator resistance P208** is determined by multiple measurements.

- Function {2} **identification motor**:

  By means of the **motor identification** the **Stator resistance R_S** and the **Stator inductance L_d** of synchronous motors is only measured when the motor is at a standstill. The **L_q** value is calculated from the **L_d** value.
  The stator values which are determined are automatically entered ◊ into the parameters **Stator resistance P208** and **Inductance PMSM P241 [-01]** + **[-02]**.

For NORD motors, for the **Par.-identification P220**or for measurement of the **Stator resistance** (see 🕮 parameter Stator resistance P208) preferably on the function {**2** = **Identification R_s**} should be used!

Information Stator resistance and stator inductance value

After the measurement is complete, the determined stator resistance is entered or displayed **automatically** ◊ in the parameter **Stator resistance P208** .

In case of "incorrect" resistance values, the setting for the “Star Delta con. P207” and the motor connection in the connection terminal box should be checked.

The determined stator inductance value **L_d** for the **d-axis** is entered into the parameter **Inductance PMSM P241 [-01] automatically** ◊ on completion of the measurement. The inductance value **L_q** for the **q-axis** is calculated from the determined stator inductance **L_d** of the **d-axis** and is entered directly into the parameter **Inductance PMSM P241 [-02]**.

For **IPMSM** applications (**I**nterior **P**ermanent **M**agnet **S**ynchronous **M**otor) approximately corresponds to the calculated inductance value **L_q** in the parameter array **Inductance PMSM P241 [-02]**.

For **SPMSM** applications (**S**urface **P**ermanent **M**agnet **S**ynchronous **M**otor) the inductance values of both axis components (**L_d = L_q**) must be parameterised **identically**, i.e. for **parameterisation** the values in the two parameter arrays

Inductivity PMSM P241 [-02] = Inductivity PMSM P241 [-01]

must be set to the **same** value.

Information

3.3.5 Schematic circuit diagram

In general, all of the data which are necessary for control are calculated from the details on the type plate (🕮 3.3 "Motor data") or the data sheet from the specific manufacturer. The required data refer to the data in the schematic circuit diagram for the PMSMs.

For the **Para. identification P220** only the **Stator resistance R_S** and the **Stator inductance L_d** or **L_q** of the SCD are determined on the basis of measurement signals.

To some extent, the data from the schematic circuit diagram which are required for control depend on the temperature (motor and ambient temperature). A **correction of the values** at higher motor temperatures is made **automatically by the controller**.
If the **stator resistance** is measured at higher ambient temperatures or after longer operation of the motor, "**incorrect**" **starting values** result for the **automatic temperature correction**.

Information — **Displayed measurement values**

If the motor data are determined with **Par.-identification P220** and the function {**1** = **identification R_s**}, the **Stator resistance value R_S** can be checked in the parameter **Stator resistance P208** as well as in the parameter **Select of disp.value P001**.

If the function **{2 = identification motor}** is selected for the **Par.-identification P220** the values for the stator inductances **L_d** and **L_q** are only displayed in the parameter **Inductance PMSM P241 [-01]** and **[-02]**.

In the tab "**Operating Displays**" the corresponding values form the schematic circuit diagram which are to be displayed after the frequency inverter is enabled can be selected under the parameter **Select of disp.valueP001**. On the other hand, values which are calculated from the motor data, as well as other data for the schematic circuit diagram **cannot** be displayed.

3.4 Optimisation of motor data

Instructions

The motor data for **synchronous motors** are in principle **specific to the motor** or **manufacturer**. The designations of the **further motor data** differ to some extent in the manufacturer's data sheets or on the type plates of third party motors.

For operation of **third party motors** with **frequency inverters** from **Getriebebau NORD** it is **recommended**, that the user always carries out a further **optimisation** of individual, motor-specific parameters, i.e. the following parameters, after basic commissioning of the synchronous motor (entry of the motor data from the motor type plate / data sheet).

These parameters can be found in the tab "**Motor data / Characteristic curve parameters** and must be optimised accordingly.

- **EMF voltage PMSM P240**
- **Inductance PMSM P241**
- **Reluctance angle IPMSM P243**
- **Mass inertia PMSM P246**

The reluctance torque should only be optimised as necessary by the user for third party IPMSM motors. The procedure for optimising the parameter Reluctance angle IPMSM P243 is described in 🕮 Section 7 "Reluctance torque".

On the other hand, the mass inertia should only be optimised in certain circumstances or for application-specific circumstances.

3.4.1 NORD motors

The motor data for IE4 **synchronous motors** from **Getriebebau NORD**, see 🕮 parameter **Motor list P200**, are already **implemented** in the **system software** in the **motor list** of the two frequency inverter series **SK 2xxE and SK 5xxE**.

Optimisation of the **specific motor data** for **Getriebebau NORD IE1**, **IE4 synchronous motors** is only necessary, or must be carried out by the user in **exceptional cases or for special applications**.
In general, this applies for all **NORD motors** (e.g. field test drive units, special versions, etc.), which are not included in the **Motor list P200**.

For special applications, special motors and in case of application problems, we **recommend** that you contact the **Service department** of **Getriebebau NORD**.

3.4.2 Third party motors

Third party motors or **third party brands** are **specific to the motor** or **manufacturer** and for operation with **frequency inverters** from **Getriebebau NORD** should always be further optimised after entry of the **motor data** (from the motor type plate / data sheet).

Optimisation should be carried out on completion of **basic commissioning**, see 🕮 3 "Basic Commissioning" and after

- Parameterisation of motor data from the **motor type plate** or **data sheet**
- Motor identification with **Par.-identification P220** function {**1** = **Identification R_S**}

by the user.

3.4.3 EMF constant

The **EMF constant** or the **EMF voltage PMSM P240** can be calculated with the **Voltage constant k_e** and subsequently optimised, see 3.3.2 "NORD – Motor type plates / Data sheet".

The EMF constant or the parameter **EMF voltage PMSM P240** of a synchronous motor can **not** be identified **when the motor is at a standstill**. However, the value can be **determined** experimentally and **optimised** with the drive operating without a load.

The following procedure should be followed for optimisation of the **EMF voltage PMSM P240**:

Parameter No. [-Array]	Name [Unit]	Factory setting	Setting related to parameter set (P1, ... , P4)
MOTOR DATA/ CHARACTERISTIC CURVE PARAMETERS			**Third party motor**
P209 (P)	No load current [A]	4.4*	**3.8 → 0**
P240 (P)	EMF voltage PMSM [V]	0	**275 → optimal**
P247 (P)	Changeover frequency VFC PMSM [%]	25	25 (leave as set)
Speed control			
P300 (P)	Servo mode	0 (Off = VFC Open-Loop)	0 (leave as set)

* To "0" for IE4 synchronous motors from Getriebebau NORD
To "0" for synchronous motors from other manufacturers

For synchronous motors which are running without load, the **EMF constant** can be optimised with the following specifications by means of the "disabled" parameter **Servo Mode P300**, i.e. **function** {**0** = **Off** (**VFC Open-Loop**)}:

- **No load current P209** = "**0**" and
- Adequate setpoint specification, i.e.
  Setpoint frequency > Switch-over frequency.VFC PMSM P247

The objective is to determine the optimum value for the parameter EMF voltage P240.

The "correct" value for the **EMF constant** has been found when the **Actual current P719** under no-load conditions reaches "**0**" or **almost** "**0**".

The following diagram shows the optimum setting for the EMF voltage PMSM P240:

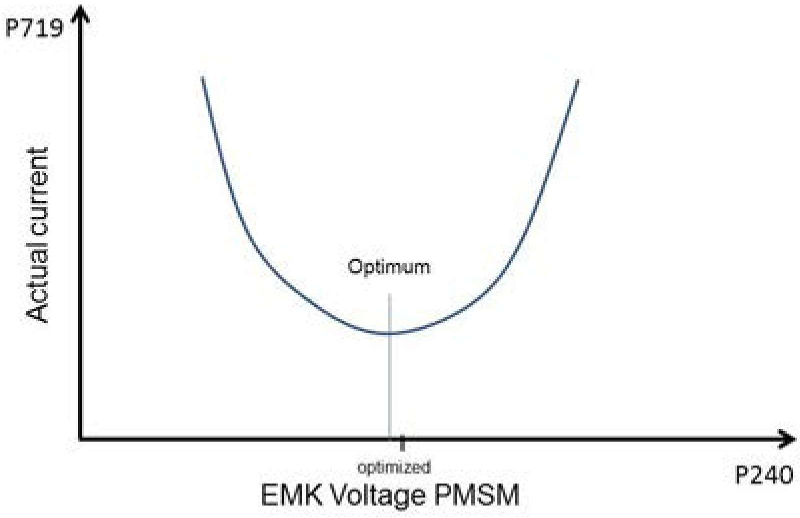


Fig. 17: Diagram for optimum current / EMF constant

Start with smaller setpoint specifications / setpoint frequencies and carry out optimisation of the **EMF voltage PMSM P240** After this, the **setpoint frequency** is increased up to shortly before the **weak field range** and then fine adjustment is carried out.

3.4.4 Stator inductance

After adoption of the stator inductances from the manufacturer's data sheets, see 3.3.2 "NORD – Motor type plates / Data sheet", the **Stator inductance L_d** should be optimised.

The **Stator inductance L_d** or the parameter **Inductance PMSM P241 [-01]** of a synchronous motor can **not** be optimised if the **drive is at a standstill**.
The value for **L_d** can and **may** only be determined experimentally after the **correct determination** of the **EMF constant**, with the **drive running under no-load conditions**.

The following procedure should be followed for optimisation of the **Inductance PMSM P241 [-01]**:

Parameter No. [-Array]		Name [Unit]	Factory setting	Setting related to parameter set (P1, ... , P4)
MOTOR DATA/ CHARACTERISTIC CURVE PARAMETERS				**Third party motor**
P203	(P)	Nominal current [A]	8.3	**5.2 → 1.5**
P209	(P)	No load current [A]	4.4*	**0 → 1.5**
P241	[-01]	Inductance PMSM (d axis) [mH]	20	**8.5 → optimal**
P241	[-02]	Inductance PMSM (q axis) [mH]	20	**18.3 → calculated ****
P247	(P)	Changeover frequency VFC PMSM [%]	25	25 (leave as set)
Speed control				
P300	(P)	Servo mode	0 (Off = VFC Open-Loop)	0 (leave as set)

* To "0" for IE4 synchronous motors from Getriebebau NORD
To "0" for third party motors /synchronous motors from other manufacturers

** Refer to the information for IPMSM or SPMSM

If the synchronous motor is running under no-load conditions, the **Stator inductance L_d** can also be optimised in "disabled" **Servo Modus P300**, i.e. **Function** {**0** = **Off** (**VFC Open-Loop**)} and with a

- Specified setpoint as high as possible (**the setpoint frequency** should be at least **< weak field range**)

.

After this, the parameter **No Load Current P209** is set to the value of the **Nominal current P203**.

The objective is to determine the optimum value for the Stator inductance L_d or the parameter Inductance PMSM P241 [-01].

Inductance PMSM P241 [-01]

The "correct" or optimum value for the **Stator inductance L_d** has been found when the parameter **Actual current P719** under no-load conditions corresponds to the **No Load Current P209**.

Otherwise, the parameter for the **Inductance PMSM P241 [-01]** must be corrected until the value in the parameter **Actual current P719** approximately corresponds to the **No Load Current P209** or the **Nominal motor current P203**.

Inductance PMSM P241 [-02]

For the parameterisation of **stator inductances** attention must be paid to the **version** or type of the **synchronous motor** (PMSM):

- **IPMSM**

  For **IPMSM** drives, the value of the **Stator inductance** L_q in the parameter **Inductance PMSM P241 [-02]** for the **q-axis** should not be changed.

- **SPMSM**

  For **SPMSM** drives, the two values for the **Stator inductance** L_d and L_q should always be **equal**, i.e. the parameter **Inductance PMSM P241 [-02]** for the **q-axis** must be parameterised to the **identical** value of **Inductance PMSM P241 [-01]** for the **d-axis**.

3.5 Incremental encoder (IG)

Step 3

Information & instructions

For the speed feedback, **incremental encoders (IG)** are usually used, which convert the rotary movement into electrical signals (TTL or HTL). Incremental encoders both with and without zero tracks can be used.

Three different encoder resolutions (1024, 2048 and 4096) are available as standard Getriebebau NORD encoders. As the default rotary encoder, a resolution of 4096 pulses (pulses/rotation) is pre-set at the factory in the frequency inverter. Technical data for the incremental encoder, e.g. the relevant connections can be obtained from catalogue 🕮 M7000 Electric Motors.

NOTICE **Installation of rotary encoders**

The incremental encoder **must** be mounted on the **end of the motor shaft**. Otherwise, **inaccuracy** of the **speed** and / or the **position control** may result.

Instructions

3.5.1 Parameterisation of encoders (IG)

For connection of the incremental encoder to the control terminals of decentralised **SK 2xxE** frequency inverters, adjustment of the parameterisation of the **digital inputs DIN2** and **DIN3** is required via the parameters **digit inputs P420** [**-02**] and [**-03**]. The connection of an IG with a **zero track** via **DIN1** must be parameterised via the parameter **Digital inputs P420** [**-01**], for further details see 🕮3.5.2 "Encoder connection (IG)".

For control in **CFC Closed-Loop** mode (servo mode) it is essential that speed control with speed measurement is enabled via an incremental encoder (IG). In the "**Control parameters**" tab, the parameter **Servo mode P300** with the function {**1** = **On** (**CFC Closed-Loop**)} is available for this.

Information **Enabling of control parameters**

For **decentralised SK 2xxE frequency inverters**, the **Control parameters** P3xx tab is enabled with the parameter **P003 Supervisor-Code** {**3** = **all parameters visible**}

For the **control cabinet frequency inverters SK 53xE** and **SK 54xE** the tab is enabled as the default in the **factory settings**.

The corresponding pulse number / resolution for the encoder system must be parameterised in the parameter **Incremental encoder P301**, taking the appropriate prefix (note the installation position) into account.

Parameter No. [-Array]		Name [Unit]	Factory setting	Setting related to parameter set (P1, ... , P4)
Speed control				
P300	(P)	Servo mode	0 (Off = VFC Open-Loop)	Refer to 📖 3.5.5 "Activating the speed control"
P301		Incremental encoder	6*	☝ **6 → 5** (2048 pulses)
			* 6 corresponds to 4096 pulses	

Incremental encoder (IG) with zero track

For applications with an incremental encoder with a zero track, the offset between the zero pulse and the actual rotor position "0" must be set **manually** ☝ in the parameter **Encoder offset PMSM P334**.

Parameter No. [-Array]		Name [Unit]	Factory setting	Setting related to parameter set (P1, ... , P4)
Speed control				
P334	(S)	Encoder offset PMSM [rev]	0.000	☝ **0 → 0.491** *
P335 **		Sync. 0-pulse **	0	See 📖 3.5.4 "Incremental encoder (IG) with zero track"
			*For the value, see on the label in the motor terminal box	
			* Parameter P335 Sync. 0-pulse encoders are only available for SK 54xE	

Details of the parameters **Encoder offset PMSM P334** and **Sync. 0-pulse P335** can be obtained from Section 📖 9.1 "Manuals".

3.5.2 Encoder connection (IG)

Connection of the incremental encoder to the control terminals of the frequency inverter is different for the two frequency inverter series **SK 2xxE** and **SK 5xxE** and requires appropriately modified parameterisation. The connection of an incremental encoder with a **zero track** is also different for the two frequency inverters.

SK 2xxE

For decentralised **SK 2xxE** frequency inverters, connection of the incremental encoder (**HTL**) is made exclusively via the two **digital inputs DIN2** (Terminal 22) and **DIN3** (Terminal 23). In the "**Control terminals**" tab in parameter **Digital inputs P420** [**-02**] and [**-03**] these **must** be switched to the function {**0** = **No function**}.

Parameter No. [-Array]		Name [Unit]	Factory setting	Setting related to parameter set (P1, ... , P4)
CONTROL TERMINALS				
P420	[-01]	Digital inputs (DIN1)	1	☝ **1 → 43** (only for IG with zero track)
P420	[-02]	Digital inputs (DIN2)	2	☝ **2 → 0**
P420	[-03]	Digital inputs (DIN3)	4	☝ **4 → 0**

If the **incremental encoder** is connected and the **Digital inputs DIN2** and **DIN3** are **not** parameterised to the function {**0** = **No function**} there will be a "**clicking**" **noise** when the drive unit is enabled!

Connection of **incremental encoders** with a **zero track**may only be made to **Digital input 1** (DIN1). **Only** the signal **+ zero track** is connected to Terminal 21 (DIN1).

In the parameter **Digital inputs P420** [**-01**], by selecting the function {**43** = **0-track HTL encoder DI1**}, the **starting behaviour** of the **synchronisation** of the **rotor position** is specified.

SK 520E to SK 535E

Connection of the incremental encoder (**TTL**) for control cabinet frequency inverters of performance levels ≥ **SK 520E** is made via the terminal bar X6 (Terminals 51 … 54).

Connection of **incremental encoders** with a **zero track** is only made to the Universal encoder interface, terminal bar **X14**, terminals **63** (Signal CLK-) and **64** (Signal CLK+) in the case of **SK 540E** and **SK 545E** control cabinet frequency inverters.

Information — Power supply

Encoder systems with a suitable power supply (10 V to 30 V) should be planned and used.

The technical data can be obtained from catalogue 🕮 **M7000 Electric Motors** or from the data sheets 🕮 9.3.1 "TIs – Incremental encoder (IG)".

3.5.3 Function test of rotary encoders (IG)

After completion of connection and basic commissioning the **correct function** of the incremental encoder (IG) should always be **checked**.

The prefix (+ or - pulse numbers) **depends** on the **installation position** of the incremental encoder on the motor shaft. For example, if the direction of rotation of the IG does not correspond to the direction of rotation of the frequency inverter (**recommended specification: positive** values = **clockwise rotation**) a **negative** pulse number must be set in the **Incremental encoder P301**.

Information **Checking the encoder speed**

To check the correct selection of the **Incremental encoder P301** the parameter **Speed encoder P735** is available in the "**Information Parameters**" tab.

For the function test of the parameterised encoder function, the motor can be enabled e.g. with a setpoint of **10 Hz** depending on the Nominal frequency P201, e.g. 50 Hz or 70 Hz in **clockwise rotation**. With this, for a 4-pole motor the parameter **Speed encoder P735** should have a value of approx. **300 rpm**.

However, the value for the Speed encoder P735 may vary according to the application, as the setting for the Maximum frequency P105 parameter and the selected setpoint source must also be taken into account.

Parameter No. [-Array]	Name [Unit]	Factory setting	Setting related to parameter set (P1, ... , P4)
INFORMATION, read only			
P735	Speed encoder		approx. 300 rpm

3.5.4 Incremental encoder (IG) with zero track

With the SK 54xE, the **zero track** of an incremental encoder is only evaluated if no universal encoder is connected to the universal encoder interface, terminal bar X14. Refer to 3.5.2 "Encoder connection (IG)" for further details.

The **zero track** of an incremental encoder can be used to determine either the

- Zero rotor position of the synchronous motor or the PMSM

The parameter **Regulation PMSM P330** must be set to either the **function**
- {0 = Voltage-controlled} or
- {1 = Test signal method}

if an incremental encoder is used..

For IE4 synchronous motors manufactured by Getriebebau NORD, the **encoder offset** between the **d-axis** of the **rotor** and the **zero pulse** is measured and documented with a "rpm" and "°" **label** in the terminal box.
For further details, refer to P334 Encoder offset PMSM 3.5.1 "Parameterisation of encoders (IG)".

or for the synchronisation of the

- Zero point (reference point) of the incremental encoder.

The following parameters are available for synchronisation of the zero pulse of the incremental encoder.

Sync. 0-pulse P335

Various functions can be selected for synchronisation:

- **Function** {**0** = **Sync. off**}

  Synchronisation is disabled or switched off and corresponds to the factory setting.

- **Function** {**1** = **Sync rotor pos. PMSM**}

  Synchronisation of the rotor position of a PMSM, i.e. a synchronous motor is enabled or switched on.

- **Function** {**2** = **Sync. reference pos.**}

  Synchronisation of the reference point for positioning applications (POSICON) is enabled or switched on.

- **Function** {**3** = **Sync. PMSM + pos.**}

  Both the synchronisation of the rotor position of a PMSM / synchronous motor as well as the reference point for positioning applications (POSICON) is enabled or switched on.

3.5.5 Activating the speed control

For activation of the speed feedback (**CFC Closed-Loop** mode), under the tab "**Control parameters**" the parameter **Servo mode P300** must be set to Function {**1** = **On** (**CFC Closed-Loop**)}.

CAUTION | **Servo mode activation**

This setting should only be made after the check of the direction of rotation of the incremental encoder has been successfully completed.

Otherwise, unexpected movements (wrong direction of rotation) may result. This may cause both material damage as well as injuries to persons

Parameter No. [-Array]		Name [Unit]	Factory setting	Setting related to parameter set (P1, ... , P4)
Speed control				
P300	(P)	Servo mode	0 (Off = VFC Open-Loop)	**0** → **1** (On = CFC Closed-Loop)

3.6 Absolute encoder (AG)

Information & instructions

For the speed feedback a **combined absolute encoder (AG)** with a separate **incremental track (IG track)** which as a measurement sensor converts the rotary movement into electrical signals (TTL or HTL) can also be used. Both **CANopen absolute encoders**, as well as various **universal encoders** can be used.

Four different encoder types with 13 Bit single turn resolution (8192) as well as 12 Bit (4096) or 16 Bit (65536) multiturn resolution are available as standard Getriebebau NORD encoders. A pulse number of 2048 (pulses/rotation) is used as the standard resolution of the incremental track and is pre-set at the factory in the frequency encoder. Technical data **CANopen absolute encoders**, e.g. the relevant connections can be obtained from catalogue 🕮 M7000 Electric Motors.

NOTICE **Installation of rotary encoders**

It is **essential** that the **combination absolute encoder** (single and multiturn with integral incremental track) is mounted on the **end of the motor shaft**.

Other types of absolute encoder (e.g. Type AG1 / Part no. 19551881 / Kübler Type 8.5888.0421.2102. S010.K014) must **not necessarily** be mounted on the end of the motor shaft.

In this case, the speed ratio in the frequency inverter must be parameterised with the aid of the Ratio P607 and the Reduction Ratio P608. Otherwise, **inaccuracy** of the **speed** (incremental track) and / or the **position control** may result.

Instructions

3.6.1 Parameterisation of CANopen encoders (absolute encoders)

For control in **CFC closed loop** mode (servo mode), for a **CANopen standard combined absolute encoder** (AG) with an additional **incremental track (IG)** it is essential that the speed control with speed measurement is enabled. In the "**Control parameters**" tab, the parameter **Servo mode P300** with the function {**1** = **On** (**CFC Closed-Loop**)} is available for this.

For an encoder system with incremental signals, the corresponding pulse number / resolution must be parameterised in the parameter **Incremental encoder P301**, taking the appropriate prefix (note the installation position) into account.

Parameter No. [-Array]	Name [Unit]	Factory setting	Setting related to parameter set (P1, ... , P4)
Speed control			
P300 (P)	Servo mode	0 (Off = VFC Open-Loop)	☝ **0** → **1** (On = CFC Closed-Loop)
P301	Incremental encoder	6*	☝ **6** → **5** (2048 pulses)
		* 6 corresponds to 4096 pulses	

For the position detection of the position controller with a **standard combination encoder** with a **CANopen** interface (see Section 🕮 2.6 "Selection of absolute encoders"), several parameters must be set under the "**Positioning**" tab for position detection by the position controller.

Parameter No. [-Array]		Name [Unit]	Factory setting	Setting related to parameter set (P1, ... , P4)
POSITIONING / CONTROL PARAMETERS				
P604		Encoder type	0	**0** → **1** (CANopen absolute)
P605	[-01]	Absolute encoder (Multi)	10	**10** → **12** (4096 pulses)
P605	[-02]	Absolute encoder (Single)	10	**10** → **13** (8192 pulses)

3.6.2 Parameterisation of the CANopen interface

For the communication interface of a **CANopen standard combination absolute encoder** (see Section 2.6 "Selection of absolute encoders") further parameters must be set in the "**Extra parameters** tab.

Parameter No. [-Array]		Name [Unit]	Factory setting	Setting related to parameter set (P1, ... , P4)
ADDITIONAL PARAMETERS				
P514		CAN bus baud rate * [kBaud]	5 **	5 (250 kBaud) ** (leave as set)
P515	[-01]	CAN bus address * *Slave address*	32(dec)	32 (leave as set)
P515	[-02]	CAN bus address * *Broadcast slave adr.*	32(dec)	32 (leave as set)
P515	[-03]	CAN bus address * *Master address*	32(dec)	32 (leave as set)
			* System bus	
			** Depending on the frequency inverter, ≥ SK 530E factory setting = 4	
			*** Depending on the frequency inverter, ≥ SK 530E factory setting = 50	

The default settings for the parameters **CAN Baud rate P514** as well as the **CAN address P515** Array [**-01** … **-03**] vary between the **SK 2xxE** and the **≥ SK 530E** control cabinet frequency inverters. These two parameters must be parameterised differently for application-specific requirements or deviations.

Information | **CANopen parameterisation**

For connection of a standard combined absolute encoder to the particular frequency inverter, the **standard address setting** on the CAN open absolute encoder is pre-set at the factory to the value / address {**33**} or {**51**}.

For control cabinet frequency inverters **≥ SK 530E** the standard Baud rate setting / function {**4** = **125 kBaud**} deviates from that of decentralised frequency inverters with {**5** = **250 kBaud**} and is pre-set at the factory for CANopen absolute encoders from Getriebebau NORD.

3.6.3 Connection of CANopen encoders (absolute encoder)

The connection and the necessary 24 V power supply of the **CANopen absolute encoders** is different for the frequency inverter series SK 2xxE and ≥ SK 5xxE.

SK 2xxE

Direct connection to the relevant bus option with system bus interface to the terminals:

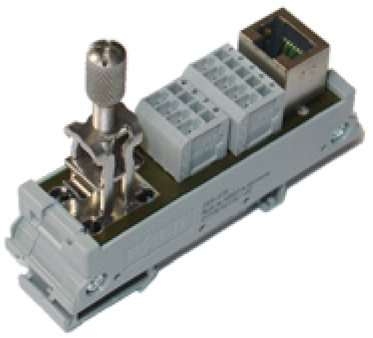
Terminal	Designation	Function	Information
44	VO / 24 V	24 V supply	
40	GND / 0 V	0 V supply	
77	SYS H	System bus +	SYS H / (CAN High)
78	SYS L	System bus -	SYS I / (CAN Low)
		Shield	via large-area earthing using the EMC cable connector

Table 6: SK 2xxE interface connection to the system bus

For detailed information regarding the connection of a **CANopen absolute encoder** to an **SK 2xxE** please refer to the supplementary manual 🕮 BU 0210 and the manual 🕮 BU 0200, see Section 🕮 9.1 "Manuals".

SK 53xE and SK 54xE

An optional **RJ45 WAGO connection module** (Part No. 278910300) is available for connection of the external power supply of the CANopen absolute encoder of SK 53xE and SK 54xE for frequency encoder applications.



Detailed information for the connection of a **CANopen absolute encoder** to a frequency inverter **≥ SK 530E** and to the RJ45 WAGO connection manual can be obtained from the supplementary manual 🕮 BU 0510 and the manuals 🕮 BU 0500 or BU 0505, see Section 🕮 9.1 "Manuals".

Fig. 18: RJ45 WAGO connection module

3.6.4 Function test of CANopen encoders (absolute encoders)

After completion of connection and basic commissioning the **correct function** of the **CANopen absolute encoder** (AG) should always be **checked**.

Information **CANopen status**

The **CANopen status** of the absolute encoder interface and the frequency inverter can be evaluated or checked with the parameter **CANopen status P748** under the tab "Information Parameters".

Further CANopen participants (nodes / addresses) may possibly be connected to the CANopen field bus, so that the assignment of double addresses or different Baud rates etc. may have been parameterised.

Parameter No. [-Array]	Name [Unit]	Factory setting	Setting related to parameter set (P1, ... , P4)
INFORMATION, read only			
P748 [-01]	CANopen status * [hex]		Check display of CANopen status
	* System bus		

The parameter **CANopen state P748** shows the status of the CANbus /CANopen in bit-coded form, i.e. therefore the state of CANopen MNT For detailed information, please refer to the relevant manual for the frequency inverter, see 9.1 "Manuals".

Procedure

For both the function test of the CANopen encoder as well as for commissioning of the position control, it is recommended that a set procedure is followed.

CAUTION **Servo mode activation**

Ensure that the Emergency Stop and safety circuits are functional! For lifting gear applications, prior to switching on for the first time measures must be taken to prevent the load from falling. In addition, for the load take-up, the parameters **Brake reaction time P107** and **Brake delay off P114** should be optimised **after the optimisation of the speed controller.**

Otherwise, unexpected movements (wrong direction of rotation) may result. This may cause both material damage as well as injuries to persons

1 Commission the axis without position control

After the input of all parameters the drive unit should first be commissioned without control of the position or speed.
For this the speed control must be switched off in the parameter **Servo mode P300** with the function {**0** = **Off** (**VFC Open-Loop**)} and the parameter **Position control P600** and the function {**0** = **Off**}.

2 Commissioning the speed controller

This step may be omitted if no speed control is required or if an incremental encoder is used. Otherwise the **Servo mode P300** should be switched to {**1** = **On (CFC Closed-Loop)**}

Information — Servo mode

If the motor only runs at a slow speed with a high current consumption after activation of the **Servo mode P300** with the function {**1** = **On** (**CFC Closed-Loop**)}, there is usually an error in the wiring or the parameterisation of the incremental encoder connection. The most frequent cause is an incorrect assignment of the direction of rotation of the motor to the counting direction of the encoder.

The optimisation of the speed control is optimised after commissioning of the position control, as the behaviour of the position control circuit can be influenced by changes to the speed control parameters.

3 Commissioning the position controller

After setting parameter **Encoder type P604** and **Absolute encoder P605** it must be checked whether the actual position is correctly detected. The actual position is displayed in the parameter **actual position P601**.
The value must be stable and become larger if the motor is switched on with rotation to the right enabled. If the value does not change when the axis is moved, the parameterisation and the encoder connection must be checked. The same applies if the displayed value for the actual position jumps although the axis has not moved.

4 Specify and move to the setpoint position

After this a setpoint position in the vicinity of the actual position should be specified and moved to by enabling the drive unit.

Information — Testing the absolute encoder function

The encoder position of the absolute encoder can be checked with the parameter **Actual position P601** using NORD CON. If the direction of action of the absolute encoder is not correct, i.e. after being enabled, the axis moves away from the setpoint position instead of towards it, this indicates an incorrect assignment between the direction of rotation of the motor and the direction of rotation of the encoder. In this case, there is the possibility of changing this by a **negative input** of the speed ratio value in the parameter **Ratio P607.**

Under the "**Positioning Parameters**" tab, using the parameter **Encoder type P604**, the corresponding encoder system is parameterised for detection of the **actual position value**.

The direction of effect of the absolute encoder, i.e. the prefix (+ or - pulse numbers) **depends** on the **installation position** of the incremental encoder on the motor shaft. For example, if the **direction of rotation** of the incremental encoder does not correspond to the direction of rotation of the frequency inverter (recommended specification: **positive** values = **clockwise rotation**) a **negative** pulse number must be set in the **Incremental encoder P301**.

Parameter No. [-Array]		Name [Unit]	Factory setting	Setting related to parameter set (P1, ... , P4)
POSITIONING / CONTROL PARAMETERS				
P601		actual position [rev]	---	Check display
P602		Actual Ref. Pos. [rev]	---	Check display
P603		Curr. position diff. [rev]	---	Check display
P604		Encoder type	0	**0 → 1** (CANopen absolute)
P607	[-02]	Ratio (absolute encoder)	1	
P608	[-02]	Reduction Ratio (absolute encoder)	1	

If the function test is complete and the detection of the actual position operates correctly, the position controller can be optimised according to the following procedure, see 6 "Position control".

3.7 Identification of the rotor position

Instructions

For the determination of the **start position of the rotor** a **determination procedure** is required, which depends on the encoder system which is used (IG or AG).

NOTICE **Incorrect positioning**

For applications with **incremental encoder feedback**, **determination of the start position of the rotor is necessary each time that the mains are switched on**.

If this is not done, there is a danger of incorrect positioning or damage to the drive unit or the entire system.

Incremental encoders (IG) both with and without zero tracks can be used for the **identification of the rotor position**.

For this, the identification method is set in the "**Control parameters**" tab using the parameter **Control method PMSM P330** and on the basis of the required functionality.

Further parameters are available for **identification of the rotor position** and for setting specific parameter values for the encoder system:

Parameter No. [-Array]		Name [Unit]	Factory setting	Setting related to parameter set (P1, ... , P4)
MOTOR DATA/ CHARACTERISTIC CURVE PARAMETERS				
P212	(P) (S)	Slip compensation [%]	100	(check if necessary)
P213	(P) (S)	Amplification ISD control [%]	100	(check if necessary)
Speed control				
P300	(P)	Servo mode	0 (Off = VFC Open-Loop)	1 (On = CFC Closed-Loop)
P330	(S)	Regulation PMSM	1 (test signal method)	**1 → …** (depending on the encoder system)
P334	(S)	Encoder offset PMSM [rev]	0.000	**0.000 → …** (depending on the encoder system)
P335		Sync. 0-pulse	0	**0 → …** (depending on the encoder system)

Information **Applications with a brake**

Identification of the rotor position by means of the parameter **Control method PMSM P330** is **only possible to a limited extent** if a **brake** is used (e.g. release of the brake).

For determination of the start position of the rotor, only **enabling** of the **drive** is necessary for the identification method, i.e. the specified setpoint can be left as **0 Hz**.

3.7.1 Procedure for determining the start position of the rotor

Determination of the **start position of the rotor** is carried out with the parameter **Control method PMSM P330**. Depending on the encoder system which is used, four different functions are available for synchronous motors.

The function to be set for identification of the rotor position or the control method depends on the frequency inverter series and the performance level which is used.
For **incremental encoders** the **Control method PMSM P330** must be set with either the **function** {**0** = **Voltage controlled**} or {**1** = **Test signal method**}.
For **absolute encoders** either the **function** {**2** = **Value for universal encoder**} or {**3** = **Value for CANopen encoder**} must be set.
For detailed information regarding the particular encoders and their parameterisation, please refer to the relevant supplementary manual **POSICON Positioning Control** (see 🕮 BU 0210 or 🕮 BU 0510) see 🕮 <dg_ref_source_inline>Handbücher</dg_ref_source_inline>)

Function {**0** = **Voltage controlled**} (only for incremental encoders)

With the first start of the machine, a voltage indicator is memorised which ensures that the rotor of the machine is set to the rotor position "zero". This type of determination of the starting position of the rotor can only be used if there is no counter-torque from the machine (e.g. flywheel drive) at frequency "zero". If this condition is fulfilled, this method of determining the position of the rotor is very precise (<1° electrical).
The function {**0** = **Voltage controlled**} may only be used for horizontal or "torque-free" applications (without a brake). In principle, this method is unsuitable for lifting equipment applications, as there is always a counter-torque. In case of parameter changes or mains failure / mains switch-off the method is always restarted automatically. If the rotor position is changed while a voltage is applied to the frequency inverter, this is automatically taken into account on condition that the incremental encoder is connected.

Function {**1** = **Test signal method**} (only for incremental encoders)

The function {**1** = **Test signal method**} which is to be set for the detection of the rotor position / control method may **only** be used for **synchronous motors** with **permanent magnets which are integrated in recesses**, i.e. so-called **IPMSM** (Interior Permanent Magnet Synchronous Motors).
Detailed information about IE4 synchronous motors from Getriebebau NORD is contained in the Technical Information **TI 80-0010**; refer to 🕮 <dg_ref_source_inline>TIs Richtlinien</dg_ref_source_inline> for further details.

The starting position of the rotor is determined with a test signal. This method also functions at a standstill with the brake applied, however it requires a PMSM with sufficient anisotropy between the stator inductance L_d und L_q, see 🕮 <dg_ref_source_inline>Statorinduktivität</dg_ref_source_inline>.
This difference exists for IE4 synchronous motors from Getriebebau NORD (IPMSM). The higher this anisotropy (direction dependence) is, the greater the precision of the method. The voltage level of the test signal can be changed via the parameter **Slip compensation P212**.
The position of the rotor position controller is adjusted with the parameter **Adjust ISD control P213**. For motors which are suitable for use with the test signal method, a rotor position accuracy of 5°…10° electrical can be achieved (depending on the synchronous motor and the anisotropy).

In case of parameter changes or mains failure / mains switch-off the rotor position is always redetermined automatically.

Information — Incremental encoders with zero track

If there is an **incremental encoder** with a "**zero track**" on the motor shaft, the "zero track" can also be used to determine the starting position of the rotor. The **zero pulse** can be used with both decentralised **SK 2xxE** and **SK 54xE** frequency inverters for **synchronisation of the rotor position**.

Detailed information for the parameterisation and connection of an incremental encoder with a zero track can be found in Section 🕮 <dg_ref_source_inline>Inkrementaldrehgeber</dg_ref_source_inline>.

Function {**2** = **Value from universal encoder**} (Universal encoder only for ≥ SK 54xE)

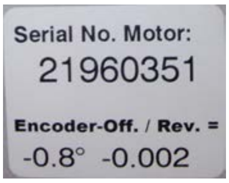
With this method the starting position of the rotor is determined from the absolute position of a universal encoder (Hiperface, EnDat with Sin/Cos track, BISS with Sin/Cos track or SSI with Sin/Cos track). The universal encoder type is set in the parameter **Encoder type P604** (see 🕮 Function {8 - 15}).
For this position information to be unique it must be known (or determined) how this rotor position relates to the absolute position of the universal encoder. This is performed via the offset parameter **Encoder offset PMSM P334**.

Synchronous motors from **Getriebebau NORD** are always supplied with a defined rotor start position or **encoder offset**. The value or the encoder offset are always documented in "**°**" and "**rev**" details on the synchronous motor by means of a label in the terminal box.

If this value is not known, the **offset value** can also be determined by setting the function {**0 = Voltage controlled**} or {**1** = **Test signal method**} of the parameter **Control method PMSM P330**. For this the drive unit is started with the function setting {**0 = Voltage controlled**} or {**1** = **Test signal method**}. After the first start, the determined offset value is stated in the parameter **Encoder offset P334**.

Information — Encoder offset label

This **value** in the parameter **Encoder offset P334** is **volatile**, and therefore is only saved in the RAM of the frequency encoder. In order to overwrite the value in the EEPROM, the value must be changed and then parameterised back to the value which was originally determined. After this, fine adjustment can be carried out with the synchronous motor running under no load.



For this, in **Servo mode P300** the drive is parameterised to the function {**1** = **On** (**CFC Closed-Loop**)} and run with a speed which is as high as possible, but ≤ weak field range. From the starting point, the offset is gradually adjusted so that the value of the **Voltage component** U_{sd} in parameter **Voltage d P723** is as close as possible to "**0**”. A balance between the positive and negative direction of rotation should be sought. In general the value "**0**" cannot be achieved, as the synchronous motor has a load due to the fan wheel at high speeds. The universal encoder should be located on the motor shaft.

Function {**3** = **Value for CANopen encoder**} (only for CANopen absolute encoders)

Identical function description as for function {**2** = **Value of universal encoder**}, see above, however for the determination of the rotor start position or the absolute position, a **CANopen** absolute encoder is used instead of a universal encoder. The type or function of the CANopen absolute encoder is set in the parameter **Encoder type P604** (see 🕮 Function {1, 5 - 7}).

For the determination of the **start position of the rotor** with incremental encoders, with the parameter **Regulation PMSM P330** a measurement precision of approx.± 3 to 10° (electrical) is achieved.

For **CANopen standard combination absolute encoders** from Getriebebau NORD determination of the start position of the rotor is normally unnecessary. The encoder adjustment is carried out at the factory and does not require further determination of the encoder offset. The encoder must be readjusted if it is not adjusted, or the adjustment has been changed due to impact or removal of the synchronous motor

4 Current control

Step 4

Information

The current control is comprised of two different **PI controllers**:

- Torque current controller (P312, P313, P314)
- Field current controller (P315, P316, P317)

These are divided into parameters P312 / P315 for the **P component** and parameters P313 / P316 for an **I component**. In addition, two further "limit parameters" P314 or P317 complete the particular controller. These are used to limit the maximum voltage range (🕮 9.1 "Manuals").

Information — Controller values

The settings for the **P component** and the **I component** of the particular controller should **always** have the **same setting**, i.e. P312 = P315 and P313 = P316. The limit parameters P314 or P317 are **not** considered in further detail in this guide!

The following diagrams show several control curves / transient responses which occur after a sudden change of the setpoint for various **PI controllers**.

Diagram 1

Selected P component too small

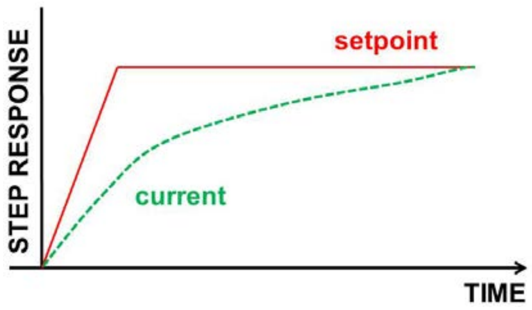


Diagram 2

P component optimised and I component selected too small

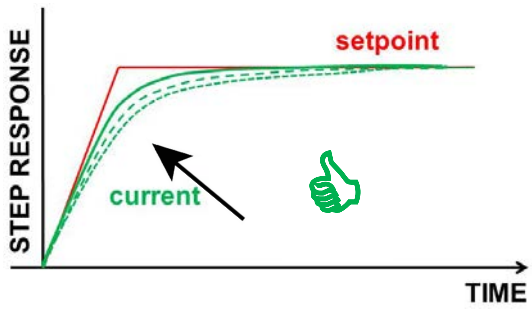


Diagram 3

P and I component optimal

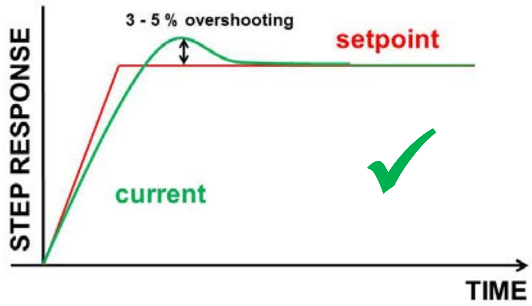


Diagram 4

P component optimised and I component selected too large

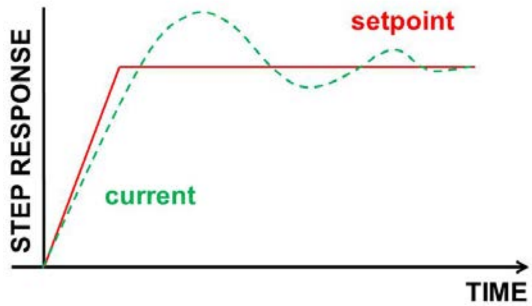


Fig. 19: Control value curves

The various control curves, where the **setpoint** is shown in **RED** and the **actual value** is shown in **GREEN**, describe the dynamic curve for the transient response, which is set via the individual control parameters (**P** and **I component)** of the controller.

It is recommended that the following **optimisation steps** are performed to systematically adjust a current controller.

Overview of the optimisation procedure

- Set the **I component** to a **low value**
- **Increase the P component** from the **standard value** in e.g. **50 % increments** until no further rapid increase of the actual value (**Flux current ~P721**) can be achieved. A curve as shown in **Diagram 2** results.
- This is followed by an **increase** of the **I component** in e.g. **20 % / ms increments** until an **overshoot** of approx. **3** to **5 %** is achieved.
  Diagram 3 shows the optimised curve, whereby in this diagram, the overshoot is slightly exaggerated for clarity.

Diagram 1 shows the curve if the P components is selected too small. In contrast **Diagram 4** shows the curve for the actual value when the I component is set too large. In this case, the I component should be gradually reduced to set a curve as shown in **Diagram 3**.

☞ **The aim is to optimise the curve for the Flux current ~P721 with the "correct" settings of the P and I components.**

The practical implementation for optimisation of a current controller is described in Section 🕮 4.4 "Optimisation procedure".

4.1 Further settings

Instructions

For optimisation of the current controller, it is essential that the following two parameters are set in advance.

Parameter No. [-Array]	Name [Unit]	Factory setting	Setting related to parameter set (P1, ... , P4)
MOTOR DATA/ CHARACTERISTIC CURVE PARAMETERS			
P209 (P)	No load current [A]	8.3*	**0** → e.g. **5.4** (Nominal motor current P203) **
		*) dependent on FI power or P200 / P220	
		** To "0" for IE4 synchronous motors from Getriebebau NORD To "0" for synchronous motors from other manufacturers	
EXTRA PARAMETERS			
P505 (P)	Absolute mini. freq. [Hz]	2.0	**2.0** (check whether factor setting)

For optimisation of the current controller of a synchronous motor, the Absolute mini. Freq. P505 must not be "0". It is recommended that the value is left at the factory setting.
Furthermore, for optimisation it should be noted that after a change to the motor-specific parameter value (P2xx) the rotor position must always be redetermined (see 🕮 **Fehler! Verweisquelle konnte nicht gefunden werden. "Fehler! Verweisquelle konnte nicht gefunden werden."**).
Enabling or performance of the measurement must only be carried out after redetermination of the rotor position.
Before starting the scope recording and enabling the drive unit, the **setpoint** must always be set to **0 %** (**0 Hz**).

4.2 NORD CON

Information & instructions

NORD CON should be used for programming, operation and optimisation of the controllers.
Optimisation of the controllers for NORD frequency inverters can be performed with this parameterisation and control software. The **oscilloscope function** provides e.g the possibility to assess the particular optimisation steps on the basis of several scope recordings.
Further information about the latest version can be found under the following link: NORD CON
The functions **Remote Control** and **Control** as well as the **Device Overview** are available for control of the frequency inverter.

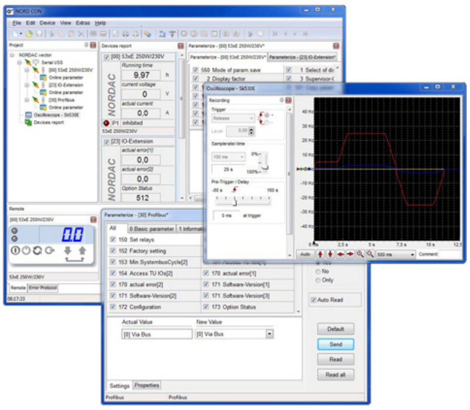
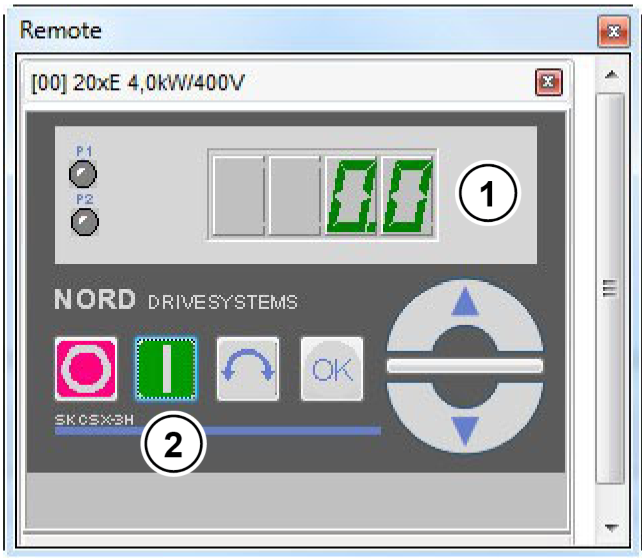


Fig. 20: NORD CON

Detailed information about the various functions, e.g. interface configuration, operation, oscilloscope settings, etc. can be found in the **NORD CON** Manual **BU 0000**, see 🕮 9.1 "Manuals".

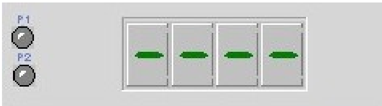
4.2.1 Remote control

The following setting must be made in the **Remote Control screen** to optimise the current controller before starting the scope recordings.



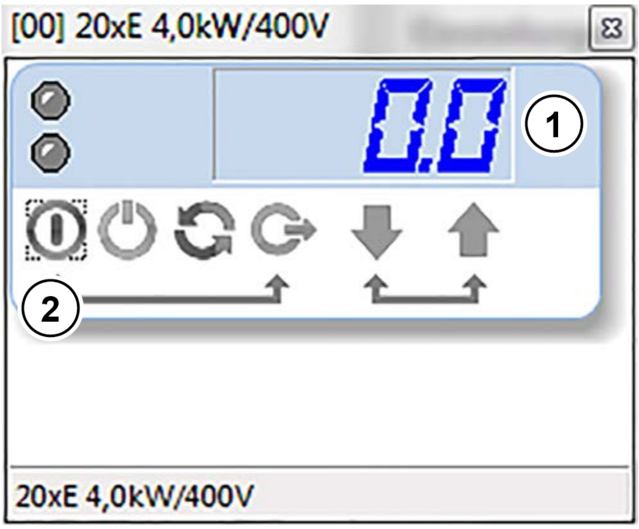
1 **Leave the setpoint at 0 %, i.e. leave the setpoint frequency at 0 Hz**

Alternative display possibility



2 **Press the Enable button**

Fig. 21: Remote control of the current controller, setpoint and enabling



New display in NORD CON

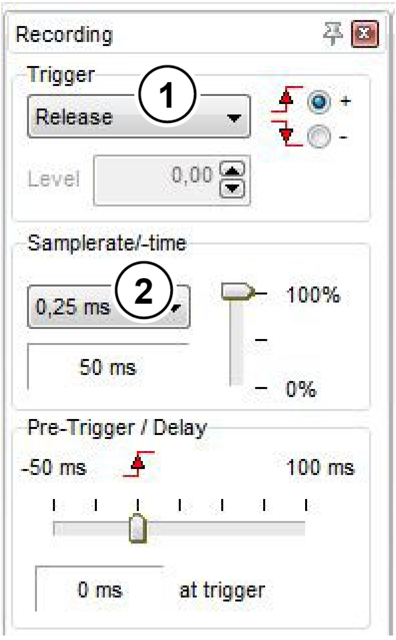
Fig. 22: Remote control of the current controller, setpoint and enabling

Information **Remote Control display**

The display in the Remote Control screen may vary for different NORD CON settings and versions. E.g. the Remote Control screen is displayed differently for SK 5xxE frequency inverters.

4.2.2 Oscilloscope

The following settings should be made under the two tabs **Recording** or **Channel Settings** of the NORD CON **Oscilloscope Function** before starting the oscilloscope recordings. The settings and graphic displays in the illustrations may differ according to the frequency inverter types, versions and software status.



1 **Set Trigger to Enable**

2 **Set the scan rate to 0.25 ms**

→ Scan duration 50 ms

Note
The scan rate should be selected so that it corresponds to the scope recordings in the illustrations in Section 🕮 4 "Current control"!

Fig. 23: Oscilloscope settings for trigger and scan rate / scan duration

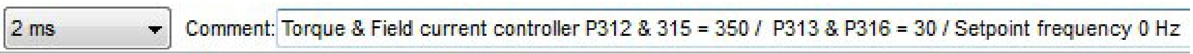


Fig. 24: Resolution settings for the time axis, comment examples

Various types are available for selection of the measuring values which are to be recorded. Depending on the controller, the "**unfiltered**" (~P7xx / with approx. 250 µs) and the "**filtered**" (≈P7xx / with approx. 50 ms) values should be set for the oscilloscope recordings.

Mesure value	Description
(= [illegible]umber]) [Name]	The value of this measuring function is updated in the time slot pattern by approx. 100 ms and corresponds to the value indicated of the parameter.
[Name]	The value of this measuring function is highly filtered and updated in a time slot pattern by approx. 100 ms. updated in a time slot pattern by approx. 100 ms.
(≈ P[Number]) [Name]	The value of this measuring function is filtered and updated in a time slot pattern by approx. 50 ms.
(~ P[Number]) [Name]	The value of this measuring function is updated in a time slot pattern of approx. 250 µs.

Fig. 25: Legend / Meaning of measurement functions

ⓘ Information **Oscilloscope recordings**

To obtain a better depiction of the measurement values, in this guideline the **colours** in the **channel settings** for the particular **measurement values** have been modified for the oscilloscope settings.

For the use of the application guide it would be generally **advantageous** if during the **optimisations / oscilloscope- recordings** which are carried out (e.g. for the current, speed, position controllers, etc.) the **identical settings** are selected for the **colour** and **resolution** of the **measurement values** which are to be displayed.

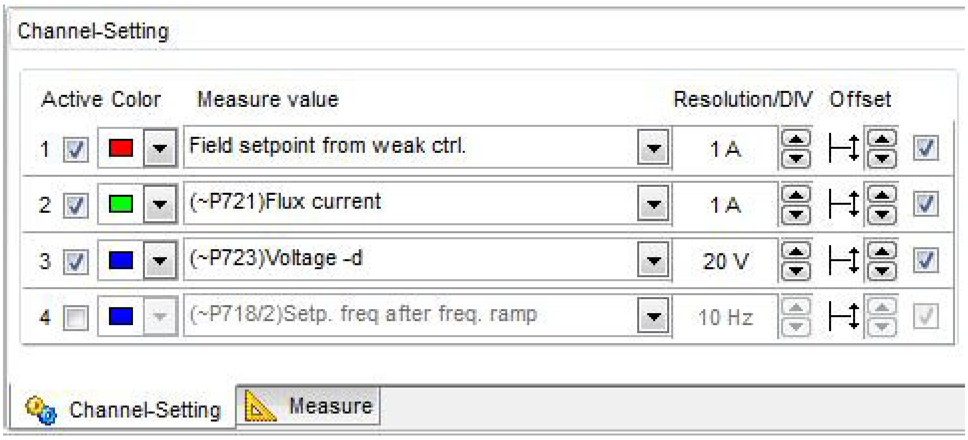
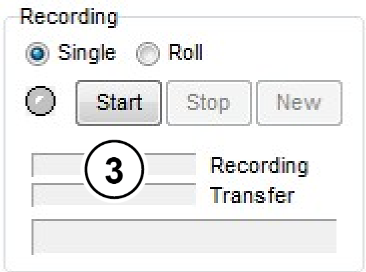


Fig. 26: Oscilloscope channel settings for the three measurement values



3 **Press the Start button**

Fig. 27: Start the scope recording

Information | Initialisation

After pressing the start button, the initialisation phase of the oscilloscope recording begins. This is indicated with the (yellow) indicator light. Because of this, **enabling** must only be carried out after **completion** of the **initialisation phase** for the oscilloscope recording.

Completion of the initialisation phase is indicated with a (green) colour change.

Fig. 28: Initialisation phase of scope recording

4.3 Torque and field current controller

Information & instructions

For current controllers, in general both the **P** and the **I component** of the **torque current control** and the **field current control** should always be changed simultaneously for the particular optimisation step.

As the pre-setting for optimising the current controller, the **P component** (P313 / P316) for the **1st optimisation step** should be set to **55 %** and the **I component** (P313 / P316) should be set to **5 % / ms**.

Parameter No. [-Array]		Name [Unit]	Factory setting	Setting related to parameter set (P1, ... , P4)
Speed control				
P312	(P)	Torque curr. Ctrl. P [%]	400	**50 → vary**
P313	(P)	Torque curr. ctrl. I [%/ms]	50	**50 → 5**
P314	(P)	Torq. curr. ctrl. limit [V]	400	400 (leave as set)
P315	(P)	Field curr. ctrl. P [%]	400	**50 → vary**
P316	(P)	Field curr. ctrl. I [%/ms]	50	**50 → 5**
P317	(P)	Field curr ctrl lim [V]	400	400 (leave as set)

The changes to the control parameters must be checked with the **NORD CON Oscilloscope Function** (4.2.2 "Oscilloscope").

Before optimisation of the current controller it is **essential** that the parameter **No Load Current P209** described in Section 4.1 "Further settings" is adjusted.

The next optimisation steps and the corresponding scope recordings should be carried out as follows:

Information — Oscilloscope recording

If a range is reached in which the changes in the curve cannot be viewed directly, it is advisable to save the oscilloscope recordings. With the facility for **displaying several recordings simultaneously** a **direct comparison** with the previous settings is possible.

4.3.1 Current control P components

Starting from the standard value [50 %], increase the parameter for the P component of the **Torque current controller P P312** and the **Field current controller P P315** in **50 % increments** until a rapid increase of the actual value, i.e. of the **Flux current ~P721** no longer occurs.

The curve is as illustrated in **Diagram 2** (see 🕮 4 "Current control").

With this setting, the **Voltage component U_{sd} ~P723** or the parameter **Voltage -d P723** must **not exceed** the maximum value of **20 %** of the **nominal voltage P204**, i.e. for 385 V this corresponds to UN ≈ 77 V).

Information **Standard values of P components**

For some motor sizes it may be the case that with the standard setting for the **P components** of the current controller (**P312** and **P315**) the maximum permissible value for the **Voltage component U_{sd} ~P723** is already exceeded.

In this case a **starting value < 50 %** (standard value) must be selected for the **P components**.

4.3.2 Current control I components

Increase the parameter for the **I component** of the **Torque current control I P313** and the **Field current control I P316** from the set starting value [5 % / ms] in **5 % increments** until a slight overshoot of approx. **3 %** to **5 %** of the actual value, i.e. of the **Flux current ~P721** occurs.

The curve is as illustrated in **Diagram 3** (see 🕮 4 "Current control").

The **Voltage component U_{sd} ~P723** or the parameter **Voltage -d P723** must **not exceed** the maximum value of **25 %** of the **Nominal voltage P204**, i.e. for 385 V this corresponds to U_N ≈ 96 V.

Information **Voltage component U_{sd}**

Depending on the motor data a more rapid or slower reduction of the **Voltage component U_{sd} ~P723** may occur after reaching the maximum value **(≈ 25 %** of the **nominal voltage P204**).

4.3.3 Criteria

The following criteria should be noted for optimisation of the field weakening control:

The aim is to optimise the curve for the Flux current ~P721 with the "correct" settings of the P and I components.

- Keep the rise time of the **Flux current ~P721** to a minimum
- Aim for a maximum overshoot of 3 – 5 % of the **Magnetisation current ~P721**
- Only allow an amplitude of the **Voltage component U_{sd} ~P723** which does not exceed 20 % or 25 % of the **Nominal voltage P204**

Information **Optimisation steps**

The step widths stated for control optimisation may differ depending on the application. Furthermore, the step widths can be selected even finer for the final optimisation steps.

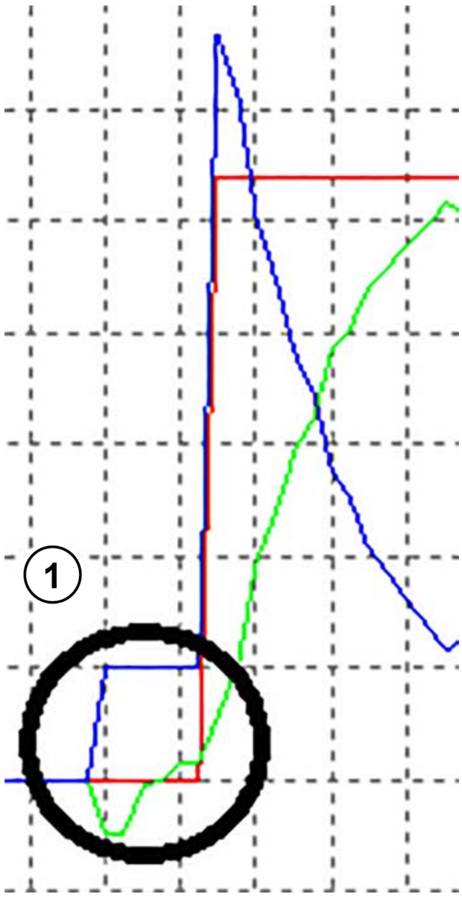
4.4 Optimisation procedure

Instructions

Information — Short circuit detection

It is possible that an oscillation may occur at the start of the curve. This oscillation occurs with frequency inverters with an integrated "**automatic short circuit detection**".

This has **no** effect on the optimisation of the current controller.



1 **automatic short circuit detection for SK 200E 4.0 kW frequency inverter, with 3.0 kW IPMSM (IE4)**

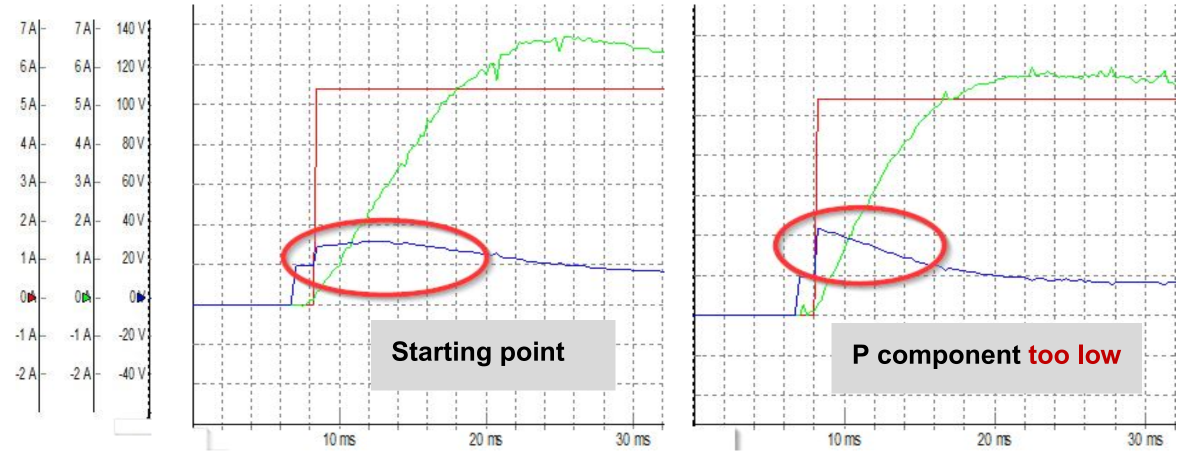
Legend	Field setpoint vs. Weak field	Flux current ~P721	Voltage component ~P723

Fig. 29: Short circuit measurement of SK 200E frequency inverter

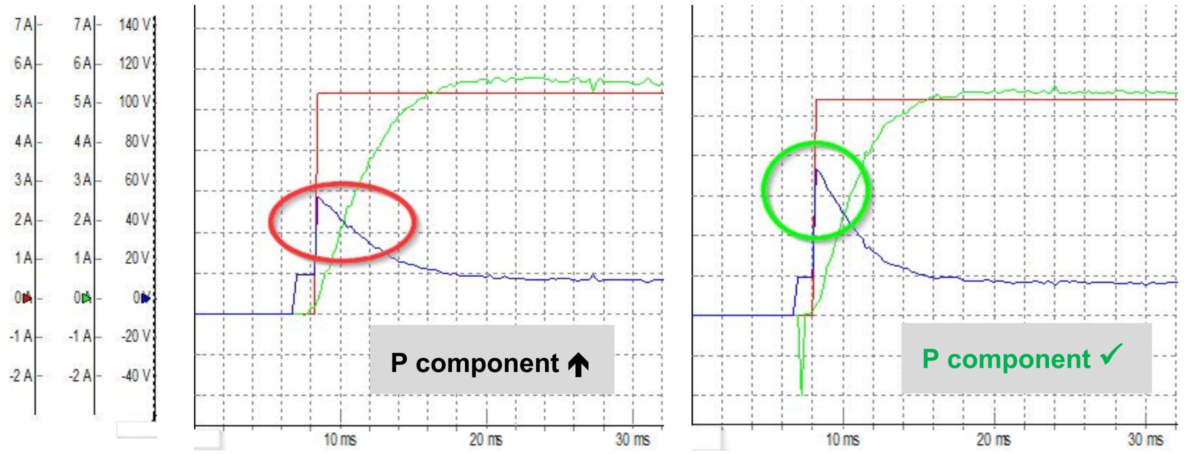
The following illustrations show the optimisation process for the current controller using the example of a **3.0 kW synchronous motor** with efficiency class **IE4** on the basis of individual scope recordings.

Legend	Field setpoint vs. Weak field	Flux current ~P721	Voltage component ~P723

Step	1. "P" scope recording	2. "P" scope recording
Parameter settings	P312 / P315 = **50 %** P313 / P316 = **5 % / ms**	P312 / P315 = **100 %** P313 / P316 = 5 % / ms



Step	3. "P" scope recording	4. "P" scope recording
Parameter settings	P312 / P315 = **150** % P313 / P316 = 5 % / ms	P312 / P315 = **200 %** P313 / P316 = 5 % / ms



Step	5. "P" scope recording	8. "P" scope recording
Parameter settings	P312 / P315 = **250 %** P313 / P316 = 5 % / ms	P312 / P315 = **400 %** P313 / P316 = 5 % / ms

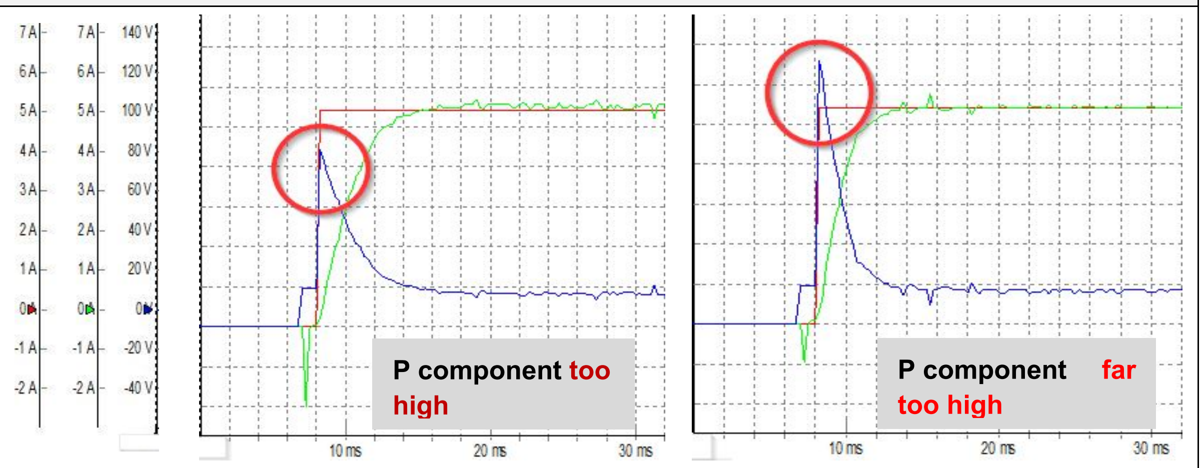


Fig. 30: Curve for the P component of the current control

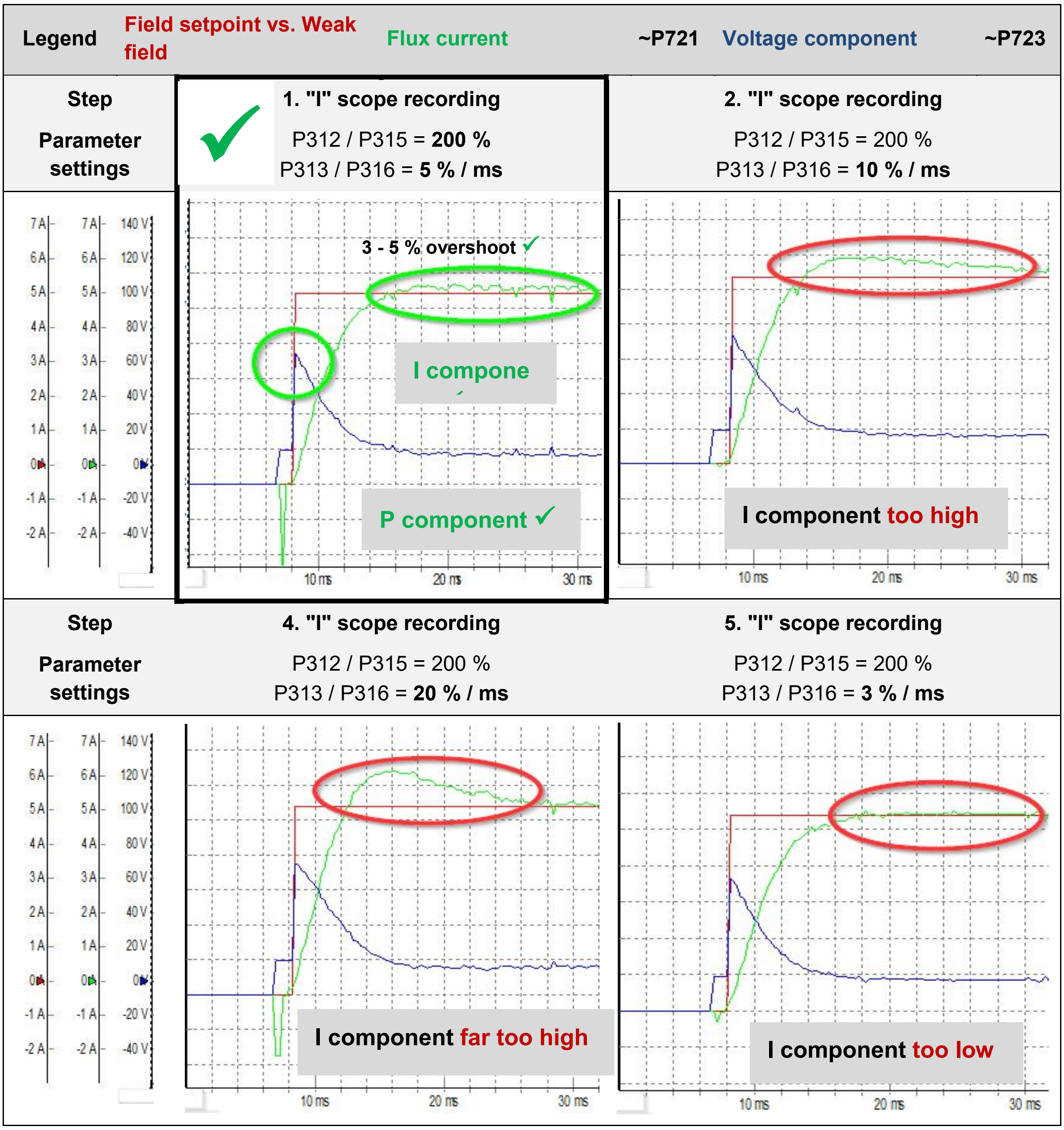


Fig. 31: Curve for the I component of the current controller

4.5 Setting the no load current

After completion of optimisation of the current controller, the following parameter must be reset accordingly.

Parameter No. [-Array]	Name [Unit]	Factory setting	Setting related to parameter set (P1, ... , P4)
MOTOR DATA/ CHARACTERISTIC CURVE PARAMETERS			
P209 (P)	No load current [A]	8.3*	☞ e.g. **5.4 → 0**

*) dependent on FI power or P200 / P220

5 Speed control

Step 5

Information

The speed controller is a **PI controller** and comprises the two following parameters.

- Speed controller (P310, P311)

The parameter **Speed Ctrl P P310** influences the **P component** of the controller. For the **I component** the parameter **Speed Ctrl I P311** is available.

It is recommended that the following **optimisation steps** are performed to systematically adjust the speed controller for constant loads.

Overview of optimisation procedure

- Set the **I component** to a **low value**

- Set the **P component** to a **low** value and e.g. **increase in 50 % increments** until the **Torque current ~P720** has a curve which is as **rectangular** as possible.
  The **Speed encoder ~P735** should have a linearly increasing curve.

- This is followed by the **increase** of the **I component** in e.g. **5 % / ms increments**, in order to further optimise the **rectangular curve** of the **Torque current ~P720**. This optimisation causes a **slight overshoot** of the speed.

The aim is to optimise the curve for the Torque current ~P720 with the "correct" settings of the P and I components.

The practical implementation for optimisation of a speed controller is described in Section 5.4 "Optimisation procedure".

5.1 Further settings

Instructions

For optimisation of the speed controller, the ramp time must be set under the "**Basic Parameters**" tab in the parameter **Acceleration time P102**. In addition the **Jog frequency P113** and the **Absolute mini. freq. P505** must be parameterised as necessary.

Parameter No. [-Array]		Name [Unit]	Factory setting	Setting related to parameter set (P1, ... , P4)
BASIC PARAMETERS				
P102	(P)	Acceleration time [s]	2.0	**2.0 → 0.3 ***
P113	(P)	Jog frequency [Hz]	0.0	**0.0 → 50**
EXTRA PARAMETERS				
P505	(P)	Absolute mini. freq. [Hz]	2.0	**2.0 → 0.0**

* Notice: this is set without load in the example

Information — Brake applications

For applications with a brake, the parameter **Brake reaction time P107** as well as the **Brake delay off P114** must be parameterised for the optimisation of the controller.

Otherwise a fault message will occur, as the drive goes into fault status due to the applied brake.

Information — Setpoint / Weak field range

Optimisation of the **speed controller must be performed below** the **weak field range**!

Because of this, the **setpoint specification** must be **matched to the design range** (70 Hz / 100 Hz **–** curves). For a standard design according to the **70 Hz characteristic curve** the **setpoint** (**frequency**) should be approx. **70 %** approx. **50 Hz**.

For applications with an **operating point** (**100 Hz – Characteristic curve**) a **setpoint** (**frequency**) in the range of approx. **70 %** (i.e. approx. **70 Hz**) must be specified.

The **weak field range** for this application depends on the load and therefore starts above the **Nominal frequency P201**, i.e. in this case > **70 Hz**.

The setting for the **Acceleration time P102** must be selected so that if possible, the **Torque current ~P720** achieves **50 % - 100 %** of the nominal current P203 (see **type plate / nominal motor current**) with the optimisation.

Setting of the **Torque current ~P720** (**I_{sq}**) sollte mit Hilfe der NORD CON Oszilloskop Funktion vorgenommen werden.

Before starting the scope recording and enabling the drive unit, the **setpoint** must be set to a value of approx. **70 %** of the **Nominal frequency P201** (70 Hz). I.e. in this example (frequency inverter 4.0 kW / motor combination 3.0 kW) a setpoint frequency of approx. **50 Hz** must be specified.

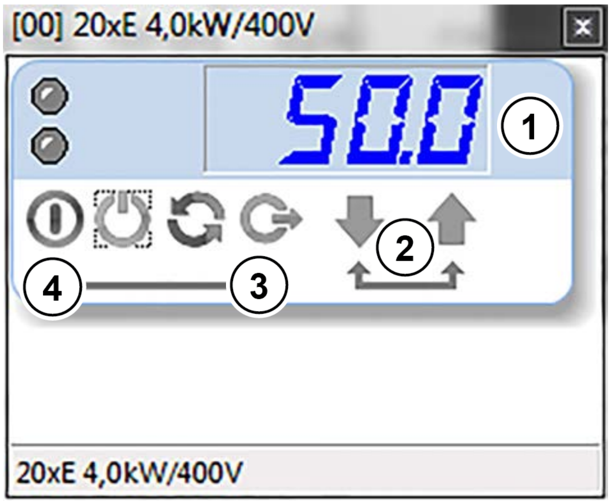
5.2 NORD CON

Information & instructions

Further information about the settings can be obtained from Section 🕮 4.2 "NORD CON" and the following.

5.2.1 Remote control

The following setting must be made in the **Remote Control screen** to optimise the speed controller before starting the scope recordings.



① Set the setpoint to 70 %, i.e.set the setpoint frequency to approx. 50 Hz

② Use the + value or the - value button

③ Press the OK button to save the frequency as the jog frequency in P113

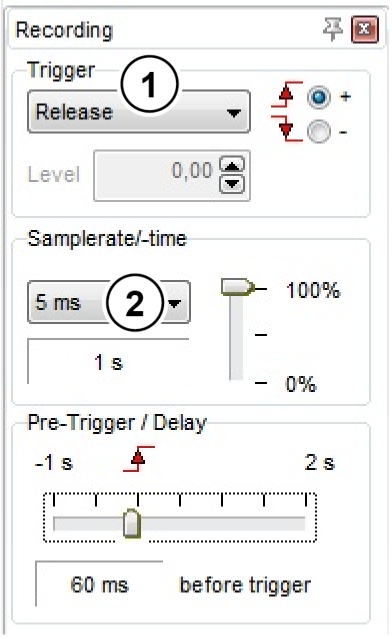
④ Press the Enable button

Steps ① ② and ③ are not required if a jog frequency has been parameterised.

Fig. 32: Remote control of the speed controller, setpoint and enabling

5.2.2 Oscilloscope

The following settings should be made under the two tabs **Recording** or **Channel Settings** of the NORD CON **Oscilloscope Function** before starting the oscilloscope recordings. The settings and graphic displays in the illustrations may differ according to the frequency inverter types, versions and software status.



1 Set Trigger to Enable

2 Set the scan rate to 5 ms

→ Scan duration 1 s
→ Scan rate depending on the run up time which is set

Note
The scan rate should be selected so that it corresponds to the scope recordings in the illustrations in Section 🕮 5.4 "Optimisation procedure"!

Fig. 33: Oscilloscope settings for trigger and scan rate / scan duration

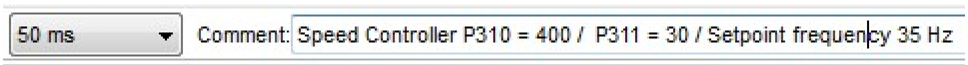


Fig. 34: Resolution settings for the time axis, comment examples

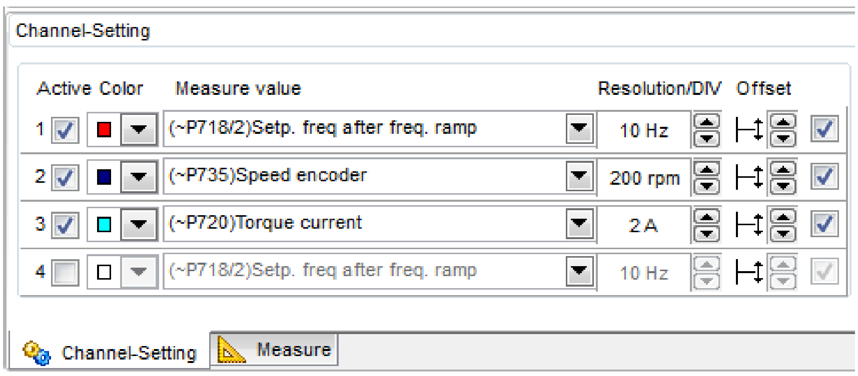
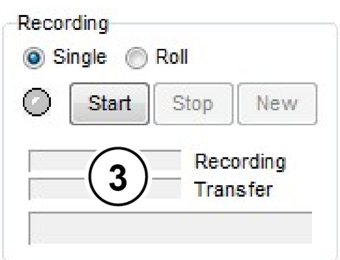


Fig. 35: Oscilloscope channel settings for the four measurement values



3 Press the Start button

Note
Note the initialisation phase, see the illustrations in Section 🕮 4.2.2 "Oscilloscope"

Fig. 36: Start the scope recording

5.3 Speed controller

Information & instructions

For the speed controller, the **P** and **I component** must be changed for the relevant optimisation steps.

As the initial for optimisation of the speed controller, for the **1st optimisation step** the **P component** (P310) should be set to **50 %** and the **I component** (P311) should be set to **5 % / ms**.

Parameter No. [-Array]		Name [Unit]	Factory setting	Setting related to parameter set (P1, ... , P4)
Speed control				
P310	(P)	Speed Ctrl P [%]	100	**100 → 50**
P311	(P)	Speed Ctrl I [%/ms]	20	**20 → 5**

The changes to the control parameters must be checked with the **NORD CON Oscilloscope Function** (see 4.2 "NORD CON").

In the following illustration, the curve for an **optimally** adjusted speed controller for a 3.0 kW synchronous motor with efficiency class IE4 is shown as the target.

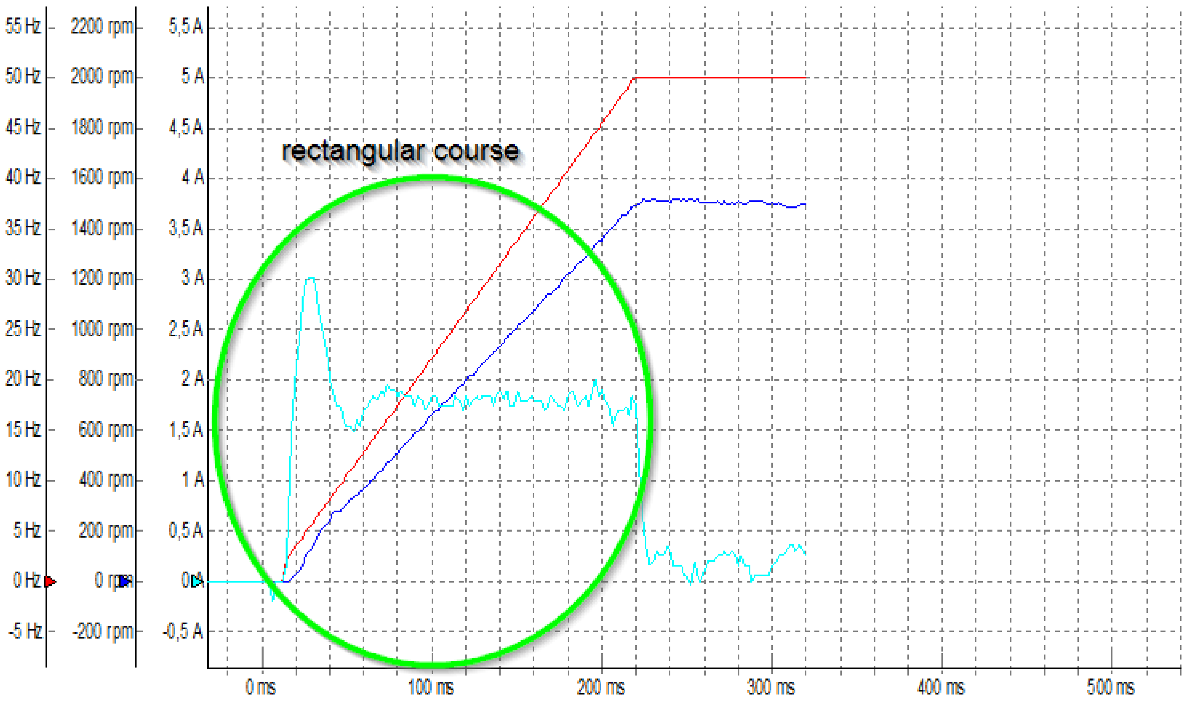


Fig. 37: Example of an optimised speed controller curve

The left-hand detailed illustration shows the almost **rectangular curve** for the **Torque current ~P720**, while the acceleration ramp in the right-hand illustration shows a linear increase of the **Speed encoder ~P735**.

As well as this, in the previous left-hand illustration a slight overshoot can be seen when the setpoint, i.e. the **Setp. freq after freq. ramp ~P718/2** is reached.

This setting ensures that the motor is fully magnetised when the acceleration ramp is applied.

The display of the required rectangular form of the **Torque current ~P720** curve during the acceleration ramp may differ, as the curve results from the requirements specific to the application.

The following illustration shows the form of the curve of the **P component** of the speed encoder is set **too high**. The value of the **Speed control P P310** which is too high results in oscillation of the **Torque current ~P720**.

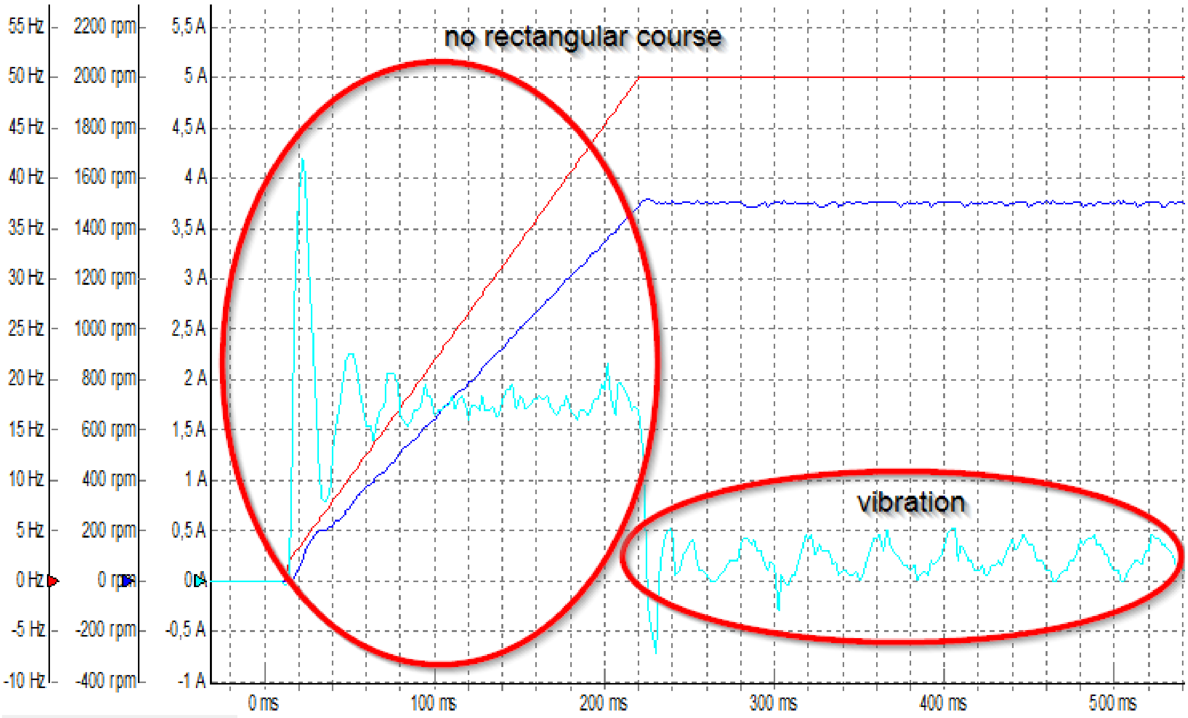


Fig. 38: Example with an excessive P component of the speed controller

The next optimisation steps and scope recordings should be carried out as follows:

Information — Oscilloscope recording

If a range is reached in which the changes in the curve cannot be viewed directly, it is advisable to save the oscilloscope recordings. With the facility for **displaying several recordings simultaneously** a **direct comparison** with the previous settings is possible.

5.3.1 Speed control P component

Increase the parameter for the **P component** in **50 % increments** until the curve for the **Torque current ~P720** is as rectangular as possible. The **Speed encoder ~P735** should have a linearly increasing curve.

The curve is as illustrated in the second illustration (see 5.3 "Speed controller").

The upper adjustment limit of the **Speed Ctrl P P310** is reached, when a further increase of the **P component** does not result in a better shape of the curve in the sense of a rectangular shape. A setting of the **P component** which is **too high** can cause oscillations of the **Torque current ~P720** as well as in the **Speed encoder ~P735**.

Once the **P component** has been determined, in operation, the controller must be slowly run down from the setpoint frequency (e.g.50 Hz) to 0 - 3 Hz. It must be **checked** that during the **brake ramp** the **torque current ~P720** remains **free from oscillations**.
Among other things, this is used to test whether the **P component** is set correctly for all speeds.
If the **P component** is set **too high** for a selected speed (setpoint specification), this is apparent from oscillations in the **Torque current ~P720** and an associated **production of noise** "**scratching noise**" during operation or during the movement profile.

5.3.2 Speed controller I component

Beginning from the set starting value [5 % / ms] increase the **I component** in small **increments** (e.g. **5 %**) until an approximately **rectangular curve** results for the act. torque current ~P720.

Information **I component increment**

If the application has a high inertial mass (relative to the inertia of the motor), the **increment** should not exceed > **5 % / ms**.

If the ratio J_{anw} / J_{Motor} **is small**, the increase of the **I- component** can be performed in **larger increments**.

The selected **increment** for the increase of the **I component** should be in the range from **5** to **20**.

As a result of the increase of the **I component** there is a **slight overshoot** of the **Speed encoder ~P735**. If the **I component** is set **too high** the rectangular form of the **Torque current ~P720** will be distorted upward to the left.

The curve is according to that in the scope recording for Step 6: "I" scope recording 5.4 "Optimisation procedure".

Once the **I component** has been determined, in operation, the controller must be slowly run down from the setpoint frequency (e.g. 50 Hz) to 0 - 3 Hz. It must be **checked** that during the **brake ramp** the **Torque current ~P720** remains **free from oscillations**.
Among other things, this is used to test whether the **I component** is set correctly for all speeds.
If the **I component** is set **too high** for a selected speed (setpoint specification), this is apparent from oscillations in the **act. torque current ~P720** and an associated **production of noise** "**scratching noise**" during operation or during the movement profile.

5.3.3 Criteria

The following criteria should be noted for optimisation of the field speed controller:

The aim is to optimise the curve for the Torque current ~P720 taking the criteria into account, with the "correct" settings of the P and I components.

- The curve for the **Speed encoder ~P735** should be linear and free from oscillations
- No, or slight oscillation (approx.. 3 – 5 %) when the setpoint of the **Speed encoder ~P735** is reached during optimisation of the **I component**
- Rectangular form of the **Torque current ~P720** in the acceleration phase
- No oscillations in the curve for the **Torque current ~P720** after completion of the acceleration phase
- No "scratching noises" when the drive unit is in operation

During operation there may be a "scratching noise", which is primarily apparent in applications with drive units ≥ 3 kW If noises are produced, the P or also the I component should be reduced.

Information **Optimisation steps**

The step widths stated for control optimisation may differ depending on the application. Furthermore, the step widths can be selected even finer for the final optimisation steps.

5.4 Optimisation procedure

Instructions

The following illustrations show the optimisation process for the speed control using the example of a **3.0 kW synchronous motor** with efficiency class **IE4** on the basis of individual oscilloscope recordings.

Legend	Set. freq after freq. ramp ~P718[02]	Speed encoder ~P735	Torque current ~P720

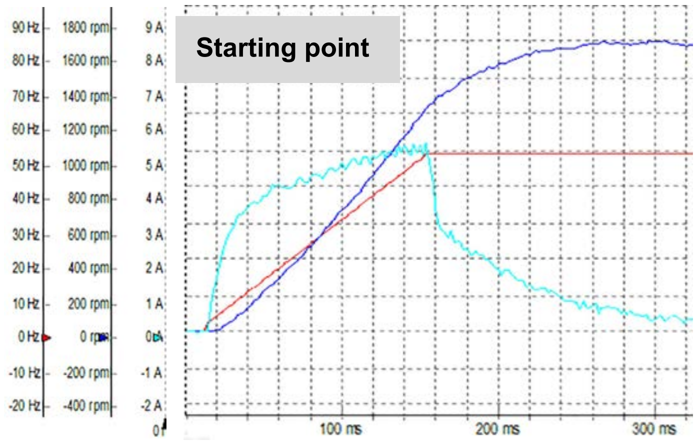
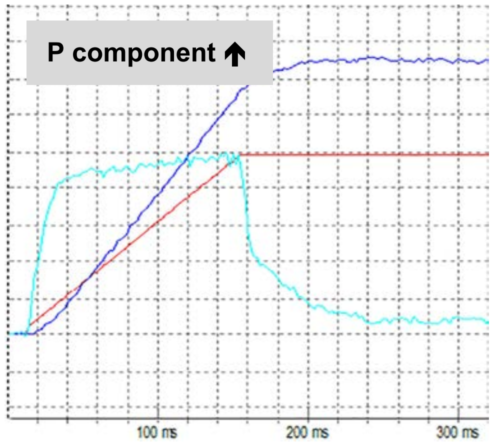
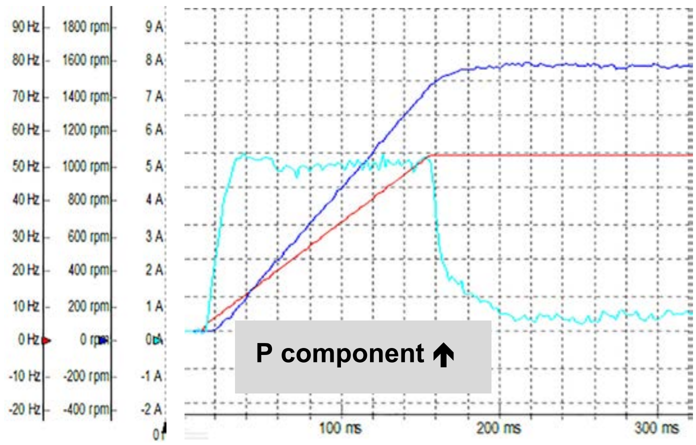
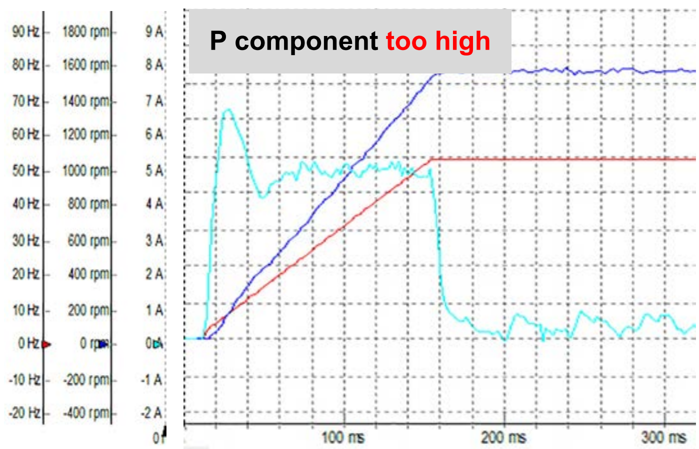
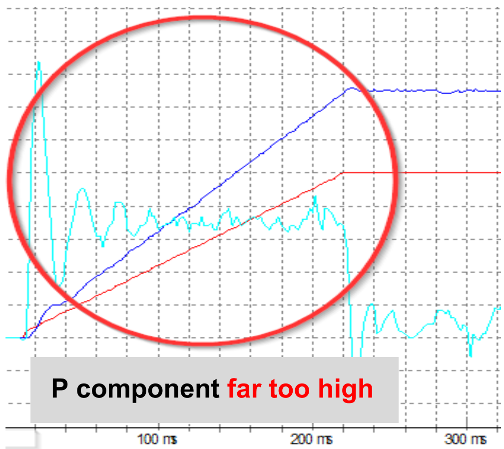
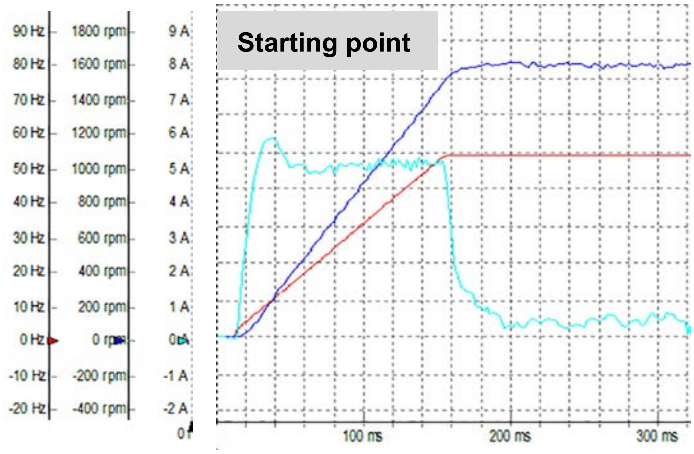
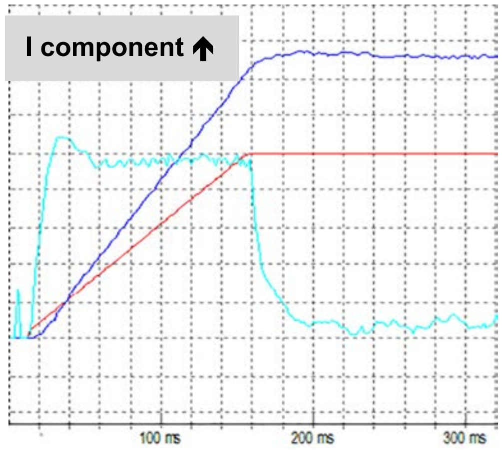
Step	1. "P" scope recording	2. "P" scope recording
Parameter settings	P310 = **50 %** P311 = **5 % / ms**	P310 = **100** % P311 = 5 % / ms
		
Step	**3. "P" scope recording**	**4. "P" scope recording**
Parameter settings	P310 = **150 %** P311 = 5 % / ms	P310 = **200** % P311 = 5 % / ms
		
Step	**8. "P" scope recording**	**12. "P" scope recording**
Parameter settings	P310 = **400 %** P311 = 5 % / ms	P310 = **600 %** P311 = 5 % / ms
		

Fig. 39: Curve for the P component of the speed control

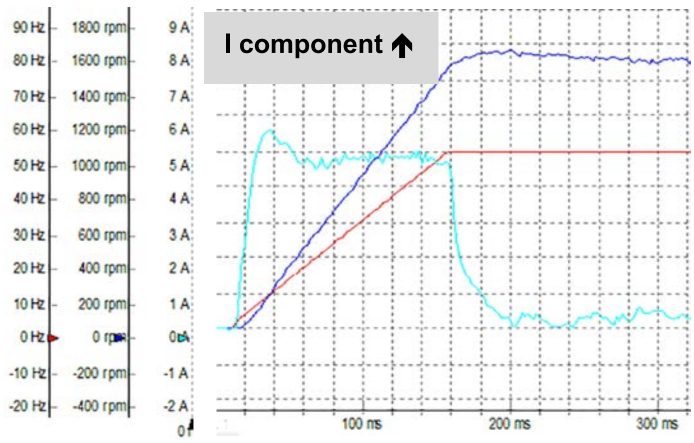
Legend Set. freq after freq. ramp ~P718[02] Speed encoder ~P735 Torque current ~P720

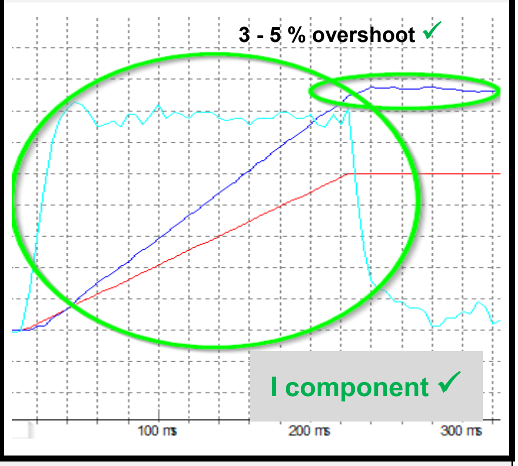
Step	1. "I" scope recording	2. "I" scope recording
Parameter settings	P310 = **200** % P311 = **5 % / ms**	P310 = 200 % P311 = **10 % / ms**



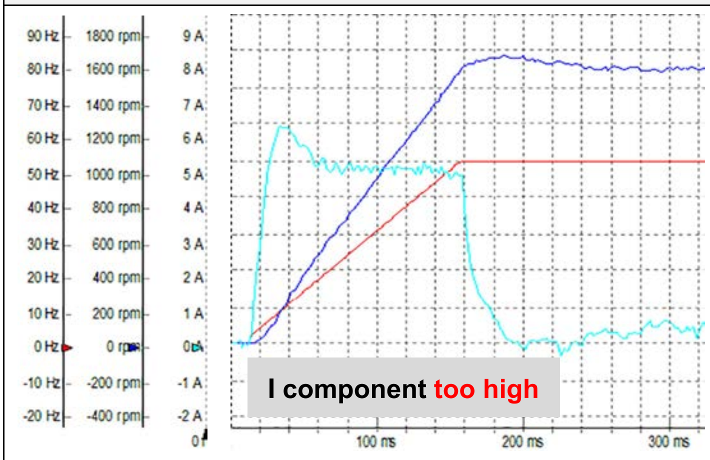


Step	3. "I" scope recording	4. "I" scope recording
Parameter settings	P310 = 200 % P311 = **15 % / ms**	P310 = 200 % P311 = **20 % / ms**





Step	6. "I" scope recording	24. "I" scope recording
Parameter settings	P310 = 400 % P311 = **30 % / ms**	P310 = 400 % P311 = **120 % / ms**



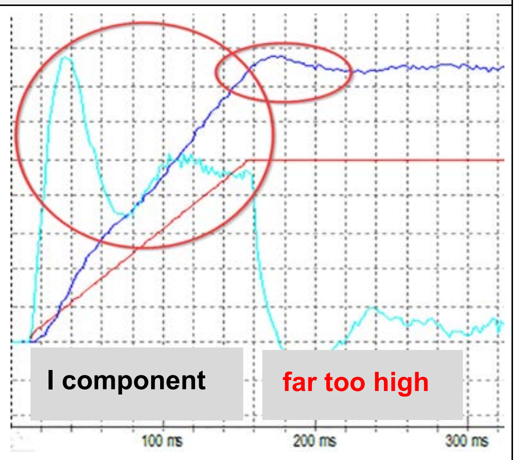


Fig. 40: Curve for the I component of the speed control

6 Position control

Step 6

Information

The position control can be used in combination with an **encoder** to provide a high precision positioning drive. Usually, various **encoder systems** e.g. **incremental encoders** or **absolute encoders** are used to provide speed feedback. These are used as measurement transducers, which convert the rotary movements and positioning data (position) into electrical signals.

The choice of the encoder system depends on the requirements of the application. This includes the following characteristics, such as:

- Encoder type: Absolute or incremental encoder
- Encoder type (TTL, HTL, combination, single-, multiturn) / resolution
- Application type (angle measurement, linear travel measurement)
- Connection method, interface drivers, filed bus system, with cable or plug-in
- Construction and mounting type (flange, shaft, hollow shaft, torque support, etc.)
- Electronic features (power supply, output drivers, etc.)
- Ambient conditions (protection type, temperature, ATEX, etc.)

Information **Encoder selection**

HTL incremental encoders (IG) as well as **CANopen absolute encoders** (AG) can be used for decentralised **SK 2xxE** frequency encoders. **TTL incremental encoders** and **CANopen absolute encoders** can be used for control cabinet frequency inverters ≥ **SK 530E**.

In addition, for performance level **SK 540E**, **SIN/COS encoders** and other **absolute encoder types** such as **Hiperface**, **Endat**, **SSI** and **BiSS encoders** can be connected to its **universal encoder interface**.

For detailed information regarding the particular encoder types, please refer to the relevant supplementary manual **POSICON Positioning Control**, see 🕮 BU 0210 or BU 0510 9.1 "Manuals".

The following features and integrated frequency inverter functions are available for positioning control:

- Programmable position memory
  - For SK 2x5E there are **63** absolute positions
  - For SK 53xE there are **63** absolute positions
  - For SK 54xE there are **252** absolute positions
- Positions are also maintained with "severe" load fluctuations
- Time-optimised and safe travel up to the target position by means of path calculation function
- In addition to travelling to absolute positions, up to 4 step lengths (so-called position increments) can be stored in the frequency inverter.
- Positions can also be saved in a control unit and specified via an appropriate field bus interface (e.g. CANopen)
- The positions can be transferred to the frequency inverter via a field bus interface

NOTICE **Power supply**

Only encoder types with a **10 - 30 V** supply may be used for frequency inverter applications.

For the **POSICON** positioning function, additional parameters (P6xx) which are required for the position control are available under the **Positioning** tab as a separate menu group.

Information **Enabling POSICON**

For decentralised **SK 2xxE frequency inverters** the **Positioning** tab is enabled with the parameter **Supervisor-Code P003** {**3** = **All parameters visible**}.

For **SK 530E control cabinet frequency inverters** the **Positioning** tab P6xx is enabled as the default in the **factory settings**.

Application information

- The positioning function / configuration and control of the frequency inverter as well as the specification of the position setpoint can be made via the
  - **Digital inputs**
  - **Bus IO In Bits**
  - **USS protocol** or a **field bus system** (e.g. PROFIBUS DP, CANopen etc.)
- Position detection can be performed with incremental or absolute encoders
- Switch-over from **speed control** and **position control** (positioning) using **parameter switch-over**
- **Synchronisation functionality** between **master** and **slave drives** (one or more) using the integrated **system bus interface**
- **Endless axis function** (**Modulo axes**) for turntables and similar applications (this controls an endless axis) **with optimised path**. The drive unit turns clockwise or anticlockwise according to the required position.

For example, the frequency inverter is controlled using a specified position described by positions which are saved in the frequency inverter. In this example, the specification of the position and enabling of the drive unit is implemented via the BUS IO In bits. An incremental encoder (IG) or a standard CANopen combination absolute encoder as well as other types of rotary encoder (only ≥ SK 540E) can be used for the encoder system.

It is recommended that the following **optimisation steps** are performed to systematically adjust a position controller:

Information **Application notes for brake resistor**

An external **brake resistor** was used for the optimisation of the position control described in this guide, see 🕮 2.1 "System components". The selection of an internal or external brake resistor for the SK 2xxE results from the **application requirements**.

Overview of optimisation procedure

- Select the **encoder system** and parameterise it accordingly
- **Connect the encoder system and test the function**
- Select and parameterise the interface for the **setpoint** or **position specification**
- Set the acceleration and braking ramps, i.e. **Acceleration time P102** and **Deceleration time P103**
- **Selection** / Specification of the **setpoint or target position**

- Set the **P component** to a **small value** and e.g. **increase this in 10% increments** until the speed curve is as **linear as possible** for the **Speed encoder =P735**. In this case, a limit due to the brake ramp / **Deceleration time** (**P103**) should be apparent and effective.

- If the **P component** is set too high, this is apparent from **oscillations** of the **Speed encoder =P735** in the **actual position** when braking. In addition there is an **overshoot** of the **Torque current ~P720** in this range. In this case, the **P component** must be reduced again.

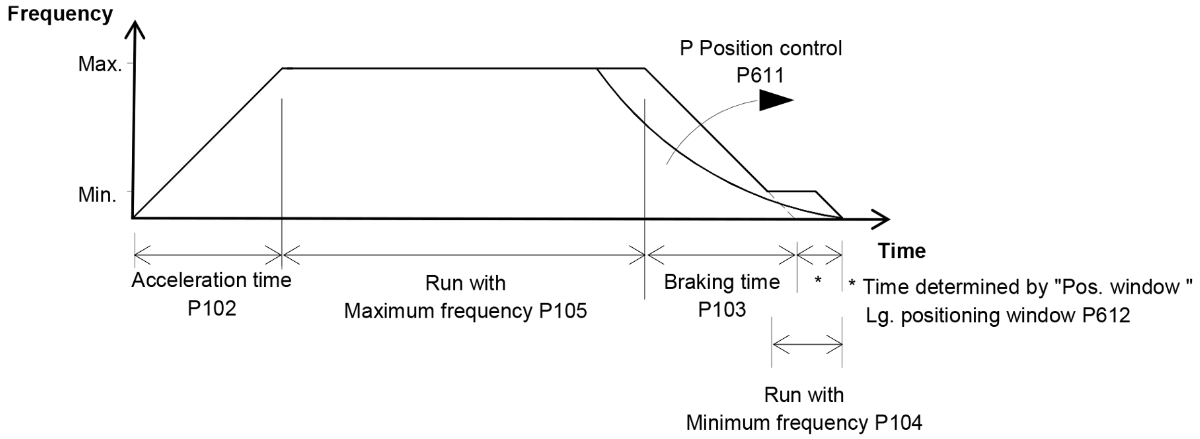


Fig. 41: Position control movement profile

For detailed information regarding the movement profile or the parameters which have to be set, please refer to the relevant supplementary manual **POSICON Positioning Control** (BU 0210 or BU 0510 see 🕮 9.1 "Manuals"). In addition, the relevant parameters are described in Sections 🕮 6.4 "Position controller" and 6.4.3 "Positioning".

☞ **The aim is to obtain the optimum curve of the movement profile with the "correct" setting of the P component. The Speed encoder ~P735 should follow the braking ramp and should not pass over the setpoint position.**

The practical implementation for optimisation of a position controller is described in Section 🕮 6.5 "Optimisation procedure".

6.1 Further settings

Instructions

For optimisation of the position controller, the following two parameters must be set in advance. Some of the setting are listed here in order to illustrate the control, position specification and position selection with BUS IO In Bits or the USS interface. However, this may differ according to the application.

Information — Application information

The ramp times for the **Acceleration time P102**, the **Deceleration time P103** and the **setpoint specification** (required speed) result from the **requirements of the application**. For use of the **slow movement** function at the end of a positioning procedure, the minimum frequency P104 must be taken into account. This is used during slow movement.

The ramp time must be set under the "**Basic Parameters**" tab in the parameter **Acceleration time P102** and **Deceleration time P103**.

Parameter No. [-Array]		Name [Unit]	Factory setting	Setting related to parameter set (P1, ... , P4)
BASIC PARAMETERS				
P102	(P)	Acceleration time [s]	2.0	**2.0 → 0.3** *
P103	(P)	Deceleration time [s]	2.0	**2.0 → 0.3** *
P104	(P)	Minimum frequency [Hz]	0.0	**0.0 → …** **
CONTROL TERMINALS				
P480	[-11]	Funct. Bus I/O In Bits *Bit 8 Bus control word*	0	**0 → 55** (Bit 0 position (increment) array)
ADDITIONAL PARAMETERS				
P509		Source Control Word	0	**0 → 2** (USS) ***
P510	[-01]	Source Setpoints *Source main setvalue*	0 (Auto)	0 (leave as set) ***
P510	[-02]	Source Setpoints *Source 2nd setpoint*	0 (Auto)	0 (leave as set) ***

* To be set according to the specific application (Notice: in this example without load)

** To be set according to the specific application (Note: only relevant for slow running / Pos. Window P612)

*** Leave P510 Source main setvalue at the factory setting (0 = Auto)

Information — Setpoint and position specification

The **setpoint specification** and the setting of the **Position control P600** should **correspond to the design range** (70 Hz / 100 Hz characteristic curves).

For optimisation of the position control, the setpoint should be selected according to the **application requirements**!

For the SK 200E frequency inverter / motor combination (4,0 kW) and the supply voltage of 400 V (50 Hz) described in this guide, the function {2 = Lin. ramp (setpoint frequency)} is set and a **specified setpoint** of e.g. **65 %** is selected.

Optimisation of the position control should be made with the aid of the NORD CON oscilloscope function.

Before starting the scope recording and enabling the drive unit, the **setpoint** is set to 65 % I.e. in this example (frequency inverter 4.0 kW / motor combination 3.0 kW) a setpoint frequency of **45 Hz** is specified.
It should be noted that the **setpoint** position "**0**" is used as the **first** specified position. From this, it follows that as the **second setpoint position** "**10**", in parameter **position P613**, only the array [**-01**] is to be parameterised!

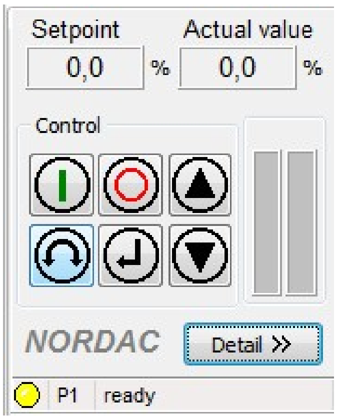
6.2 NORD CON

Information & instructions

Further information about the settings can be obtained from Section 🕮 4.2 "NORD CON" and the following.

6.2.1 Control

The following setting must be made in the **Control screen** to optimise the position controller before starting the scope recordings.



By pressing the button 

in the "Standard" view, the control screen changes to the "Detail" view.

Fig. 42: Standard control view

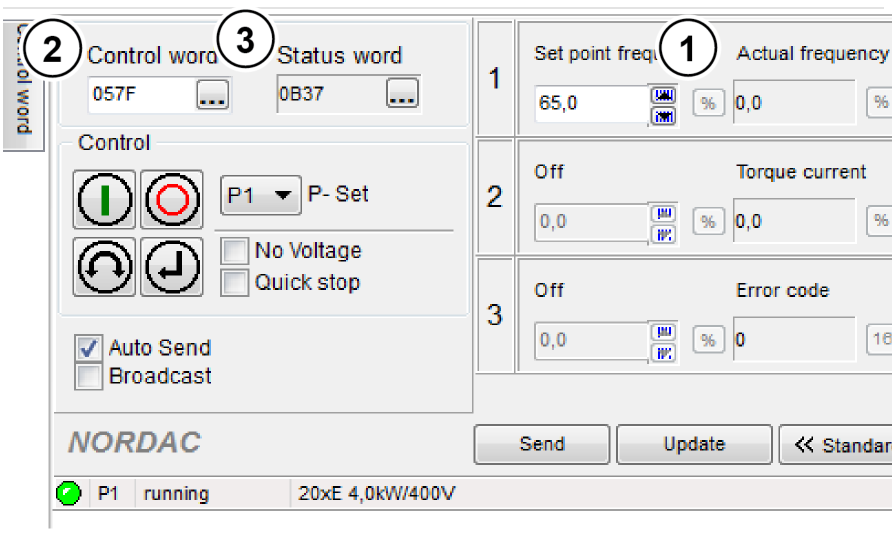


Fig. 43: Control of the speed controller, setpoint and enabling

(1) Set the setpoint to e.g. 65 %, i.e. the setpoint frequency to *45.5 Hz*, using the Value + or Value – button or enter *65 %* directly

(2) in the control word, enter the value *047F* for *Position 0* or press the Start button or enter the value *057F* for *Position 1*

Alternatively, a further (3) “Detailed Control“ view can be opened and used to enter the individual control bits directly.

(4) Set Bit 3 ✓ = *Enable operation*

(5) Set Bit 8 ✓ = Specify *Position 1* and then set Bit 3 ✓ = *Enable operation*

(4)

Control word

Bit		Name	State
0	☑	Ready	1
1	☐	Disable voltage	1
2	☐	Fast hold (inhibited)	1
3	☑	Enable operation	1
4	☑	Pulse enabled	1
5	☑	Enable ramp	1
6	☑	Setpoint enabled	1
7	☐	Error quit (0->1)	0
8	☐	Start function 480.11	0
9	☐	Start function 480.12	0
10	☑	Control data enabled	1
11	☐	Right turn on	0
12	☐	Left turn on	0
13	☐	Reserved	0
14	☐	Parameterset bit 0 on	0
15	☐	Parameterset bit 1 on	0

(5)

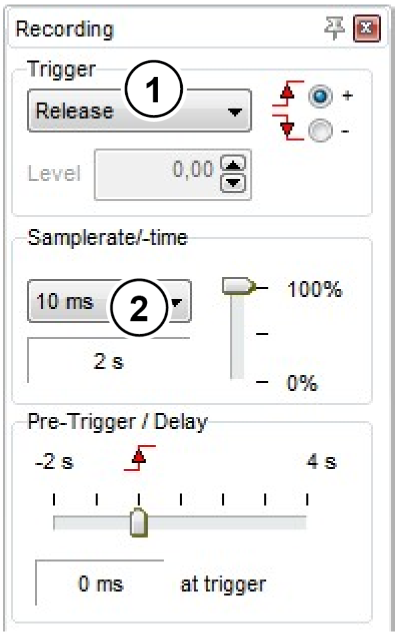
Control word

Bit		Name	State
0	☑	Ready	1
1	☐	Disable voltage	1
2	☐	Fast hold (inhibited)	1
3	☑	Enable operation	1
4	☑	Pulse enabled	1
5	☑	Enable ramp	1
6	☑	Setpoint enabled	1
7	☐	Error quit (0->1)	0
8	☑	Start function 480.11	1
9	☐	Start function 480.12	0
10	☑	Control data enabled	1
11	☐	Right turn on	0
12	☐	Left turn on	0
13	☐	Reserved	0
14	☐	Parameterset bit 0 on	0
15	☐	Parameterset bit 1 on	0

Fig. 44: Control of position control, control bits left setpoint position 0, right setpoint position 1

6.2.2 Oscilloscope

The following settings should be made under the two tabs **Recording** or **Channel Settings** of the NORD CON **Oscilloscope Function** before starting the oscilloscope recordings. The settings and graphic displays in the illustrations may differ according to the frequency inverter types, versions and software status.



1 **Set Trigger to Enable**

2 **Set the scan rate to 10 ms**

→ Scan duration 2 s

→ Scan rate depending on the run up time which is set

Note

The scan rate should be selected so that it corresponds to the scope recordings in the illustrations in Section 🕮 6.5 "Optimisation procedure"!

Fig. 45: Oscilloscope settings for trigger and scan rate / scan duration

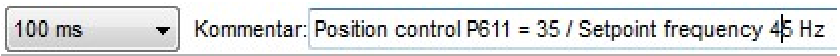


Fig. 46: Resolution settings for the time axis, comment examples

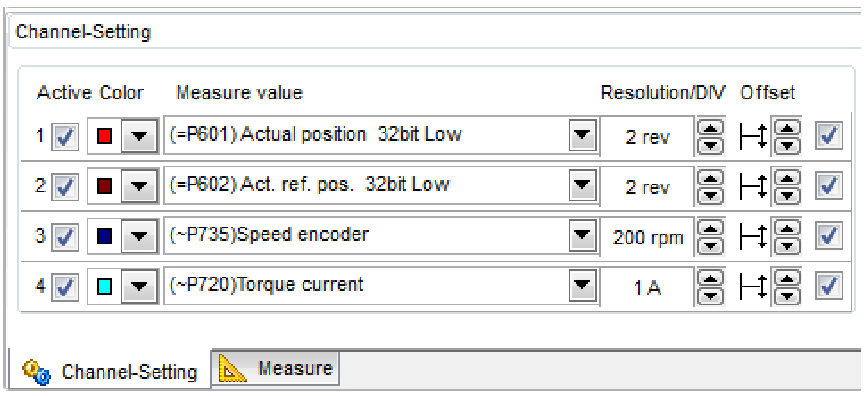
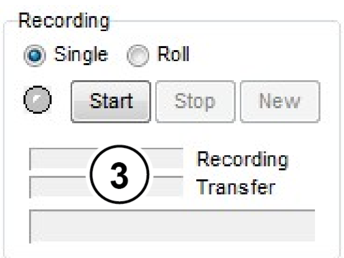


Fig. 47: Oscilloscope channel settings for the four measurement values



3 **Press the Start button**

Note

Note the initialisation phase, see the illustrations in Section 🕮 4.2.2 "Oscilloscope"

Fig. 48: Start the scope recording

6.2.3 Device overview

The course of positioning can be observed with the following settings of the three display possibilities in the NORD CON **Device Overview function.**

Setpoint position 1 reached **Setpoint position 0 is being approached**

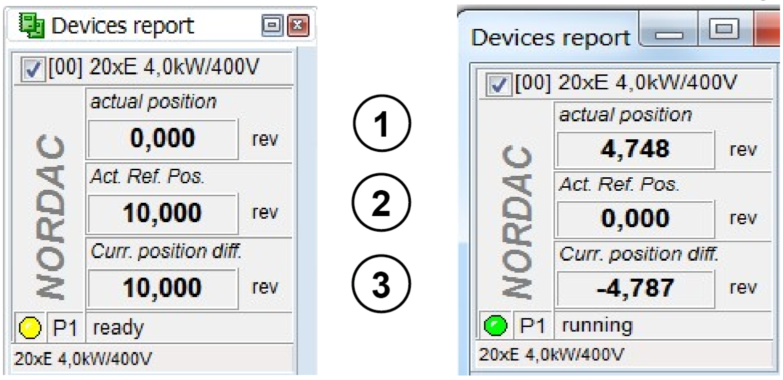


Fig. 49: Position control device overview, display settings

(1) **Set Display 1 to *actual position*,** (2) **set Display 2 to *Act. Ref. Pos.***

(3) **Set Display 3 to *Curr. position diff.***

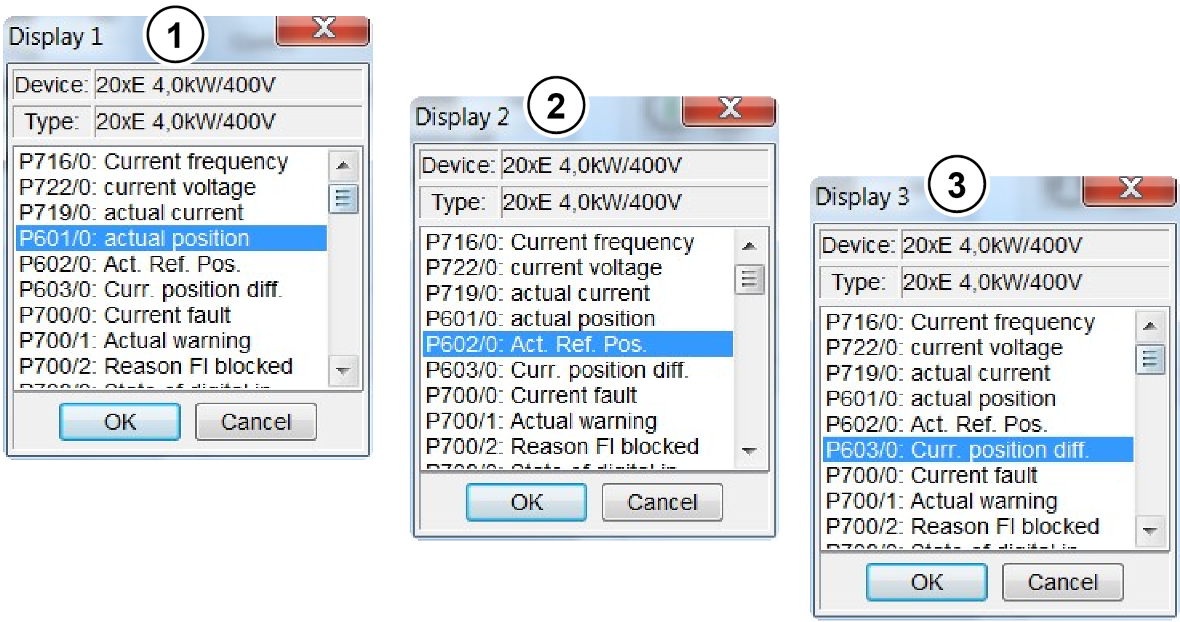


Fig. 50: Overview of position control devices, display selection

6.3 Function test of rotary encoders (IG)

Information & instructions

For **incremental** and **absolute encoders**, e.g. a **CANopen standard combined absolute encoder** (AG) with **integrated incremental signal track** (IG) the function or the detection of the direction of rotation should be checked.

Further information for the function test of the incremental encoder on the relevant frequency encoder is provided in Section 🕮 3.5.3 "Function test of rotary encoders (IG)".

In addition, it is advisable to maintain a certain sequence for the commissioning of the CANopen encoder or the function test of the position control. Refer to 🕮 3.6.4 "Function test of CANopen encoders (absolute encoders)" for further details.

6.4 Position controller

Information & instructions

For the position controller, the **P component** must be changed for the relevant optimisation steps.

The **1st optimisation step** step for optimising the position controller can be started with the standard setting for the **P component** (P611).

Parameter No. [-Array]	Name [Unit]	Factory setting	Setting related to parameter set (P1, ... , P4)
POSITIONING			
P611	P Pos. Control [%]	5	5 (leave at standard)

The changes to the positioning parameters must be checked with the **NORD CON Oscilloscope Function** (see 🕮 4.2 "NORD CON").

In addition, depending on the application, further positioning parameters, e.g. position, ramp criteria, travel measurement system, etc. must also be set.

NOTICE | **Position control**

In case of a different setting of the position control P600 from the function {0 = Off}, it is essential that under the "Basic Parameters" tab, the factory setting {0 =Voltage disable} is parameterised in the parameters **Ramp smoothing P106** and that in the **Disconnection mode P108**, the function {1 = Ramp down} is parameterised.

This should always be taken into account before setting or parameterising the position control. For positioning, four different variants (functions) are available for the Position Control P600.

For position detection by the position control with a standard combination absolute encoder with a CANopen interface (see Section 🕮 2.6 "Selection of absolute encoders"), several parameters must be set under the "**Positioning**" tab for position detection by the position controller.

6.4.1 Parameterisation of the travel measurement system

For the selection of the travel measurement system or position detection with encoder feedback (**CFC Closed-Loop** mode), several parameters must be set in the "**Positioning** tab according to the encoder system which is used.

For detailed information, please refer to the relevant manual for the frequency inverter, see 🕮 9.1 "Manuals" or 🕮 3.6.1 "Parameterisation of CANopen encoders (absolute encoders)".

6.4.2 Activating the position control

For activation of the position control or position detection with encoder feedback (**CFC Closed-Loop** mode) in the "**Positioning**" tab, the parameter **Position control P600** must be set to the function {**2** = **lin. Ramp** (**setfreq.**)}.

⚠ CAUTION **Enabling of position control**

This setting should only be made after the check of the direction of rotation of the encoder has been successfully completed.

Otherwise, unexpected movements (wrong direction of rotation) may result. This may cause both material damage as well as injuries to persons

Parameter No. [-Array]		Name [Unit]	Factory setting	Setting related to parameter set (P1, ... , P4)
POSITIONING				
P600	(P)	Position Control	0 (Off)	☝ **0 → 2** (lin. Ramp (max.freq.)) *

* To be set according to the specific application. Note 🕮: refer to the information for position control 6.4 "Position controller"

6.4.3 Positioning

For positioning or position control, further parameters are available under the "**Positioning**" tab, which must be set by the user according to the specific application.

Parameter No. [-Array]		Name [Unit]	Factory setting	Setting related to parameter set (P1, ... , P4)
POSITIONING				
P600	(P)	Position Control	0 (Off)	☝ → see 🕮 6.4.2 "Activating the position control"
P601		actual position [rev]	---	👓
P602		Actual Ref. Pos. [rev]	---	👓
P603		Curr. position diff. [rev]	---	👓
P604		Encoder type	0	☝ → see 🕮 3.6.1 "Parameterisation of CANopen encoders (absolute encoders)"
P605	[-01]	Absolute encoder (Multi)	10	☝ → see 🕮 3.6.1 "Parameterisation of CANopen encoders (absolute encoders)"
P605	[-02]	Absolute encoder (Single)	10	☝ → see 🕮 3.6.1 "Parameterisation of CANopen encoders (absolute encoders)"
P607	[-01]	Ratio (Incremental Enc)	1	
P607	[-02]	Ratio (Absolute encoder)	1	

Parameter No. [-Array]		Name [Unit]	Factory setting	Setting related to parameter set (P1, ... , P4)
P607	[-03]	Ratio (Multiplic set/actual)	1	
P608	[-01]	Reduction (Incremental Enc)	1	
P608	[-02]	Reduction (Absolute encoder)	1	
P608	[-03]	Reduction (Multiplic set/actual)	1	
P609	[-01]	Offset Position (Incr.) [rev]	0	
P609	[-02]	Offset Position (Abs.) [rev]	0	
P610		Setpoint Mode	0	0 (Position Array)
P611		P Pos. Control [%]	5	
P612		Pos. Window [rev]	0	*
P613	[-01]	Position 1 [rev]	0	✋ **0 → 10** **
P613	[-02]	Position 2 [rev]	0	
P613	[-**03**] - [-**62**]	Position **3** to **62** [rev]	0	
P613	[-63]	Position 63 [rev]	0	
P625		Hysteresis relais [rev]	1	
P626		Relais Position [rev]	0	
P630		Position slip error [rev]	0	
P631		Abs/Inc slip error [rev]	0	
P640		unit of pos. Value	0	

* To be set according to the specific application, also known as slow movement Notice: This should be used for large moments of inertia and "backlash" in the gear unit.

** To be set according to the specific application. Note 🕮: refer to the information for position control 6.4 "Position controller"

In the following illustration, the curve for an **optimally** adjusted position controller for a 4 kW IE2 motor is shown as the target.

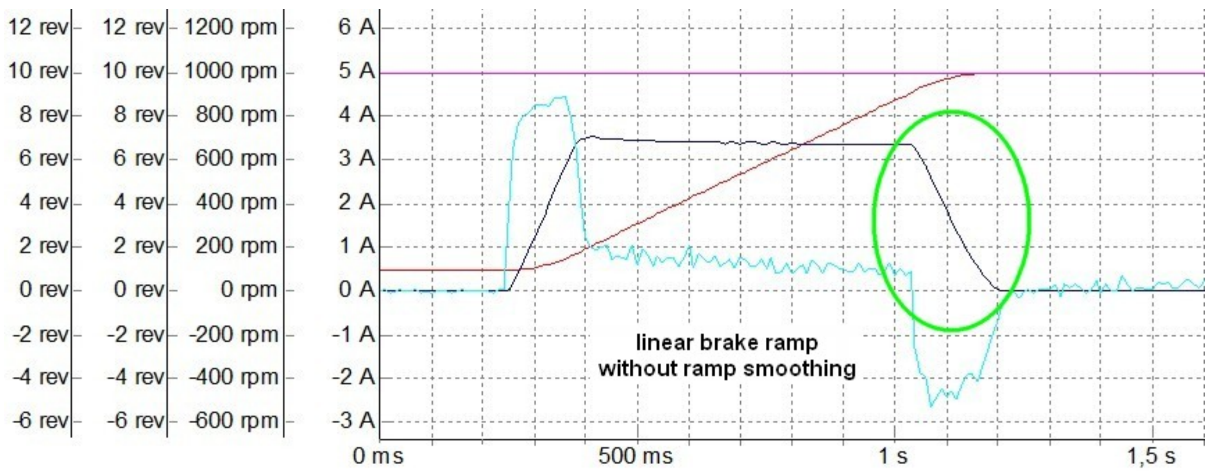


Fig. 51: Example of an optimised position controller curve

An almost **oscillation-free curve** for the **Torque current ~P720** can be seen when the setpoint position is reached, as well as a linear form of the **Speed encoder ~P735** without rounding of the ramp when braking.

The following illustrations show the shape of the curve if the **P component** of the position control is set "**too high**" and "**too low**". Setting the value of the **Position Control P P611** too low causes **ramp rounding** of the **Speed encoder ~P735** when the setpoint position is reached. A value which is set too high causes an **overshoot** of the **Speed encoder ~P735** and a visible **oscillation** of the **Torque current ~P720** when the setpoint position is reached.

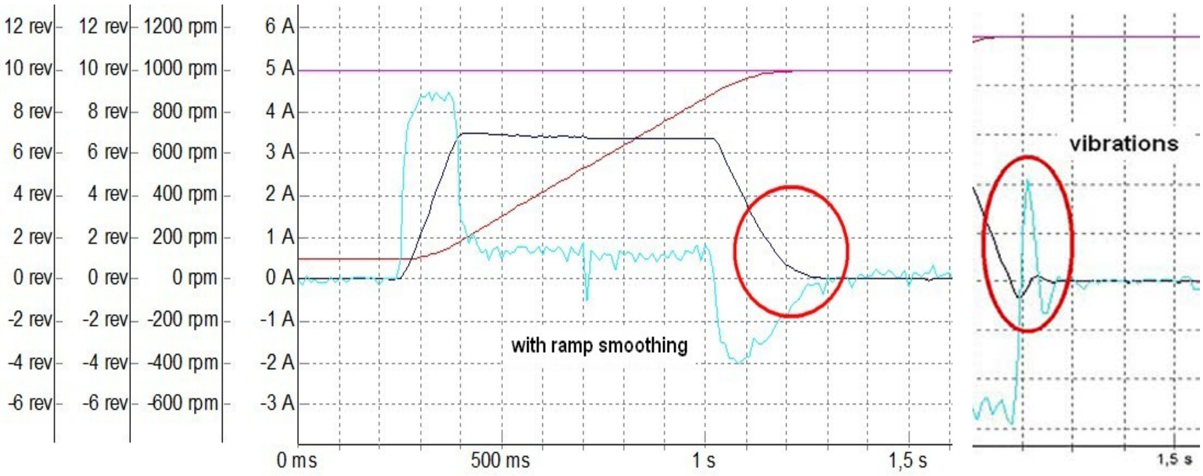


Fig. 52: Example with P component of the position control too small (left) and too high (right)

The next optimisation steps and scope recordings should be carried out as follows:

Information — Oscilloscope recording

If a range is reached in which the changes in the curve cannot be viewed directly, it is advisable to save the oscilloscope recordings. With the facility for **displaying several recordings simultaneously** a **direct comparison** with the previous settings is possible.

6.4.4 Position control P component

Increase the parameter for the **P component** in **10 % increments** until the **Speed encoder ~P735** has a curve which linear as possible and which follows the braking ramp. In addition, ramp rounding for the brake process of the **Speed encoder ~P735** should no longer be visible.

> The correct setting of the **P component** of the position controller depends on the **dynamic characteristics of the system as a whole**.
> **Rule of thumb**: the greater the masses and the smaller the friction if the system, the greater is the tendency of the system to oscillate and the smaller is the maximum possible P amplification.

The curve is as illustrated in the first illustration (see 🕮 6.4 "Position controller").

The upper adjustment limit of the **P Pos. Control 611** is reached, when a further increase of the **P component** does not result in a better shape of the curve. If the **P component** is set **too high**, this causes an overshoot of the Speed encoder ~P735 when the setpoint position is reached.

To determine the **critical value**, the **P component** is increased until the drive unit oscillates about the position (leave the position and then approach it again).

Recommended guide value: Then set the P component from **0.5** to **0.7 times this value**.

> For **POSICON applications** with a **subordinate speed control** (Servo Mode P300 {1 = ON (CFC closed-loop)} use of a setting which deviates from the standard setting of the speed control is usually to be recommended for applications with large masses.
> For the **P component** of the **speed control** a value of **100 to 150%** should be set in the parameter **Speed Ctrl P P310**. As the I component in the parameter **Speed Ctrl I P311**, a value of between **3 % / ms** and **5 % / ms** has proved to be effective.

6.4.5 Criteria

The following criteria should be noted for optimisation of the field position controller:

The aim is to optimise the curve for the Torque current ~P720 taking the criteria into account, with the "correct" setting of the P component.

- The curve for the **Speed encoder ~P735** should be linear and follow the braking ramp
- No overshoot of the **Speed encoder ~P735** when the setpoint position is reached
- No ramp rounding of the **Speed encoder ~P735** during braking or in the braking ramp
- No oscillation of the **Torque current ~P720** should be evident when the setpoint position is reached

Information **Optimisation steps**

The step widths stated for control optimisation may differ depending on the application. Furthermore, the step widths can be selected even finer for the final optimisation steps.

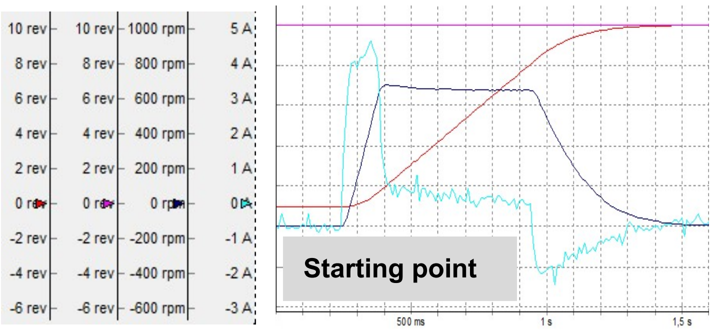
6.5 Optimisation procedure

Instructions

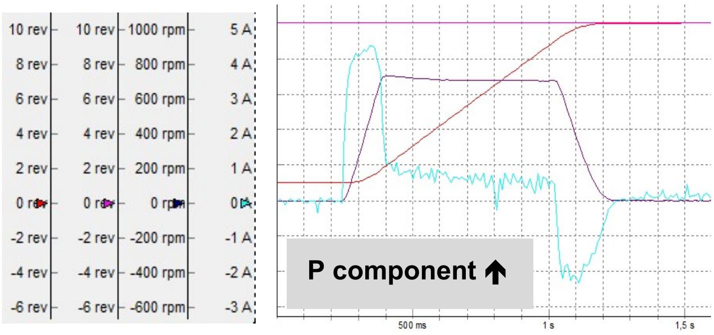
The following illustrations show the optimisation process for the position control using the example of a **3.0 kW synchronous motor** with efficiency class **IE4** on the basis of individual scope recordings.

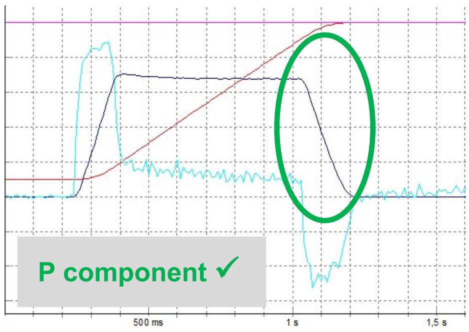
Legend	Actual position 32bit Low	=P601	Speed encoder	~P735
	Act. ref. pos. 32bit Low	=P602	Torque current	~P720

Step	1. "P" scope recording	2. "P" scope recording
Parameter settings	P611 = **5 %**	P611 = **15** %

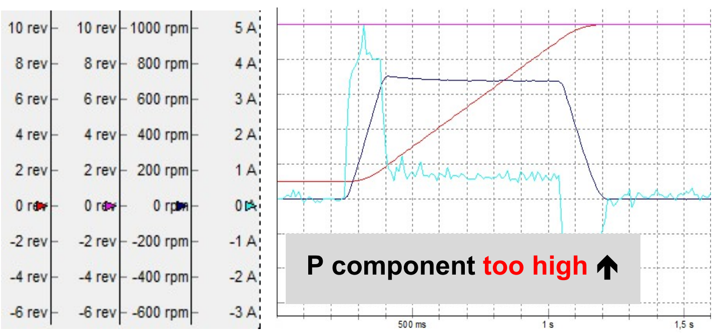


Step	3. "P" scope recording	4. "P" scope recording
Parameter settings	P611 = **25 %**	P611 = **35** %





Step	5. "P" scope recording	9. "P" scope recording
Parameter settings	P611 = **45 %**	P611 = **85** %



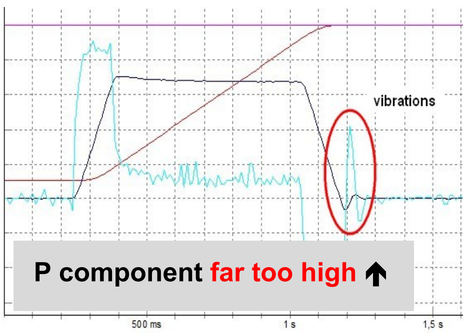


Fig. 53: Curve for the P component of the position control

7 Reluctance torque

Step 7

Information

For applications in which an **even** and **sufficiently high load** is moved, i.e. a **load > 0.5** M_N, by setting the parameter **Servo mode P300** to the function {**1 = CFC Closed-Loop**}, the approximate reluctance angle, see 🕮 parameter **Reluctance angle IPMSM P243**, can be determined.

Experimental determination must always be carried out **below** the **weak field range** and should only be carried out for **IPMSM** drives. With gradual adjustment of the parameter **Reluctance angle IPMSM P243** the corresponding current change must be observed in the parameter **Actual current P719** and must be adjusted until the current reaches the **minimum** value.

Note

Determination or **optimisation** of the **reluctance torque** must**not** be carried out in the **weak field range**.
The smaller the reluctance angle, the smaller the reluctance component of the synchronous motor with embedded magnets, i.e. for so-called IPMSM drives.

For further information regarding the reluctance torque or angle, please refer to Section 🕮 3.3.2 "NORD – Motor type plates / Data sheet"

The determination should then be carried out according to the following procedure after optimisation of the controller has been carried out (see 🕮 Section 4, 5 und 6).

Overview of optimisation procedure

- Set the **Reluctance angle IPMSM P243** to an **initial value** of **0°** and **increase** this in **increments of 1°** or **2°** , until the **Actual current P719** reaches a **minimum** under constant operating and load conditions.
- Optimum adjustment of the **Reluctance angle IPMSM P243** has been achieved if no improvement of the shape of the curve can be obtained by increasing the value.
  A curve as shown in 🕮 **Figure 1** or **Figure 2**7.3 "Reluctance angle".
- For the optimisation, care must be taken that the setpoint which is selected corresponds to the design point or the load conditions!

The objective is to achieve the minimum Actual current P719 under nominal load conditions by the "correct" setting of the reluctance angle.

The practical implementation for optimisation of the slip compensation is described in Section 🕮 7.4 "Optimisation procedure".

7.1 Further settings

Instructions

For the determination or optimisation of the reluctance torque, all parameters of the

- Particular controller optimisation (see 🕮 previous section) must be optimised
- All of the corresponding parameters for the application-specific requirements

must be optimised in advance.

Information **Application information**

All parameters which are to be set in advance, as well as the **setpoint specification** (required speed) result from the **application requirements**. When setting the **Acceleration time P102**, care must be taken that the frequency inverter **does not** enter the current limit (Warning **C004** = **Overcurrent measured**).

Parameter No. [-Array]	Name [Unit]	Factory setting	Setting related to parameter set (P1, ... , P4)
BASIC PARAMETERS			
P113 (P)	Jog frequency [Hz]	0.0	**0.0 → 65.0**
Speed control			
P300 (P)	Servo mode	0 (Off = VFC Open-Loop)	1 (On = CFC Closed-Loop)

Setting or optimisation of the reluctance angle should be carried out using observation of the **Actual current =P719**) e.g. with the aid of the NORD CON oscilloscope function.

Before starting the scope recording and enabling the drive unit, the **setpoint** must be set to a value which corresponds to the requirements of the application or the designed operating point. I.e. in this example (frequency inverter 4.0 kW / motor combination 3.0 kW) a setpoint frequency of e.g. **65 HZ**must be specified.

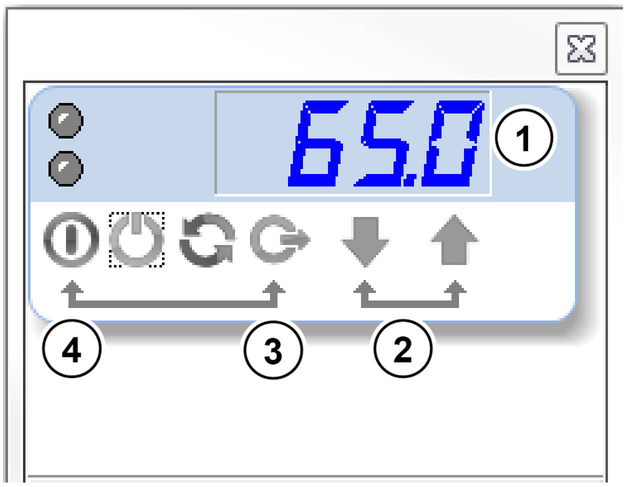
7.2 NORD CON

Information & instructions

Further information about the settings can be obtained from Section 🕮 4.2 "NORD CON" and the following.

7.2.1 Remote control

The following setting must be made in the **Remote Control screen** to optimise the reluctance torque before starting the scope recordings.



(1) Set the setpoint to e.g. 92 %, i.e.set the setpoint frequency to approx. 65 Hz

(2) Use the + value or the - value button

(3) Press the OK button to save the frequency as the jog frequency in P113

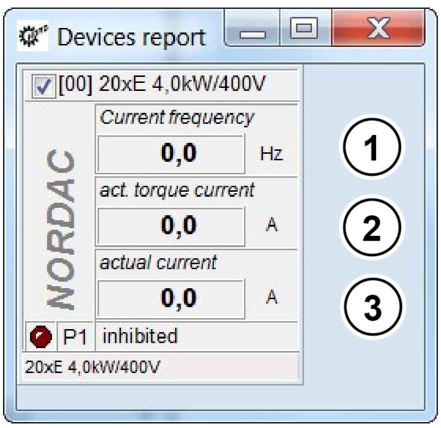
(4) Press the Enable button

Steps (1) (2) and (3) are not required if a jog frequency has been parameterised.

Fig. 54: Remote control of the reluctance torque setpoint and enabling

7.2.2 Device overview

Optimisation can be carried out with the following settings of the three display possibilities in the NORD CON **Device Overview function**.



Set Display (1) to *Current frequency*

Set Display (2) to *act. torque current*

Set Display (3) to *actual current*

Fig. 55: Reluctance torque device overview, display settings

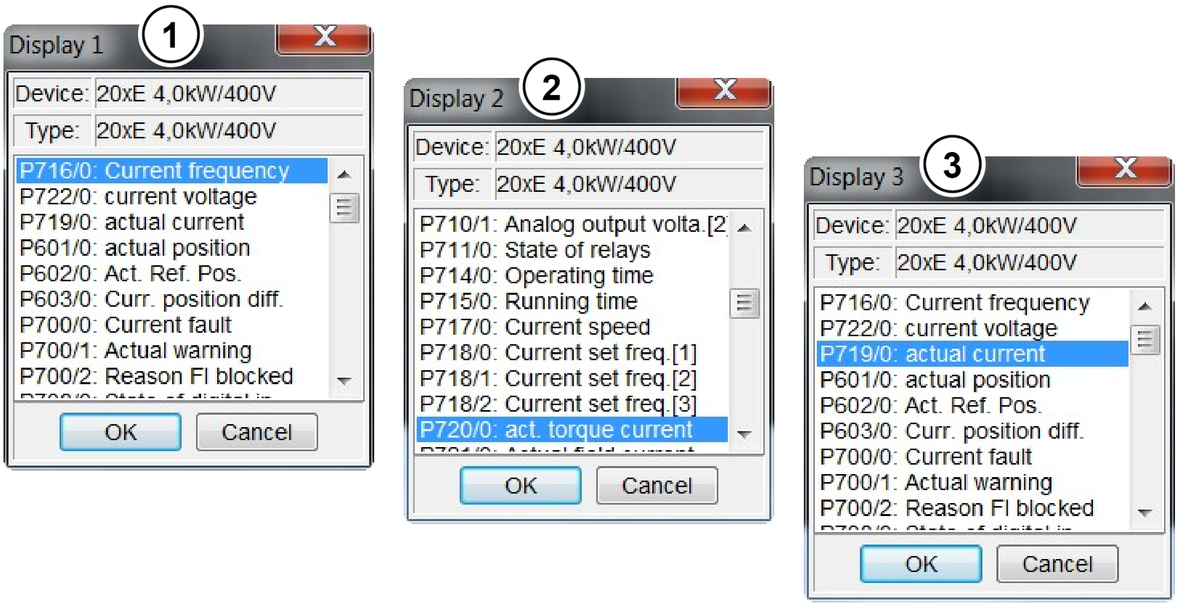


Fig. 56: Slip compensation device overview, display options

7.3 Reluctance angle

Information & instructions

To determine the reluctance torque, the reluctance angle must be changed for the various optimisation steps.

As the initial for optimisation of the reluctance torque for the **1st optimisation step** the **reluctance angle** should be set to **0 °** in the parameter **Reluctance angle IPMSM P243**.

Parameter No. [-Array]	Name [Unit]	Factory setting	Setting related to parameter set (P1, ... , P4)
MOTOR DATA/ CHARACTERISTIC CURVE PARAMETERS			
P243 (P)	Reluctance angle IPMSM [°]	10	**0 → optimal**

With constant load, the **Reluctance angle IPMSM P243** must be optimised until the **Actual current P719** is at a minimum.

A value for the **reluctance angle** which is **not optimally** set causes an **increased current consumption** of the **drive unit** under the same load conditions. **Optimisation** should **always** be carried out under **nominal load** operation and at the designed **operating conditions** (operating mode, operating temperature, load conditions etc.)!

The following diagram / illustration shows the optimum setting for the **Reluctance angle IPMSM P243**:

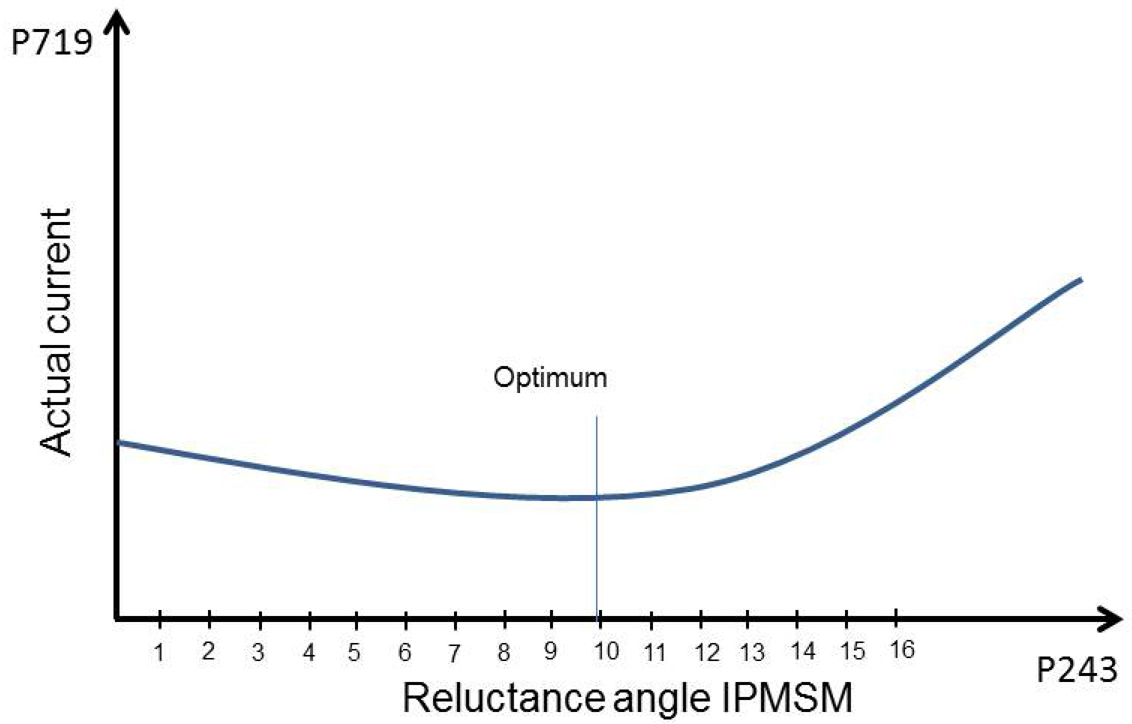


Fig. 57: Diagram for optimum current / reluctance angle IPMSM

The changes to the reluctance angle must be checked with the **NORD CON Oscilloscope Function** (4.2 "NORD CON").

In the following illustration, the curve for an **optimally** adjusted reluctance angle for a 3.0 kW IPMSM synchronous motor (third party motor) is shown as the target.

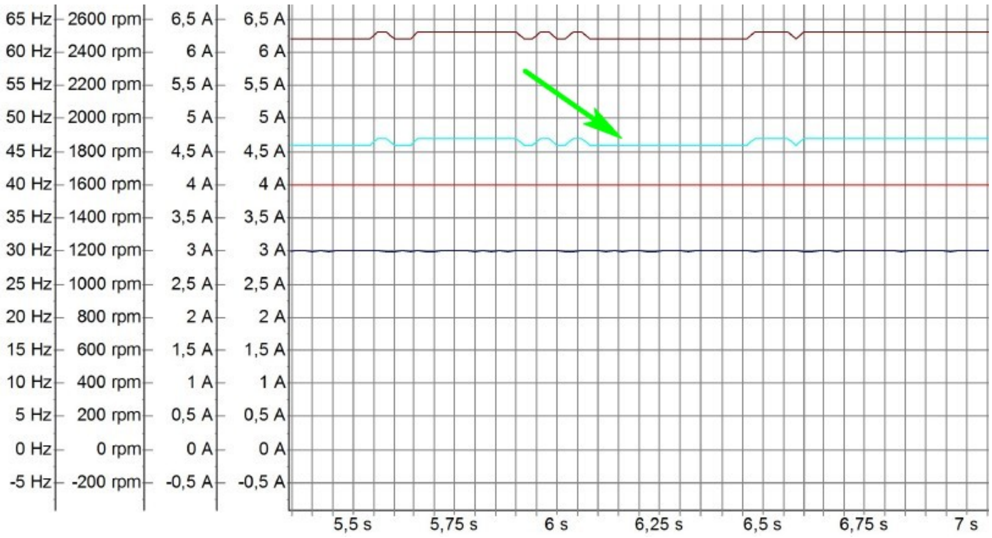


Fig. 58: Example of an optimised reluctance angle

The **optimum curve** for the Torque current =P720 at the operating point under nominal load conditions is illustrated.

The following illustrations show the shape of the curve if the **reluctance angle** is set "**too high**" and "**too low**". The value for the **Reluctance angle IPMSM P243** which is set too high or too low causes an increased Torque current =P720 or an increase in the current consumption of the motor.

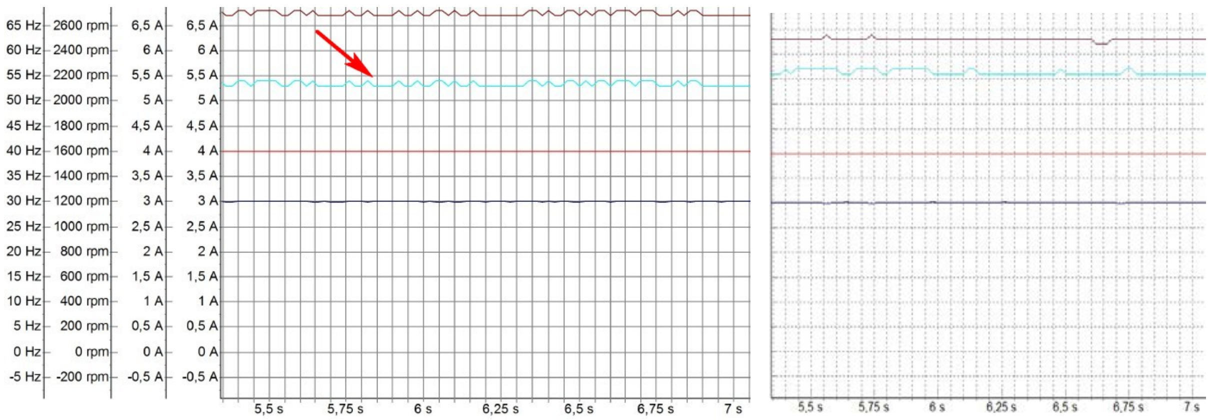


Fig. 59: Example with the reluctance angle set too high (right) and too low (left)

The next optimisation steps and scope recordings should be carried out as follows:

Information Oscilloscope recording

If a range is reached in which the changes in the curve cannot be viewed directly, it is advisable to save the oscilloscope recordings. With the facility for **displaying several recordings simultaneously** a **direct comparison** with the previous settings is possible.

7.3.1 Reluctance angle value

Increase or reduce the parameter for the **Reluctance angle IPMSM P243** in e.g. **1°** or **2° increments** until the **Actual current P719** reaches the lowest possible **minimum** e.g. during the acceleration ramp for movement applications.

The curve is as illustrated in the first Illustration (🕮 7 "Reluctance torque").

The optimum setting of the **Reluctance angle IPMSM P243** has been achieved, when a further increase or decrease of the **value** does not result in a better shape of the curve (in the sense of the minimum current). A **value** which is set "**too low**" or "**too high**" **always causes an increase** of the **Torque current =P720**.

7.3.2 Criteria

The following criteria should be noted for optimisation of the reluctance angle:

The objective is to achieve a minimum Torque current = P720 with the "correct" setting of the reluctance angle.

- For movement applications, the curve for the **Torque current = P720** during the acceleration ramp under **nominal load** should reach a **minimum**

Information **Optimisation steps**

The increments stated for the optimisation of the reluctance torque may differ depending on the application. In addition, the increments can be selected even finer for the final optimisation steps.

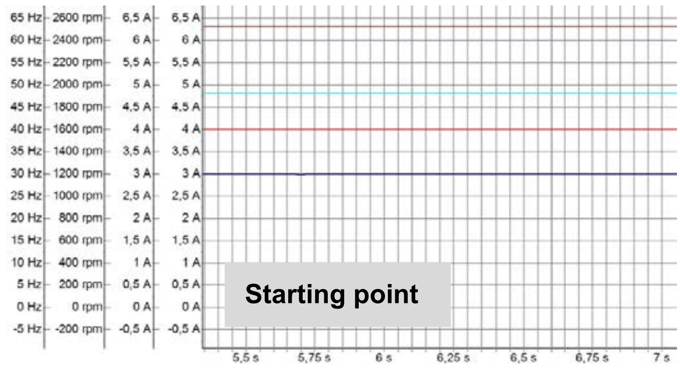
7.4 Optimisation procedure

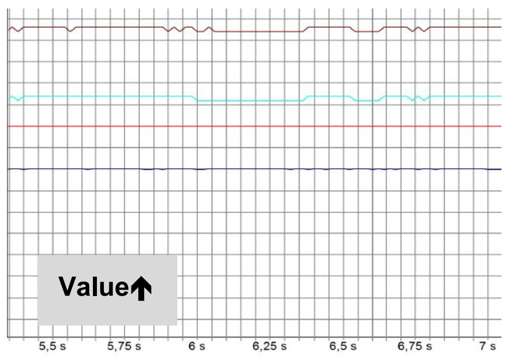
Instructions

The following illustrations show the optimisation process of the reluctance angle IPMSM using the example of a **3.0 kW synchronous motor** (third party motor) on the basis of individual scope recordings.

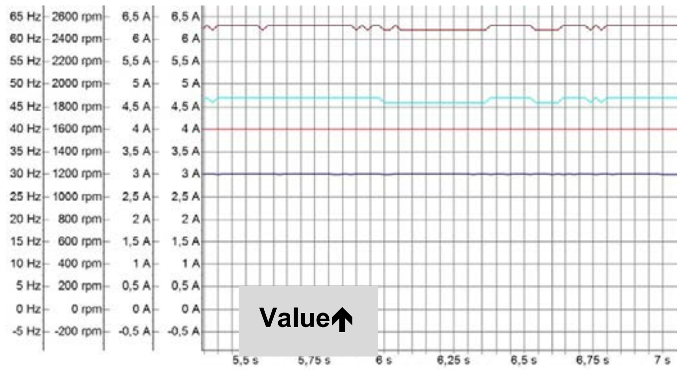
Legend	Setpoint	~P718[02]	Speed encoder	=P735
	Torque current	=P720	Actual current	=P719

Step	1. Scope recording	2. Scope recording
Parameter settings	P243 = **1** °	P243 = **2** °





Step	3. Scope recording	8. Scope recording
Parameter settings	P243 = **3** °	P243 = **8** °



Step	9. Scope recording	12. Scope recording
Parameter settings	P243 = **9** °	P212 = **12** °

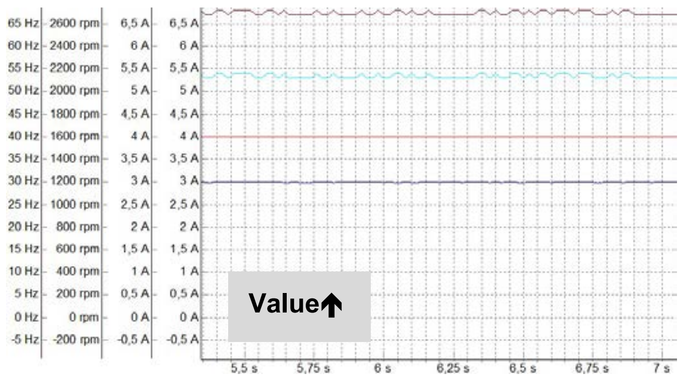


Fig. 60: Graph of reluctance angle IPMSM

8 Parameter lists

Information

8.1 Basic Commissioning

Parameter List

NORD DRIVESYSTEMS

Device Name: Offline parameterize
Device Type: 20xE 4,0kW/400V
Database: Basic setting parameter NORD IE4 100T2-4
Filter: Release: Off, No standard value: On, Info parameter: No, Supervisor: Yes

Nr	Index	Parameter Name	Parameter Set 1	Parameter Set 2	Parameter Set 3	Parameter Set 4	Unit
Operating displays							
1	0	Select of disp.value	Set point frequency [2]				
3	0	Supervisor-Code	3				
Basic parameter							
105	0	Maximum frequency	70	50	50	50	Hz
Motor data							
201	0	Nominal frequency	70	50	50	50	Hz
202	0	Nominal speed	2100	1445	1445	1445	rpm
203	0	Nominal current	5,4	8,3	8,3	8,3	A
204	0	Nominal voltage	385	400	400	400	V
205	0	Nominal power	3	4	4	4	kW
206	0	Cos phi	0,92	0,8	0,8	0,8	
207	0	Star Delta con.	Star [0]	Delta [1]	Delta [1]	Delta [1]	
208	0	Stator resistance	1,44	3,44	3,44	3,44	Ohm
209	0	No Load Current	5,4	4,4	4,4	4,4	A
240	0	EMF voltage PMSM	341	0	0	0	V
241	0	Inductivity PMSM[1]	22,6	20	20	20	mH
241	1	Inductivity PMSM[2]	45,9	20	20	20	mH
243	0	Reluct. angle IPMSM	10	0	0	0	°
244	0	Peak current PMSM	14	5	5	5	A
246	0	Mass Inertia PMSM	45,8	5	5	5	kg*cm²
Speed control							
300	0	Servo Mode	On (CFC closed loop) [1]	Off (VFC open loop) [0]	Off (VFC open loop) [0]	Off (VFC open loop) [0]	
301	0	Incremental encoder	2048 [5]				
330	0	Regulation PMSM	Value CANopen enc. [3]				
334	0	Encoder offset PMSM	0,491				rev
Control clamps							
420	1	digit inputs[2]	No function [0]				
420	2	digit inputs[3]	No function [0]				
Extra functions							
501	0	Inverter name					
Positioning							
604	0	Encoder type	CANopen abs. [1]				
605	0	Absolute encoder[1]	12				Bit
605	1	Absolute encoder[2]	13				Bit

Parameter Number 28

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Fig. 61: Parameter list for basic commissioning

8.2 Current control

Parameter List

Device Name : Offline parameterize
Device Type : 20xE 4,0kW/400V
Database : optimized torque & field controller NORD IE4 100T2-4
Filter: Release: Off, No standard value: On, Info parameter: No, Supervisor: Yes

Nr	Index	Parameter Name	Parameter Set 1	Parameter Set 2	Parameter Set 3	Parameter Set 4	Unit
Operating displays							
1	0	Select of disp.value	Set point frequency [2]				
3	0	Supervisor-Code	3				
Basic parameter							
105	0	Maximum frequency	70	50	50	50	Hz
Motor data							
201	0	Nominal frequency	70	50	50	50	Hz
202	0	Nominal speed	2100	1445	1445	1445	rpm
203	0	Nominal current	5,4	8,3	8,3	8,3	A
204	0	Nominal voltage	385	400	400	400	V
205	0	Nominal power	3	4	4	4	kW
206	0	Cos phi	0,92	0,8	0,8	0,8	
207	0	Star Delta con.	Star [0]	Delta [1]	Delta [1]	Delta [1]	
208	0	Stator resistance	1,44	3,44	3,44	3,44	Ohm
209	0	No Load Current	0 -> 5,4	4,4	4,4	4,4	A
240	0	EMF voltage PMSM	341	0	0	0	V
241	0	Inductivity PMSM[1]	22,6	20	20	20	mH
241	1	Inductivity PMSM[2]	45,9	20	20	20	mH
243	0	Reluct. angle IPMSM	10	0	0	0	°
244	0	Peak current PMSM	14	5	5	5	A
246	0	Mass Inertia PMSM	45,8	5	5	5	kg*cm²
Speed control							
300	0	Servo Mode	On (CFC closed loop) [1]	Off (VFC open loop) [0]	Off (VFC open loop) [0]	Off (VFC open loop) [0]	
301	0	Incremental encoder	2048 [5]				
312	0	Torque curr. ctrl. P	200	400	400	400	%
313	0	Torque curr. ctrl. I	5	50	50	50	%/ms
315	0	Field curr. ctrl. P	200	400	400	400	%
316	0	Field curr. ctrl. I	5	50	50	50	%/ms
330	0	Regulation PMSM	Value CANopen enc. [3]				
334	0	Encoder offset PMSM	0,491				rev
Control clamps							
420	1	digit inputs[2]	No function [0]				
420	2	digit inputs[3]	No function [0]				
Extra functions							
501	0	Inverter name					

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Fig. 62: Parameter list for optimised current control page 1

Parameter List

Device Name : Offline parameterize
Device Type : 20xE 4,0kW/400V
Database : optimized torque & field controller NORD IE4 100T2-4
Filter: Release: Off, No standard value: On, Info parameter: No, Supervisor: Yes

Nr	Index	Parameter Name	Parameter Set 1	Parameter Set 2	Parameter Set 3	Parameter Set 4	Unit
Positioning							
604	0	Encoder type	CANopen abs. [1]				
605	0	Absolute encoder[1]	12				Bit
605	1	Absolute encoder[2]	13				Bit

Parameter Number 32

Legend

(grey box) Parameter does not depend on the parameter set

[ ] The value is invalid

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Fig. 63: Parameter list for optimised current control page 2

8.3 Speed control

Parameter List

Device Name : Offline parameterize
Device Type : 20xE 4,0kW/400V
Database : optimized speed controller NORD IE4 100T2-4
Filter: Release: Off, No standard value: On, Info parameter: No, Supervisor: Yes

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Nr	Index	Parameter Name	Parameter Set 1	Parameter Set 2	Parameter Set 3	Parameter Set 4	Unit
Operating displays							
1	0	Select of disp.value	Set point frequency [2]				
3	0	Supervisor-Code	3				
Basic parameter							
102	0	Acceleration time	0,3	2	2	2	s
105	0	Maximum frequency	70	50	50	50	Hz
113	0	Jog frequency	50	0	0	0	Hz
Motor data							
201	0	Nominal frequency	70	50	50	50	Hz
202	0	Nominal speed	2100	1445	1445	1445	rpm
203	0	Nominal current	5,4	8,3	8,3	8,3	A
204	0	Nominal voltage	385	400	400	400	V
205	0	Nominal power	3	4	4	4	kW
206	0	Cos phi	0,92	0,8	0,8	0,8	
207	0	Star Delta con.	Star [0]	Delta [1]	Delta [1]	Delta [1]	
208	0	Stator resistance	1,44	3,44	3,44	3,44	Ohm
209	0	No Load Current	0	4,4	4,4	4,4	A
240	0	EMF voltage PMSM	341	0	0	0	V
241	0	Inductivity PMSM[1]	22,6	20	20	20	mH
241	1	Inductivity PMSM[2]	45,9	20	20	20	mH
243	0	Reluct. angle IPMSM	10	0	0	0	°
244	0	Peak current PMSM	14	5	5	5	A
246	0	Mass Inertia PMSM	45,8	5	5	5	kg*cm²
Speed control							
300	0	Servo Mode	On (CFC closed loop) [1]	Off (VFC open loop) [0]	Off (VFC open loop) [0]	Off (VFC open loop) [0]	
301	0	Incremental encoder	2048 [5]				
310	0	Speed Ctrl P	200	100	100	100	%
312	0	Torque curr. ctrl. P	200	400	400	400	%
313	0	Torque curr. ctrl. I	5	50	50	50	%/ms
315	0	Field curr. ctrl. P	200	400	400	400	%
316	0	Field curr. ctrl. I	5	50	50	50	%/ms
330	0	Regulation PMSM	Value CANopen enc. [3]				
334	0	Encoder offset PMSM	0,491				rev
Control clamps							
420	1	digit inputs[2]	No function [0]				
420	2	digit inputs[3]	No function [0]				
Extra functions							
501	0	Inverter name					

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Fig. 64: Parameter list for optimised speed control page 1

Parameter List

Device Name : Offline parameterize
Device Type : 20xE 4,0KW/400V
Database : optimized speed controller NORD IE4 100T2-4
Filter: Release: Off, No standard value: On, Info parameter: No, Supervisor: Yes

Nr	Index	Parameter Name	Parameter Set 1	Parameter Set 2	Parameter Set 3	Parameter Set 4	Unit
505	0	Absolute mini. freq.	0	2	2	2	Hz
Positioning							
604	0	Encoder type	CANopen abs. [1]				
605	0	Absolute encoder[1]	12				Bit
605	1	Absolute encoder[2]	13				Bit

Parameter Number 36

Legend

(grey) Parameter does not depend on the parameter set

[ ] The value is invalid

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Fig. 65: Parameter list for optimised speed control page 2

8.4 Position control

Parameter List

Device Name : Offline parameterize
Device Type : 20xE 4,0kW/400V
Database : optimized position controller NORD IE4 100T2-4
Filter: Release: Off, No standard value: On, Info parameter: No, Supervisor: Yes

Nr	Index	Parameter Name	Parameter Set 1	Parameter Set 2	Parameter Set 3	Parameter Set 4	Unit
Operating displays							
1	0	Select of disp.value	Set point frequency [2]				
3	0	Supervisor-Code	3				
Basic parameter							
102	0	Acceleration time	0,3	2	2	2	s
103	0	Deceleration time	0,3	2	2	2	s
105	0	Maximum frequency	70	50	50	50	Hz
113	0	Jog frequency	50	0	0	0	Hz
Motor data							
201	0	Nominal frequency	70	50	50	50	Hz
202	0	Nominal speed	2100	1445	1445	1445	rpm
203	0	Nominal current	5,4	8,3	8,3	8,3	A
204	0	Nominal voltage	385	400	400	400	V
205	0	Nominal power	3	4	4	4	kW
206	0	Cos phi	0,92	0,8	0,8	0,8	
207	0	Star Delta con.	Star [0]	Delta [1]	Delta [1]	Delta [1]	
208	0	Stator resistance	1,44	3,44	3,44	3,44	Ohm
209	0	No Load Current	0	4,4	4,4	4,4	A
240	0	EMF voltage PMSM	341	0	0	0	V
241	0	Inductivity PMSM[1]	22,6	20	20	20	mH
241	1	Inductivity PMSM[2]	45,9	20	20	20	mH
243	0	Reluct. angle IPMSM	10	0	0	0	°
244	0	Peak current PMSM	14	5	5	5	A
246	0	Mass Inertia PMSM	45,8	5	5	5	kg*cm²
Speed control							
300	0	Servo Mode	On (CFC closed loop) [1]	Off (VFC open loop) [0]	Off (VFC open loop) [0]	Off (VFC open loop) [0]	
301	0	Incremental encoder	2048 [5]				
310	0	Speed Ctrl P	200	100	100	100	%
312	0	Torque curr. ctrl. P	200	400	400	400	%
313	0	Torque curr. ctrl. I	5	50	50	50	%/ms
315	0	Field curr. ctrl. P	200	400	400	400	%
316	0	Field curr. ctrl. I	5	50	50	50	%/ms
330	0	Regulation PMSM	Value CANopen enc. [3]				
334	0	Encoder offset PMSM	0,491				rev
Control clamps							
420	1	digit inputs[2]	No function [0]				
420	2	digit inputs[3]	No function [0]				

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Fig. 66: Parameter list for optimised position control page 1

Parameter List

Device Name : Offline parameterize
Device Type : 20xE 4,0kW/400V
Database : optimized position controller NORD IE4 100T2-4
Filter: Release: Off, No standard value: On, Info parameter: No, Supervisor: Yes

Nr	Index	Parameter Name	Parameter Set 1	Parameter Set 2	Parameter Set 3	Parameter Set 4	Unit
480	10	Funct. BusIO In Bits[11]	Bit 0 PosArr / Inc [55]				
Extra functions							
501	0	Inverter name					
509	0	Source control word	USS [2]				
Positioning							
600	0	Position Control	lin.ramp (setfreq.) [2]	Off [0]	Off [0]	Off [0]	
604	0	Encoder type	CANopen abs. [1]				
605	0	Absolute encoder[1]	12				Bit
605	1	Absolute encoder[2]	13				Bit
611	0	P Pos. Control	35				%
613	0	position[1]	10				rev

Parameter Number 41

Legend

(grey) Parameter does not depend on the parameter set
[ ] The value is invalid

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Fig. 67: Parameter list for optimised position control page 2

8.5 Reluctance torque

Parameter List

Device Name : Offline Parametrierung
Device Type : 20xE 4,0kW/400V
Database : optimized reluct. angle IPMSM NORD IE4 100T2-4
Filter: Release: Off, No standard value: On, Info parameter: No, Supervisor: Yes

Nr	Index	Parameter Name	Parameter Set 1	Parameter Set 2	Parameter Set 3	Parameter Set 4	Unit
Operating displays							
1	0	Select of disp.value	Sollfrequenz [2]				
3	0	Supervisor-Code	3				
Basic parameter							
102	0	Acceleration time	0,3	2	2	2	s
103	0	Deceleration time	0,3	2	2	2	s
105	0	Maximum frequency	70	50	50	50	Hz
113	0	Jog frequency	50	0	0	0	Hz
Motor data							
201	0	Nominal frequency	70	50	50	50	Hz
202	0	Nominal speed	2100	1445	1445	1445	rpm
203	0	Nominal current	5,4	8,3	8,3	8,3	A
204	0	Nominal voltage	385	400	400	400	V
205	0	Nominal power	3	4	4	4	kW
206	0	Cos phi	0,92	0,8	0,8	0,8	
207	0	Star Delta con.	Stern [0]	Dreieck [1]	Dreieck [1]	Dreieck [1]	
208	0	Stator resistance	1,44	3,44	3,44	3,44	Ohm
209	0	No Load Current	0	4,4	4,4	4,4	A
240	0	EMF voltage PMSM	341	0	0	0	V
241	0	Inductivity PMSM[1]	22,6	20	20	20	mH
241	1	Inductivity PMSM[2]	45,9	20	20	20	mH
243	0	Reluct. angle IPMSM	8	0	0	0	°
244	0	Peak current PMSM	14	5	5	5	A
246	0	Mass Inertia PMSM	45,8	5	5	5	kg*cm²
Speed control							
300	0	Servo Mode	An(CFC closed-loop) [1]	Aus(VFC open-loop) [0]	Aus(VFC open-loop) [0]	Aus(VFC open-loop) [0]	
301	0	Incremental encoder	2048 [5]				
310	0	Speed Ctrl P	200	100	100	100	%
312	0	Torque curr. ctrl. P	200	400	400	400	%
313	0	Torque curr. ctrl. I	5	50	50	50	%/ms
315	0	Field curr. ctrl. P	200	400	400	400	%
316	0	Field curr. ctrl. I	5	50	50	50	%/ms
330	0	Regulation PMSM	Wert v. CANopengeber [3]				
334	0	Encoder offset PMSM	0,491				rev
Control clamps							
420	1	digit inputs[2]	keine Funktion [0]				
420	2	digit inputs[3]	keine Funktion [0]				
480	10	Funct. BusIO In Bits[11]	Bit 0 PosArr / Inc [55]				

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Fig. 68: Parameter list for optimised reluctance angle page 1

Parameter List

Device Name : Offline Parametrierung
Device Type : 20xE 4,0kW/400V
Database : optimized reluct. angle IPMSM NORD IE4 100T2-4
Filter: Release: Off, No standard value: On, Info parameter: No, Supervisor: Yes

Nr	Index	Parameter Name	Parameter Set 1	Parameter Set 2	Parameter Set 3	Parameter Set 4	Unit
Extra functions							
501	0	Inverter name					
509	0	Source control word	USS [2]				
Positioning							
600	0	Position Control	Lin.Rampe(Sollfreq) [2]	Aus [0]	Aus [0]	Aus [0]	
604	0	Encoder type	CANopen absolut [1]				
605	0	Absolute encoder[1]	12				Bit
605	1	Absolute encoder[2]	13				Bit
611	0	P Pos. Control	35				%
613	0	position[1]	10				rev

Parameter Number 41

Legend

(grey) Parameter does not depend on the parameter set

[ ] The value is invalid

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Fig. 69: Parameter list for optimised reluctance angle page 2

9 Further documentation

Information

In case of queries and for further information regarding this document, please contact Electronics Support at Getriebebau NORD GmbH & Co. KG.

On request, further information which is required, e.g. technical data sheets which are not available under www.nord.com - Documentation can be made available to users after technical consultation.

9.1 Manuals

Document	Name
BU 0000	NORD CON Software Manual (the Help function of the software should preferably be used)
BU 0200	SK 200E – Manual
BU 0210	POSICON for SK 200E - Manual
BU 0500	SK 5xxE – Manual (SK 500E ... SK 535E)
BU 0505	SK 54xE – Manual (SK 540E ... SK 545E)
BU 0510	POSICON for SK 500E – Position Control Manual ≥ SK 530E

Table 7: Manuals

9.2 Technical Information / Data Sheets

9.3 TIs - Guidelines

Document	Name
TI 80_0010	Planning and Commissioning Guide for IE4 motors operated with frequency inverters

Table 8: TIs - Guidelines

9.3.1 TIs – Incremental encoder (IG)

Document	Name	Supplier / Type	Part No.	Data sheet
Enquiries to Service	Incremental encoder IG4 4096, TTL, 5 V, 1.5 m	Fritz Kübler GmbH 8.5820.0H10.xxxx.5093.xxxx	19551020	A0828_5_8.5820.0H1 0.XXXX.5093.XXXX.pc
Enquiries to Service	Incremental encoder IG41 4096, TTL, 10 - 30 V, 1.5 m	Fritz Kübler GmbH 8.5820.0H30.xxxx.5093.xxxx	19551021	A1495_1_8.5820.0H3 0.XXXX.5093.XXXX.pc
Enquiries to Service	Incremental encoder IG42 4096, HTL, 10 - 30 V, 1.5 m	Fritz Kübler GmbH 8.5820.0H40.xxxx.5093.xxxx	19551022	A1451_0_8.5820.0H4 0.XXXX.5093.XXXX.pc

Table 9: TIs – Incremental encoder (IG)

9.3.2 TIs - CANopen absolute encoder (AG)

Document	Name	Supplier / Type	Part No.	Data sheet
Enquiries to Service	Absolute encoder with incremental track AG1 CANopen, Single / Multiturn 8192-4096/2048 TTL	Fritz Kübler GmbH 8.5888.0452.2102.S010.K014	19551881	A1259_11_8.5888.0 452.2102.S010.K014
Enquiries to Service	Absolute encoder with incremental track AG4 CANopen, Single / Multiturn 8192-4096/2048 HTL	Fritz Kübler GmbH 8.5888.0400.2102.S014.K029	19551886	A1731_4_8.5888.04 00.2102.S014.K029_
Enquiries to Service	Absolute encoder with incremental track AG6 CANopen, Single / Multiturn 8192-65K/2048 HTL	Baumer IVO GmbH & Co. KG GXMMS.Z18	19556994	AZ4654-1.PDF
Enquiries to Service	Absolute encoder with incremental track AG3 CANopen, Single / Multiturn 8192-65K/2048 TTL	Baumer IVO GmbH & Co. KG GXMMS.Z10	19556995	AZ3903-1.PDF

Table 10: TIs - CANopen absolute encoder (AG)

9.3.3 TIs - Options / Accessory components

Document	Name	Supplier / Type	Part No.	Data sheet
Enquiries to Service	RJ 45 WAGO connection module	WAGO Kontakttechnik GmbH RJ45 connection 24 V + CANopen	278910300	in preparation

Table 11: Options and accessory components

10 Appendix

10.1 Abbreviations

AG	Absolute encoder	**IG**	Incremental encoder
ASM	Asynchronous machine / motors	**IO**	Input / Output
BG	Size	**IPMSM**	Interior Permanent Magnet Synchronous Motor
CAN	Controller Area Network	**PMSM**	Permanent Magnet Synchronous Motor
CANopen	International standardised protocol	**PI controller**	Proportional-integral controller
CFC	Current Flux Control	**P**	Parameter
DIN	Digital input	**POSICON**	Positioning control
ENC	Special encoder extension	**SK**	Schlicht & Küchenmeister
SCD	Schematic circuit diagram	**SPMSM**	Surface Permanent Magnet Synchronous Motor
FI	Frequency inverter	**SSI**	Synchronous Serial Interface
HTL	High Transistor Logic		
IE1	Efficiency class of standard motors	**TI**	Technical Information / Data Sheet (Data sheet for NORD accessories)
IE2	Efficiency class of motors with higher efficiency	**TTL**	Transistor-Transistor Logic
IE4	Efficiency class of motors with even higher efficiency, e.g. synchronous motors	**VFC**	Voltage Flux Control

Notes

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