EN

AG 0100

Controller Optimisation

Guideline for AC motors - CFC Closed-Loop

NORD DRIVESYSTEMS

Documentation

Title: AG 0100

Order – No.: 6047502

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-250-112-O ... SK 2xxE-750-112-O	(0.25 - 0.75 kW, 1 ~ 100 - 120 V, output 3 ~ 230 V)
SK 2xxE-250-123-A ... SK 2xxE-111-123-A	(0.25 - 1.1 kW, 1 ~ 220 - 240 V)
SK 2xxE-250-323-A ... SK 2xxE-112-323-A	(0.25 - 11.0 kW, 3 ~ 220 - 240 V) [1]
SK 2xxE-550-340-A ... SK 2xxE-222-340-A	(0.55 - 22.0 kW, 3 ~ 380 - 500 V) [2]
SK 5xxE-250-112-O ... SK 5xxE-750-112-O	(0.25 - 0.75 kW, 1~ 115 V, output 3~ 230 V)
SK 5xxE-250-323- ... SK 5xxE-221-323-	(0.25 - 2.2 kW, 1/3 ~ 230 V)
SK 5xxE-301-323- ... SK 5xxE-182-323-	(3.0 - 18.0 kW, 3 ~ 230 V)
SK 5xxE-550-340- ... SK 5xxE-163-340-	(0.55 - 160.0 kW, 3 ~ 400 V)

1) Size IV (5.5 – 11.0 kW) only in the versions SK 2x0E
2) Size IV (11.0 – 22.0 kW) only in the versions SK 2x0E

Version list

Title, Date	Order number	Version	Remarks
AG 0100, Nov. 2014	6047502 / 4714	1.0	First edition, based on the manuals BU 0200 GB / 2314, BU 0210 GB / 2509, BU 0500 GB / 1013, BU 0505 GB / 1013, BU 0510 GB / 3911
AG 0100, April 2015	6047502 / 1615	1.0	Revised edition, based on the manuals BU 0500 GB / 0715, BU 0505 GB / 0715 • General corrections • Adaptation of various parameters
AG 0100, August 2016	6047502 / 3216	1.1	Revised edition, based on the revised manual BU 0200 GB / 1216 • General corrections and structure modifications • Further sections implemented

Table 1: Version list AG 0100

Publisher

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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.

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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 🕮 10.1 "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**	**Third party motor**
P240 ① (P) ②	EMF voltage PMSM [V] ④	⑥ 0	**0 → 341** ⑦	**0 → 296** ⑧
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):

①   ②   ③   ④

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

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.

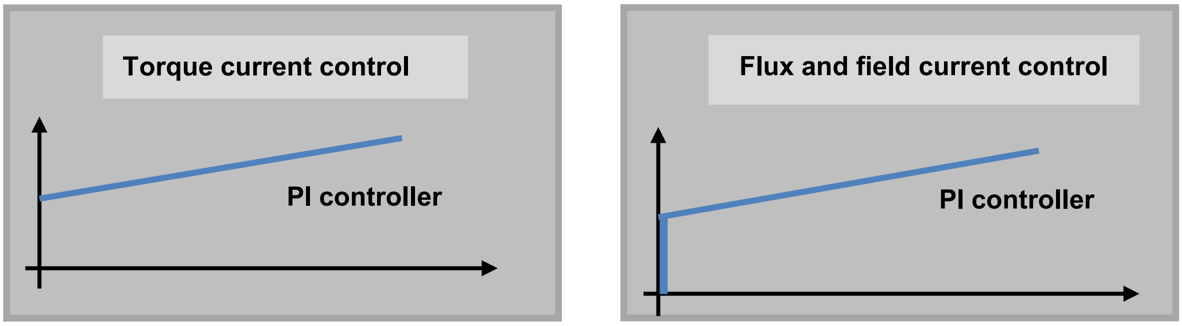
Only **CFC closed-loop mode** is considered, which has the following advantages compared with operation in VFC open-loop mode:

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

CFC closed-loop mode, also known as servo mode in older software versions, is an operating mode with encoder feedback.

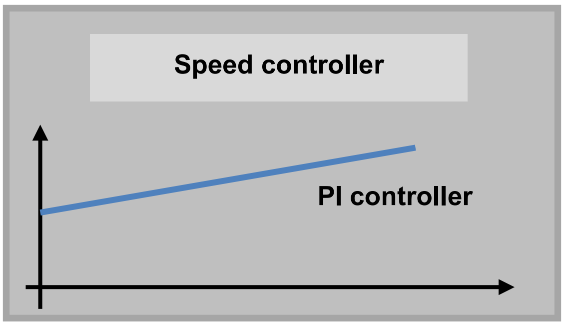
Several different control functions are implemented as standard in SK 2xxE frequency inverters and in the control cabinet versions of type SK 5xxE.

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.



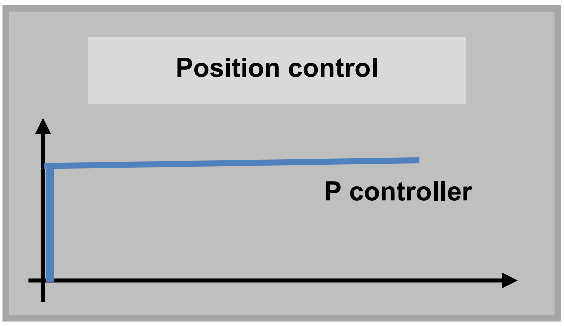
Parameters: P312, P313, P314 **Parameters: P315, P316, P317**

Fig. 6: Current controller



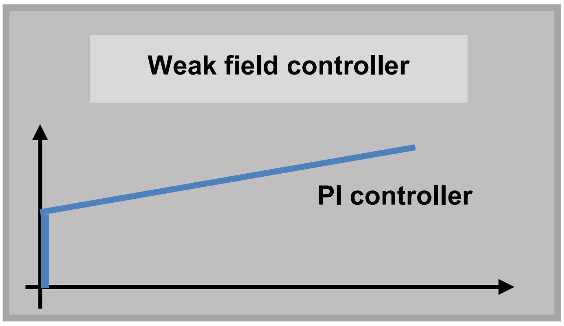
Parameters: P310, P311, P112

Fig. 7: Speed controller



Parameter: P611

Fig. 8: Position control



Parameters: P318, P319, P320

Fig. 9: Field weakening control

This guide for the optimisation of controllers uses the description for a decentralised **SK 200E-401-340-A** frequency inverter in combination with a **4.0 kW** NORD asynchronous motor (ASM) using **NORD CON** oscilloscope recordings.

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 🕮 10.1 "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

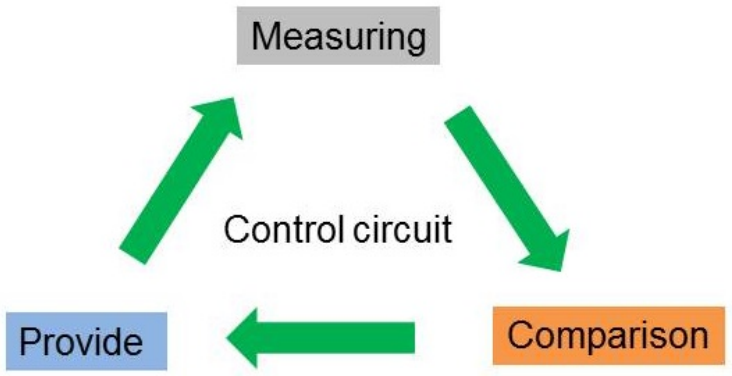


Fig. 10: Control loop

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, field weakening and position control in dynamic operation under load
- Slip compensation at the design point 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.

In a rotor flux-oriented **ASM model** the 3-phase currents and voltages are converted to vectors which are comprised of the components "**d**" and "**q**".

The following diagram shows the orientation of the current vector to the **magnetisation current I_{sd}** (rotor flux orientation) in the **vector diagram**.

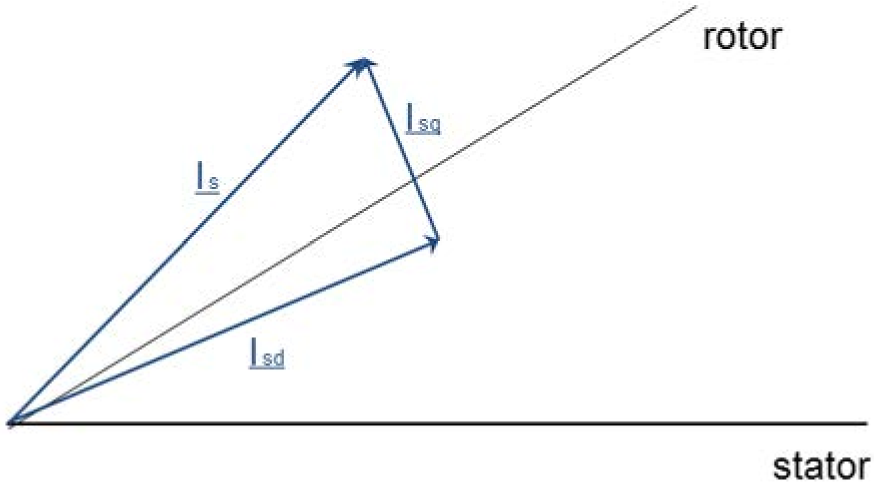


Fig. 11: Current vector diagram

I_s:	Line motor current (≈ Nominal current)	*[A]*
I_{sd}	Flux-forming current (magnetisation current (≈ no load current))	*[A]*
I_{sq}:	Torque-forming current (torque current (≈ rotor current)	*[A]*

The **current components I_{sd}** (flux-forming current, **magnetisation current** / ≈ Actual **field current** P721) and **I_{sq}** (torque-forming current, ≈ Actual **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:

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

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_{sq}:	*Torque-forming current or rotor current (≈ P720)*	*[A]*
I_{sd}:	*Flux-forming current or no load current (P209 / ≈ P721)*	*[A]*

If the flux-forming current / no load current is not known, it is automatically calculated by the frequency inverter and entered in the parameter **No Load Current P209**

1.2.1 No load current calculation

The **No Load Current P209** is calculated with the following formula:

$$I_{sd} = I_0 = I_{nom} \cdot \sin\varphi$$

I_{sd}:	*Flux-forming current (Display ~P721)*	*[A]*
I_0:	*No load current (≈ P209)*	*[A]*
I_{nom}:	*Nominal motor current or line motor current (≈ P203)*	*[A]*
cos φ:	*Motor cos phi (≈ P206) / Efficiency*	*[-]*

Therefore also:

$$M \approx \Phi \cdot I_{sq} \approx \Phi \cdot I_s \cdot \cos\varphi$$

M:	*Torque*	*[Nm]*
Φ:	*Magnetic flux*	*[Wb]*
I_s:	*Line motor current (Display ~P719)*	*[A]*
I_{sq}:	*Torque-forming current or rotor current (≈ P720)*	*[A]*
cos φ:	*Motor cos phi (P206) / Efficiency*	*[-]*

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

Information **Torque M**

The **torque M** increases (theoretically) in the ratio of $\frac{I_{sq}}{I_{sqNom}}$ if, as agreed, the magnetic flux is constant.

I_{sq}:	Torque-forming current or rotor current	*[A]*
$I_{sq_{nom}}$:	Torque-forming current under nominal conditions	*[A]*

1.3 Overview (schematic procedure)

Step	Description of procedure / Optimisation procedure	🕮 Documentation / Section Further information
"Step 1"	**Hardware** Setup and connection – Installation and connection work – Power and control terminals – DIP switches – Motor connection (check Y / ▲) – Frequency inverter ↔ Assignment of asynchronous motor – Encoder resolution selection – 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 – 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 – Adjust slip compensation (P212)	🕮 NORD CON – Manual BU 0000 🕮 Manual BU 0200 🕮 Manual BU 0500 🕮 Manual BU 0505 🕮 3.2 "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	Manual BU 0210 Manual BU 0510 3.6 "Absolute encoder (AG)"
	– 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	

"Step 4"	**Current control** Torque current controller (P312, P313, P314) Field current controller (P315, P316, P317)	4 "Current control"
	– Adjust Absolute mini. Freq. (P505) – Adjust Flux delay (P558) – 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)	

"Step 5"	**Speed control** Speed controller (P310, P311)	5 "Speed control"
	– Acceleration time (P102) – Jog frequency (P113) – Flux delay (P558) standard value – NORD CON Remote control – NORD CON Oscilloscope trigger, scan time, channel settings, etc. – Speed Ctrl P (P310) – Speed Ctrl I (P311)	

"Step 6"	**Position control / Positioning** Position controller (P611)	Manual BU 0210 Manual BU 0510 6 "Position control"
	– 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)	

"Step 7"	**Slip compensation** Slip compensation (P212) – Jog frequency (P113) – 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 Slip compensation (P212) by minimising current	🕮 7 "Slip compensation"

↓

Information — Operation in the weak field range

For applications with operation in the weak field range the weak field controller should always be optimised as the **last** optimisation step of the **weak field controller**!

↓

"Step 8"	**Field weakening control** Weak field controller (P318, P319, P320) – Acceleration time (P102) – Maximum frequency (P105) – Jog frequency (P113) – NORD CON Remote control – NORD CON Oscilloscope trigger, scan time, channel settings, etc. – P-Weak (P318) – I-Weak (P319)	🕮 8 "Weak field controller"

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 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. For use with motors with other powers or number of poles, 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 🕮 10.1 "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 / 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	4.0 kW, IE2 motor (ASM), 4 pole	SK 112MH/4 TF IG22
1	Incremental encoder IG KU 10-30 V HTL	IG22 / Resolution 2048 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 **firmware version** (see 🕮 **Software version parameter P707**) correspond to that of the frequency inverter.

2.2 Asynchronous motors (ASM)

Asynchronous motors (**ASM**) from Getriebebau NORD are specified according to the standard IEC 60034-30:2008 and can be operated both from the **mains** as well as by **frequency inverters**.

At present, Getriebebau NORD supplies asynchronous motors with the efficiency classes **IE1, IE2** and **IE3** in a **power range** from **0.12 kW** to **160 kW**.

All **asynchronous motors** from Getriebebau NORD are approved for operation with **frequency inverters**.
However, at present on the motor data for efficiency class IE1 synchronous motors are stored in the frequency inverters.
I.e. only **IE1 asynchronous motors** may be parameterised with **Motor list P200**! **Third party motors** and **Getriebebau NORD IE2** and **IE3 asynchronous motors**, must be parameterised **manually** by the user.

Information — **Third party motors**

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

If necessary **all frequency inverter – asynchronous motor combinations** for **third party motor operation** should be technically checked in advance by **Getriebebau NORD**!

2.3 Frequency inverter - motor assignment

Asynchronous motors can be operated with both decentralised frequency inverters from the SK 2xxE series, as well as by the control cabinet version SK 5xxE with all performance levels.

The selected allocation of the **frequency inverter** to the **asynchronous motor** 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 asynchronous 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, asynchronous 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 efficiency classifications IE1, IE2, etc. 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:

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

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

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

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

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. 12: 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 🕮 10.2.1 "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 🕮 10.1 "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. 13: 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 🕮 10.2.2 "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 🕮 10.1 "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 🕮 10.1 "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 🕮 10.1 "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.

Some other parameters, e.g. **Absolute mini. freq. P505** and the **Flux delay P558**, **must** be changed for the particular controller optimisation in order to obtain meaningful scope images.

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

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 Motor data

Information & instructions

The windings of an **asynchronous motor** (ASM) can be connected in 2 ways (**Y** / **▲**) depending on the mains voltage. Depending on the circuit, the asynchronous motor can be operated with or without a frequency inverter on different mains connections (including 230 V, 50 Hz and 400 V, 50 Hz) and therefore usually has several different **V/f characteristic curves**.

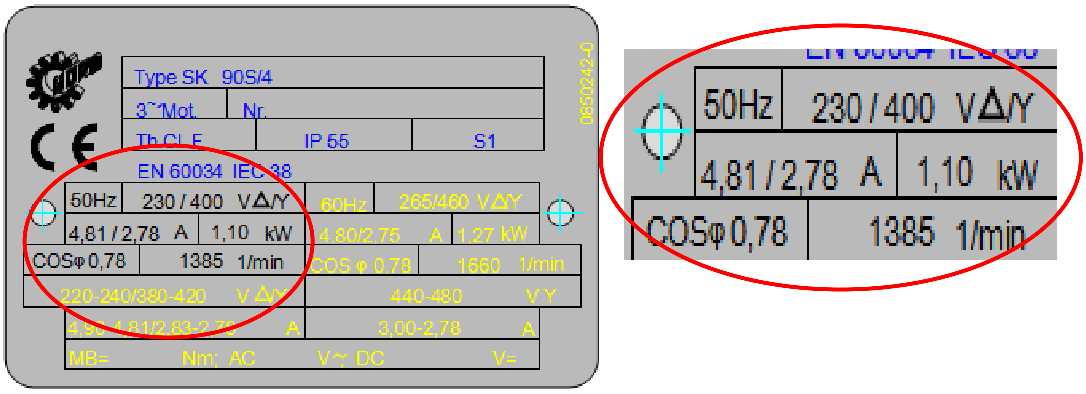


Fig. 14: Example of motor type plate

Motor data sheet

3 phase motor | Motor type: **90SH/4**

Electrical data:			
Frequency (f):	50	Hz	60
Output (P):	1,10	kW	1,10
Speed (n):	1.435	1/min	1.745
Connection of stator:	D/Y		D/Y
Voltage (V):	230/400	V	265/460
Current (I):	4,19/2,42	A	3,72/2,15
Voltage range (U_{WB}):	220-240/380-420	V	254-277/440-480
Wide range current (I_{WB}):	4,20-4,17/2,43-2,38	A	3,69-3,66/2,13-2,11
Starting current/Current (I_A/I):	6,1		7,4
Rated motor torque (M_N):	7,32	Nm	6,02
Starting motor torque (M_A):	22,7 (3,10)*	Nm	22,3 (3,70)*
Minimum motor torque (M_S):	20,9 (2,86)*	Nm	20 (3,32)*
Breakdown motor torque (M_K):	25,6 (3,50)*	Nm	25,9 (4,30)*
cos phi:	0,80	Last	0,76
Eta(%):	81,80	100%	84,00
Eta(%):	82,00	75%	83,20
Eta(%):	80,90	50%	80,10
Service Faktor:			
Code letter:			
Tested data:			
Connection of stator:	D/Y		D/Y
Voltage (V):	230/400	V	265/460
No load current (I_0):	2,50/1,43	A	2,23/1,29
No load output (P_0):		kW	
Noise level (L_{PA}):	49	dB(A)	53
Resistance stator winding at 20°C (R):	4,98 U1 U2	Ohm	
Temperature rise (T):	38,8	K	31
(at the stator resistance method)			
Insulation resistance (R_{isol}):	100	Mega Ohm	
Winding test:	2352	V/4 sek.	
Class of vibration:		A	

Order data:			
Order No.:			
Customer reference No.:			
Serial No.:			
Motor No.:			
Stator No.:	14032002		
General data:			
Direction of rotation:	CW/CCW		
Design:	783 Mot moun.acc. IEC B14 Ø140		
Duty:	S1		
Type bearing:			
Housing material:	Aluminium		
Insulation class:	F		
Type of protection:	IP 55		
Cable entry:	1 I		
Moment of inertia:	0,00340	kgm^2	
Maximum altitude of site:	1.000	m	
Ambient temperature:	-20°C	to	+40°C
Fan Type:	Standard IC 411		
Classification authorities:			
EN 60034, -1, -5, -6, -7, -9, -11, -14, -30; IE2, EN 60204-1,			
EN 61000-6-2, EN 61000-6-4			

Motor options:

* related dimension (without units)

Technical data are subject to change.

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Fig. 15: Example of a data sheet

The motor data are parameterised in the frequency inverter in the tab "**Motor data / Characteristic curve parameters**" in parameters **P201 - P209**.

If this is an **IE1** asynchronous motor from **Getriebebau NORD** it can be selected with the parameter **Motor list P200** from a list of the available 4 pole **IE1** asynchronous motors. With the selection of the motor type, the corresponding parameters **P201 - P209** 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.

If the motor is e.g. an **IE2 asynchronous motor** or an asynchronous motor from a different manufacturer, the motor data obtained from the type plate on the motor or from the manufacturer's data sheet can be used.

After entry of the motor data the **No load current P209** is always calculated **automatically** (from the values Nominal current P203 and Motor cos phi P206).

Parameter No. [-Array]		Name [Unit]	Factory setting	Setting related to parameter set (P1, ... , P4)
MOTOR DATA/ CHARACTERISTIC CURVE PARAMETERS				**NORD IE2 motor**
P200	(P)	Motor list	0	0 (leave as set), as IE2 motor
P201	(P)	Nominal frequency [Hz]	50.0*	**50.0**
P202	(P)	Nominal speed [rpm]	1445*	**1445 → 1440**
P203	(P)	Nominal current [A]	8.3*	**8.3 → 8.02**
P204	(P)	Nominal voltage [V]	400*	**400** (leave as set)
P205	(P)	Nominal power [kW]	4*	**4** (leave as set)
P206	(P)	Cos phi	0.8*	**0.8 → 0.83**
P207	(P)	Star Delta con.	1*	1 (leave as set)1 (1 = delta)
P208	(P)	Stator resistance [Ω]	3.44*	**3.44 → 3.25** (measured)
P209	(P)	No load current [A]	4.4*	**4.4** (calculated)
P220	(P)	Par.-identification	0	**0 → 1** (Identification R_S)

*) dependent on FI power or P200 / P220

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 R_S**}.

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**.

3.2.1 NORD – Motor type plates / Data sheet

The motor data can be obtained from the motor type plate, see 📖 3.2 "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 **IE1 asynchronous motors** should be selected by means of the **motor type** via the parameter **Motor list P200**, e.g. function {**34** = **4.0 kW 400 V**}.

Motor Data Sheet

3 phase motor | Motor type: **112MH/4**

Electrical data:			
Frequency (f):	50	Hz	60
Output (P):	4,00	kW	4,00
Speed (n):	1.440	1/min	1.750
Connection of stator:	D/Y		D
Voltage (V):	400/690	V	460D
Current (I):	8,02/4,63	A	6,98
Voltage range (Uws):	380-420/660-720	V	440-480
Wide range current (Iws):	8,29-7,83/4,77-4,54	A	7,10-6,89
Starting current/Current (IA/IN):	7,5		8,2
Rated motor torque (MN):	26,53	Nm	21,83
Starting motor torque (MA):	82 (3,09)*	Nm	78,2 (3,58)*
Minimum motor torque (MS):	72,7 (2,74)*	Nm	67,6 (3,10)*
Breakdown motor torque (MK):	96 (3,62)*	Nm	93,7 (4,29)*
cos phi:	0,83	Last	0,81
Eta(%):	86,70	100%	88,40
Eta(%):	87,60	75%	88,50
Eta(%):	87,40	50%	87,10
Service Faktor:			
Code letter:			
Tested data:			
Connection of stator:	D/Y		D
Voltage (V):	400/690	V	460D
No load current (I0):	4,06/2,34	A	3,72
No load output (P0):	0,216	kW	0,237
Noise level (LPA):	54	dB(A)	58
Resistance stator winding at 20°C (R):	3,06 U1 U2	Ohm	
Temperature rise (T):	62,3	K	46,8
(at the stator resistance method)			
Insulation resistance (Riso):	100	Mega Ohm	
Winding test:	2940	V/4 sek.	
Class of vibration:		A	
Motor options:			

Order data:			
Order No.:			
Customer reference No.:			
Serial No.:			
Motor No.:			
Stator No.:	16132012		
General data:			
Direction of rotation:	CW/CCW		
Design:	755 Motoranb. IEC B5 Ø250		
Duty:	S1		
Type bearing:			
Housing material:	Aluminium		
Insulation class:	F		
Type of protection:	IP 55		
Cable entry:	1 I		
Moment of inertia:	0,01400	kgm^2	
Maximum altitude of site:	1.000	m	
Ambient temperature:	-20°C	to	+40°C
Fan Type:	Standard IC 411		
Classification authorities:			
EN 60034, -1, -5, -6, -7, -9, -11, -14, -30; IE2, EN 60204-1,			
EN 61000-6-2, EN 61000-6-4			

* related dimension (without units)   Technical data are subject to change.

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Fig. 16: NORD motor (IE2) Data Sheet SK 112MH/4

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.
Getriebebau NORD **IE2** and **IE3 asynchronous motors** and third party motors must always be parameterised **manually** ✋ by the user.

3.2.2 Motor identification

If the motor data is not known, or no type plate is available, there is the possibility of automatically determining the necessary motor data using 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**".

NOTICE **IE2 Motor data**

As a 4-pole **IE2 asynchronous motor** has been used in this guide, selection or the pre-setting of the motor data (P2xx) must **not** be made with function {34 = 4.0 kW, 400 V} via the parameter **Motor list P200**!

Otherwise the calculation of the ASM model will be based on "**incorrect**" **motor data values**.

Par.-identification P220

With the parameter **Par.-identification P220** there is the possibility of obtaining some of the **motor data automatically** ⟲ from the frequency inverter. With many **ASMs better drive characteristics** are enabled or obtained with the measured motor values.

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**:

  With **identification motor** all of the other parameters (P202, P203, P206, P208, P209) for asynchronous motors are only determined when the motor is at a standstill.

Information **Stator resistance value**

After the measurement is complete, the determined stator resistance value 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.

Information

3.2.3 Schematic circuit diagram

In general, all of the data which are necessary for control are calculated from the details on the type plate (3.2 "Motor data"). The required data refer to the data in the schematic circuit diagram (SCD) for the ASM.

For the **Par.-identification P220** calculation of the motor data is based on measurement signals for the SCD data.

To some extent, the data from the schematic circuit diagram (SCD) 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 only after longer operation of the motor **"incorrect"starting values** for the **automatic temperature correction** result.

Information **Displayed measurement values**

If the motor data are determined with the **Par.-identification P220** and Function {2 = **identification motor**} it is then possible to display these values in NORD CON or with a ParameterBox.

In the "**Operating Displays**" tab 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.value P001**.

On the other hand, values calculated from the type plate data and data from the schematic circuit diagram can **not** be displayed via selection from the **Motor list P200**.

3.3 Adjusting the slip compensation

Instructions

In the ASM model which is used for pre-control. The stator frequency which is required for a particular speed is determined with an equation. The precision of this depends on the **rotor time constant t_R**.

The **rotor time constant t_R** greatly depends on the temperature. If this is inaccurately tracked in the ASM model due to temperature drift, errors in the "pre-controlled" stator frequency result.

This effect can be compensated for with the **Slip compensation P212**. The slip compensation therefore improves the pre-control of the motor model.

Information — **Slip compensation P212**

The **100 %** factor setting should initially be reduced **in advance** to a **guide value** of **80 %** for asynchronous motors.

After completion of the controller optimisation the motor can be operated at the operating point or in nominal load operation and the **Slip compensation P212** can then be **optimised**

Parameter No. [-Array]	Name [Unit]	Factory setting	Setting related to parameter set (P1, ... , P4)
MOTOR DATA/ CHARACTERISTIC CURVE PARAMETERS			
P212 (P)	Slip compensation [%]	100	**100 → 80**

The optimisation or correct setting of the **slip compensation P212** is described in detail in Section 7.3 "Slip compensation".

3.4 Optimisation of motor data

Instructions

3.4.1 NORD motors

The motor data are only **implemented** in the motor list of the **system software** of the two frequency inverter series **SK 2xxE** and **SK 5xxE** for **Getriebebau NORD** IE1 **asynchronous motors**, see Parameter **Motor list P200**.

Optimisation of the **specific motor data** for **Getriebebau NORD IE1**, **IE2** and **IE3 asynchronous motors** is only necessary, or must be carried out by the user in **exceptional cases**.
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**.

3.5 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 📖 10.1 "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 10.2.1 "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 🕮 10.1 "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.

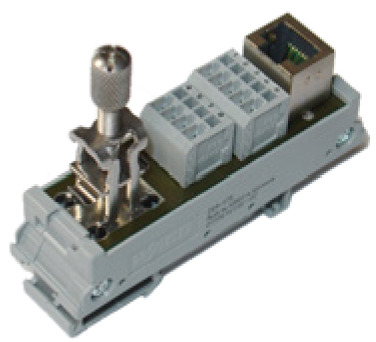


Fig. 17: RJ45 WAGO connection module

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 🕮 10.1 "Manuals".

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 🕮 10.1 "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".

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 (📖 10.1 "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

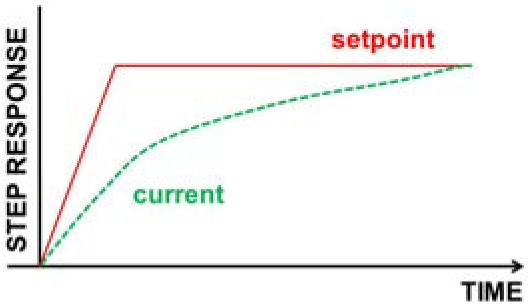


Diagram 2

P component optimised and I component selected too small

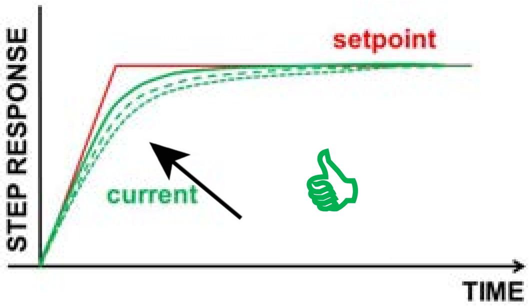


Diagram 3

P and I component optimal

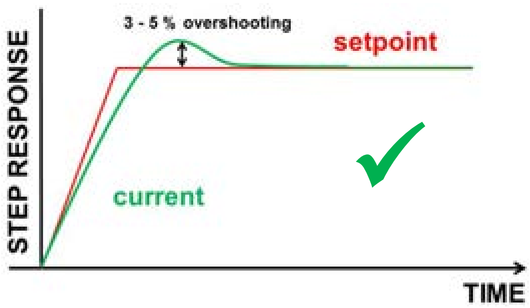


Diagram 4

P component optimised and I component selected too large

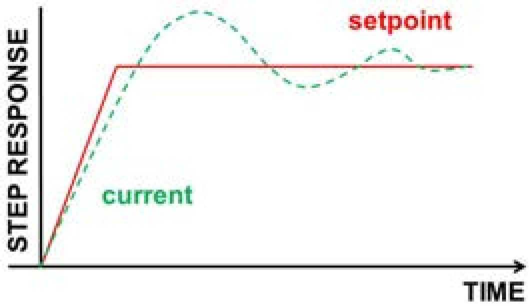


Fig. 18: Control value curves

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 parameters are set in advance.

Parameter No. [-Array]		Name [Unit]	Factory setting	Setting related to parameter set (P1, ... , P4)
ADDITIONAL PARAMETERS				
P505	(P)	Absolute mini. freq. [Hz]	2.0	**2.0 → 0.0**
P558	(P)	Flux delay [ms]	1	**1 → 0**

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.

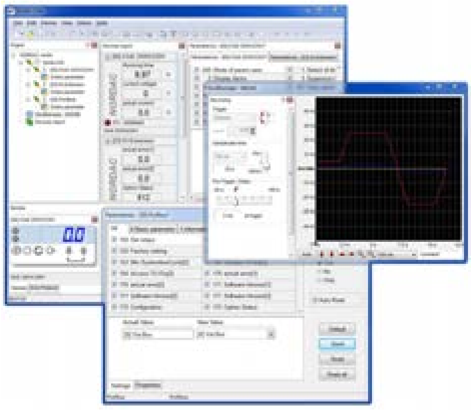
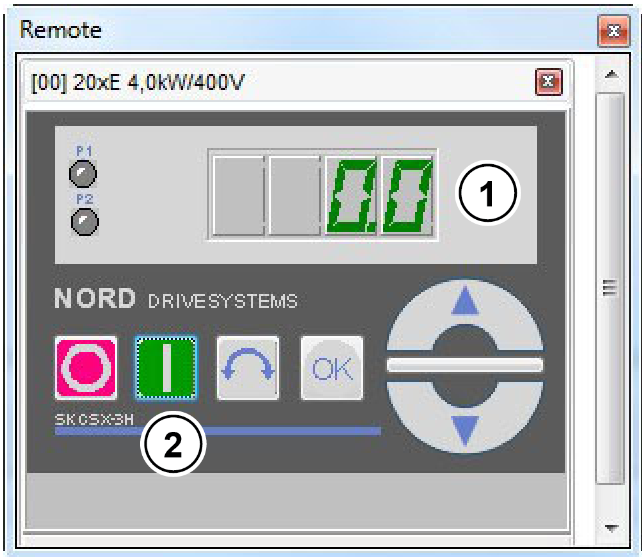


Fig. 19: NORD CON

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 🕮 10.1 "Manuals".

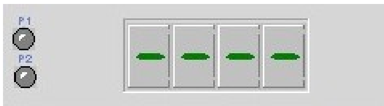
4.2.1 Remote control

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



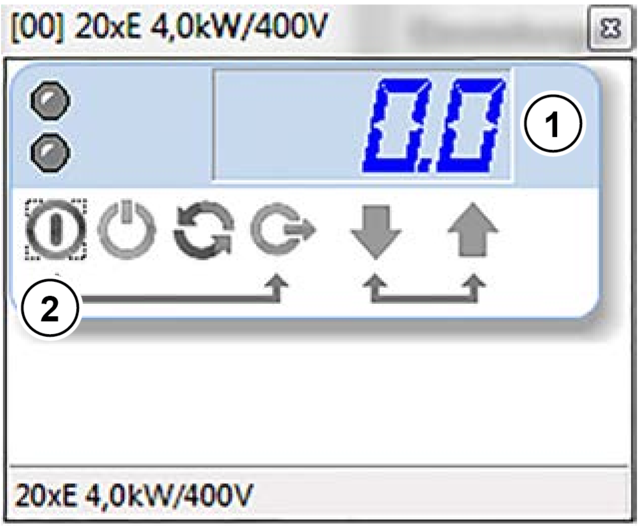
1 **Leave the setpoint at 0 %, i.e. leave the setpoint frequency at 0 Hz**

Alternative display possibility



2 **Press the Enable button**

Fig. 20: Remote control of the current controller, setpoint and enabling



New display in NORD CON

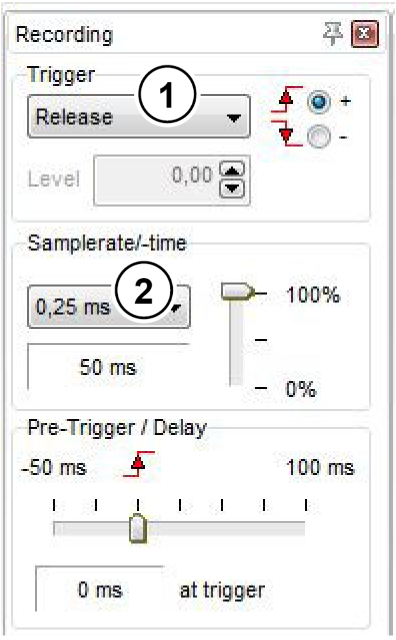
Fig. 21: Remote control of the current controller, setpoint and enabling

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 🕮 <dg_ref_source_inline>Optimierungsablauf</dg_ref_source_inline>!

Fig. 22: Oscilloscope settings for trigger and scan rate / scan duration

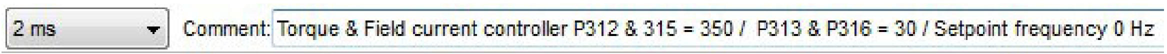


Fig. 23: Resolution settings for the time axis, comment examples

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
(= P[Number]) [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. 24: 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.

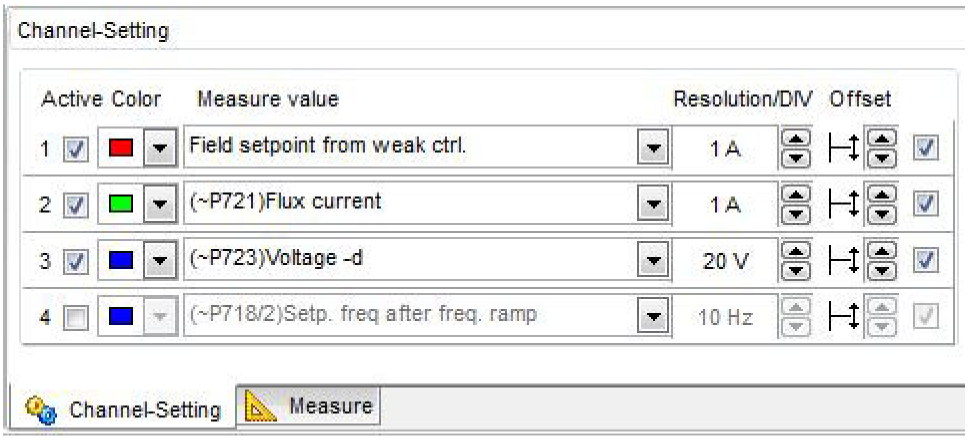
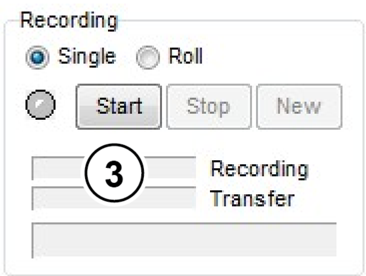


Fig. 25: Oscilloscope channel settings for the three measurement values



3 **Press the Start button**

Fig. 26: Start the scope recording

Information — Initialisation

After pressing the start button, the initialisation phase of the oscilloscope recording begins. This is indicated with the 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 colour change.

Fig. 27: 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 **50 %** and the **I component** (P313 / P316) should be set to **10 % / 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 → 10**
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 → 10**
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** (**Fehler! Verweisquelle konnte nicht gefunden werden. "Fehler! Verweisquelle konnte nicht gefunden werden."**).

For optimisation of the current controller it is **essential** that the parameters described in Section 4.1 "Further settings" **Absolute mini. freq. P505** and **Flux delay P558** are adjusted in advance. After optimisation the **Flux delay P558** should be re-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 control P P312** and the **Field current control P P315** in **50 % increments** until a rapid increase of the actual value, i.e. of the Flux current ~P721 is no longer achieved.

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

The **Voltage component U_{sd} ~P723** or the parameter **Voltage -d P723** must **not exceed** the maximum value of **20 % of the Nominal motor voltage P204**, i.e. for 400 V this corresponds to $U_N \approx$ 80 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 curr. ctrl. I P313** and the **Field curr. ctrl. I P316** from the set starting value [10 % / ms] in **20 % 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 400 V this corresponds to $U_N \approx$ 100 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.

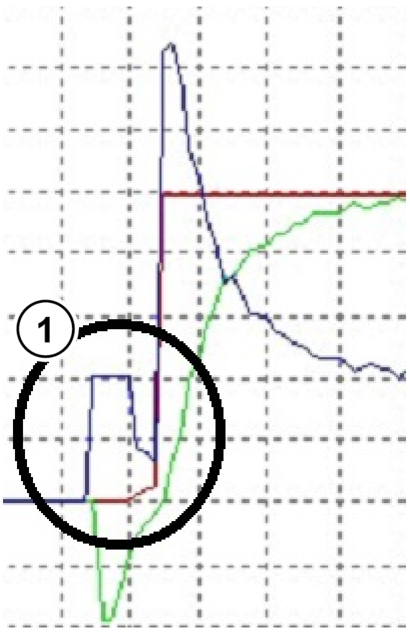
4.4 Optimisation procedure

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 measurement for SK 200E frequency inverter, 4.0 kW asynchronous motor (IE2)**

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

Fig. 28: Short circuit measurement of SK 200E frequency inverter

The following illustrations show the optimisation process for the current controller using the example of a **4.0 kW asynchronous motor** with efficiency class **IE2** on the basis of individual oscilloscope recordings.

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

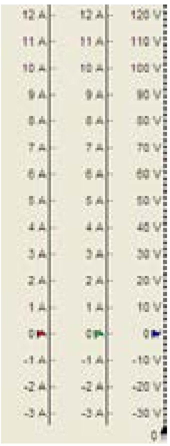
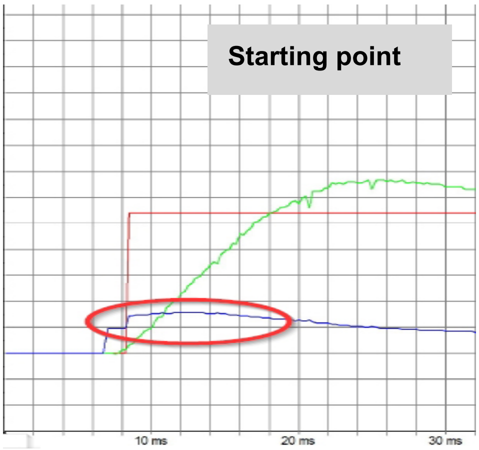
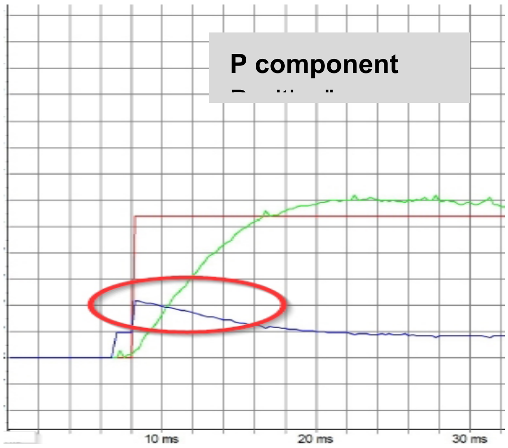
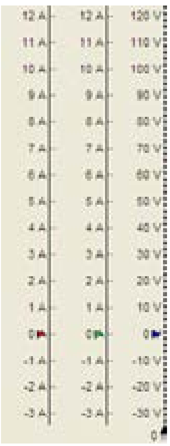
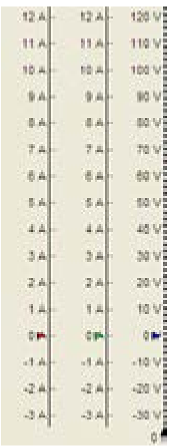
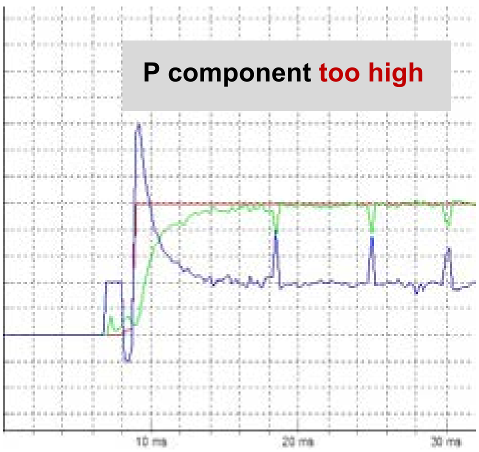
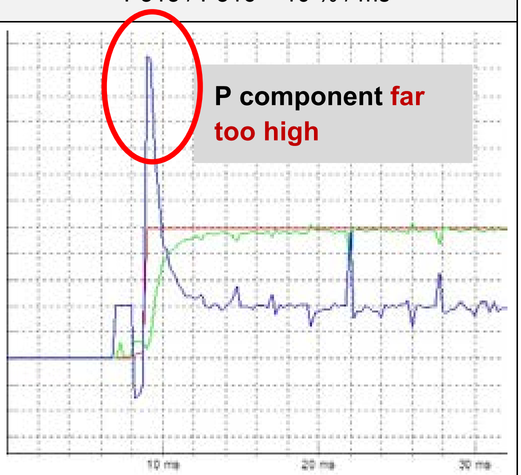
Step	**1. "P" scope recording**	**2. "P" scope recording**
Parameter settings	P312 / P315 = **50 %** P313 / P316 = **10 % / ms**	P312 / P315 = **100 %** P313 / P316 = 10 % / ms
		
Step	**6. "P" scope recording**	**7. "P" scope recording**
Parameter settings	P312 / P315 = **300** % P313 / P316 = 10 % / ms	P312 / P315 **= 350 %** P313 / P316 = 10 % / ms
		
Step	**8. "P" scope recording**	**11. "P" scope recording**
Parameter settings	P312 / P315 = **400 %** P313 / P316 = 10 % / ms	P312 / P315 = **600 %** P313 / P316 = 10 % / ms
		

Fig. 29: Curve for the P component of the current control

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

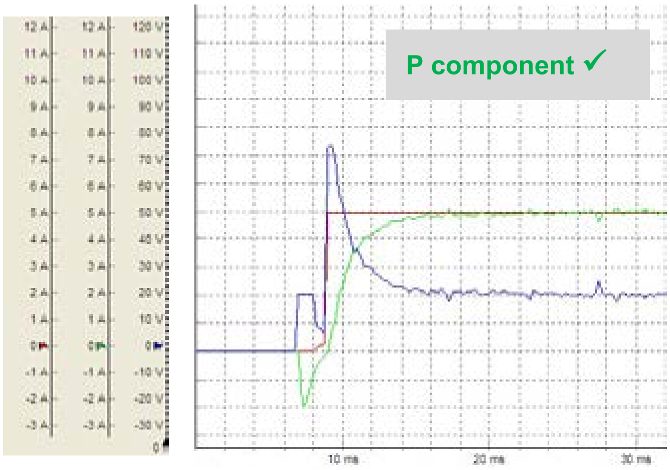
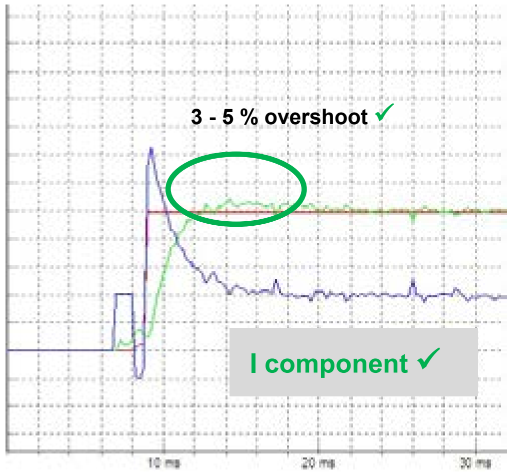
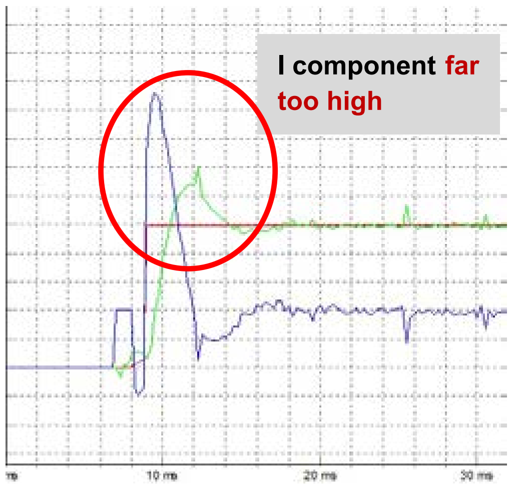
Step	1. "I" scope recording	✓ 2. "I" scope recording
Parameter settings	P312 / P315 = **350 %** P313 / P316 = **10 % / ms**	P312 / P315 = 350 % P313 / P316 = **30 % / ms**
		
Step	3. "I" scope recording	9. "I" scope recording
Parameter settings	P312 / P315 = 350 % P313 / P316 = **50 % / ms**	P312 / P315 = 350 % P313 / P316 = **150 % / ms**
		

Fig. 30: Curve for the I component of the current controller

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, 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)
ADDITIONAL PARAMETERS			
P558 (P)	Flux delay [ms]	1	**0 → 1** (back to standard)

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

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 → 0.08 *
P113 (P)	Jog frequency [Hz]	0.0	0.0 → 35

* 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** (8 "Weak field controller")!

Because of this, the **setpoint specification** must be **matched to the design range** (50 Hz / 87 Hz / 100 Hz – curves). For a standard design according to the **50 Hz characteristic curve** the **setpoint** (**frequency**) should be approx. **70 % ≈ 35 Hz**.

For applications with an **extended operating point** (**87 Hz** or **100 Hz characteristic curve**) a **setpoint** (**frequency**) in the range of approx. **70** - **80 %** (i.e. **61** - **70 Hz** or **70** - **80 Hz**) must be specified.

The **weak field range** for this application therefore begins above approx. **45 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 oscilloscope recording and enabling the drive unit, the **setpoint** must be set to a value of approx. **70** - **80 %** of the **Nominal frequency P201** (50 Hz). I.e. in this example (4.0 kW frequency inverter / motor combination) a setpoint frequency of approx. **35** - **40 Hz** must be specified.

Calculation of the torque current

The **Torque current ~P720** (**I_{sq}**) which is to be achieved is calculated according to the formula:

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

In the basic speed range, up to the rated frequency I_{sd} = I_0 = no load current.

I_s:	*Line motor current (Display ~P203)*	*[A]*
I_{sq}:	*Torque-forming current or rotor current (≈ P720)*	*[A]*
I_{sd}:	*Flux-forming current or no load current (P209 / ≈ P721)*	*[A]*

For further information regarding the calculation please refer to Section 1.2 "Field-orientated control"

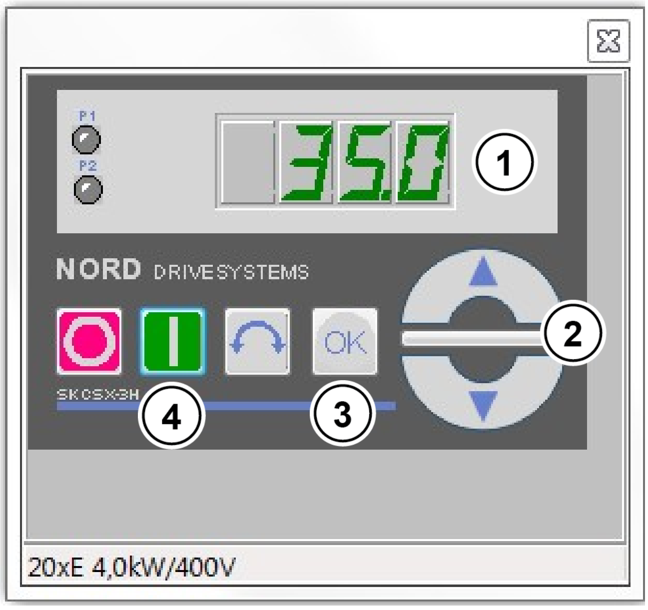
5.2 NORD CON

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 35 Hz

② Use the + value or the - value button

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

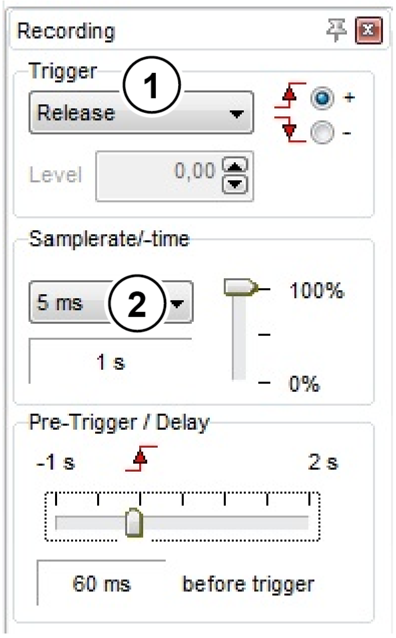
④ Press the Enable button

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

Fig. 31: 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. 32: Oscilloscope settings for trigger and scan rate / scan duration

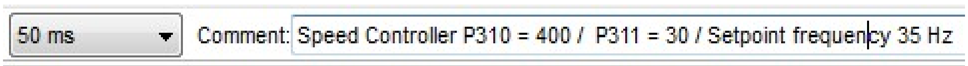


Fig. 33: Resolution settings for the time axis, comment examples

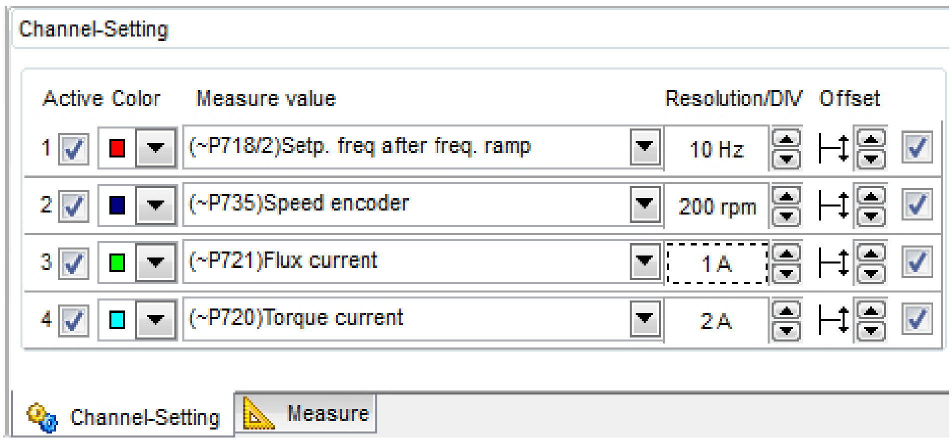
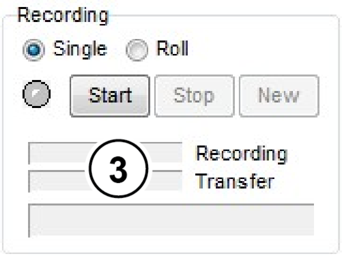


Fig. 34: Oscilloscope channel settings for the four measurement values



3 **Press the Start button**

Note

Note the initialisation phase, see the illustrations in Section 🕮 Fehler! Verweisquelle konnte nicht gefunden werden. **"**Fehler! Verweisquelle konnte nicht gefunden werden.**"**

Fig. 35: 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 4.0 kW asynchronous motor with efficiency class IE2 is shown as the target.

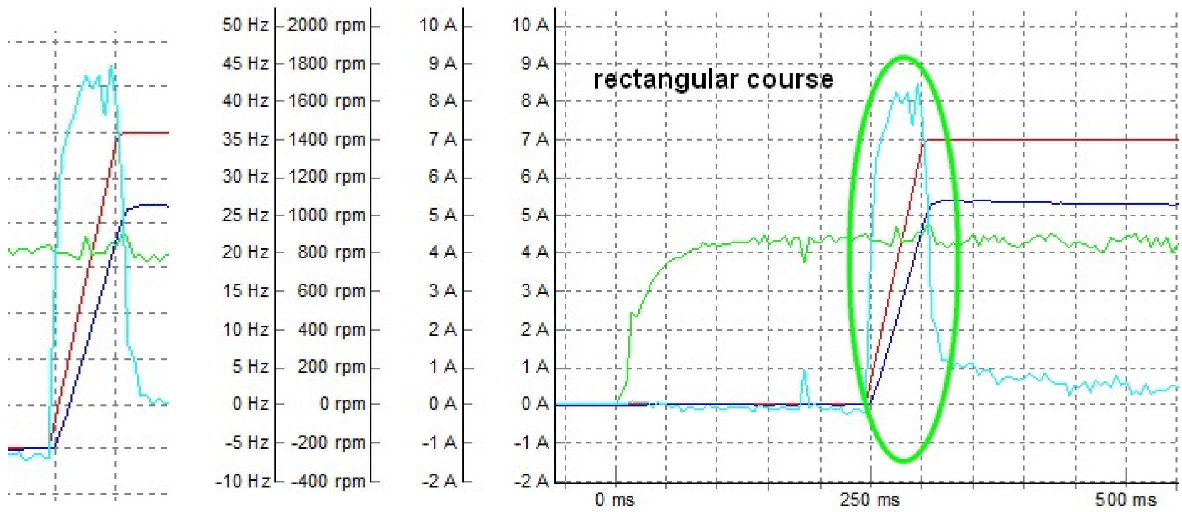


Fig. 36: Example of an optimised speed controller curve

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.

In addition, the influence of the **Flux delay P558** on the curve for the **Flux current ~P721** can be seen. This is clearly visible from the time difference between the increase in the **Flux current ~P721** and the increase of the frequency ramp.

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**.

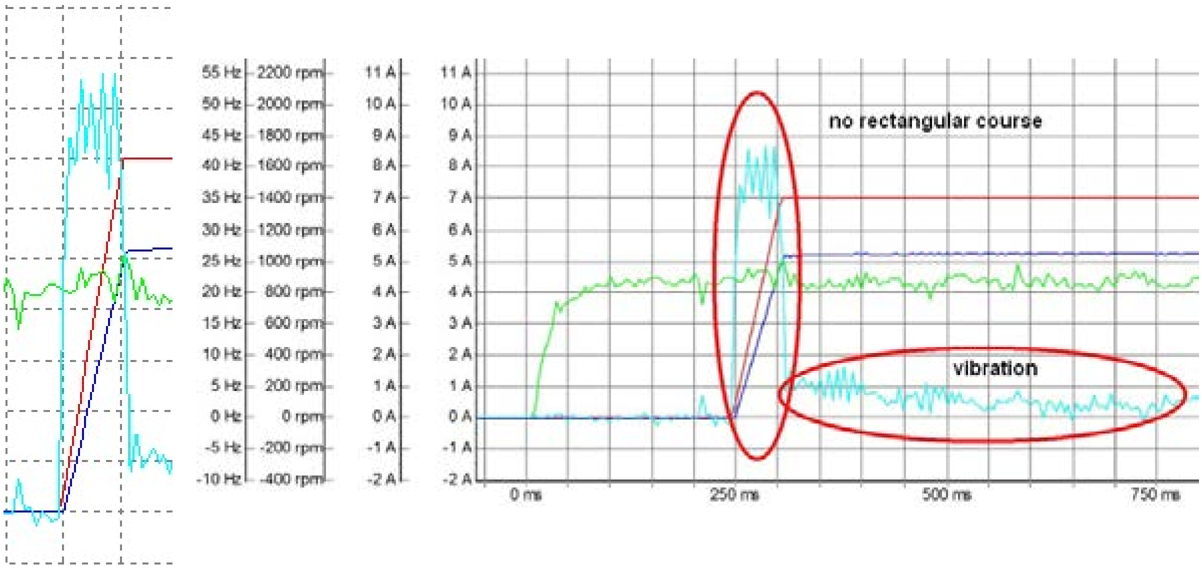


Fig. 37: Example with an excessive P component of the speed controller

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. 35 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. 35 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 **PI 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.

5.3.3 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.

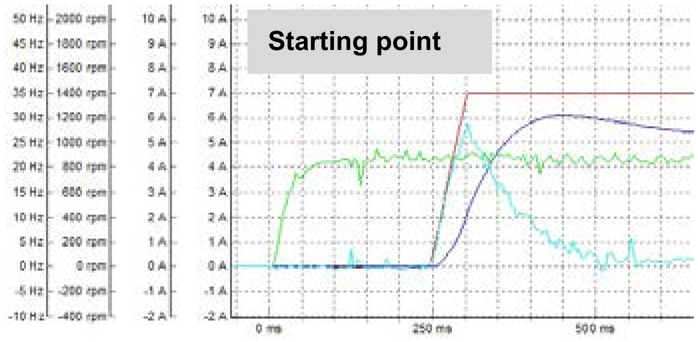
5.4 Optimisation procedure

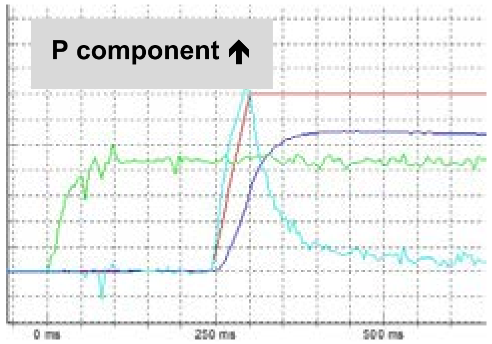
Instructions

The following illustrations show the optimisation process for the speed controller using the example of a **4.0 kW asynchronous motor** with efficiency class **IE2** on the basis of individual scope recordings.

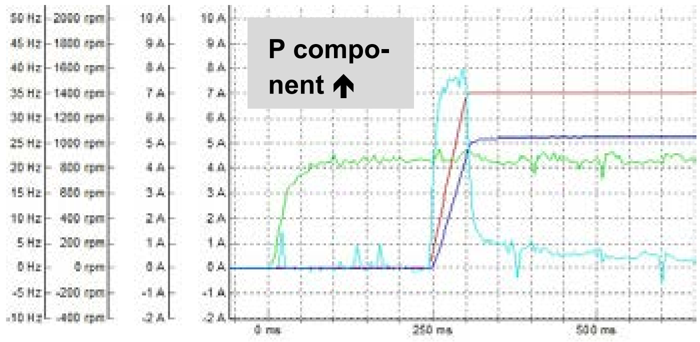
Legend	Set. freq after freq. ramp	~P718[02]	Speed encoder	~P735
	Flux current	~P721	Torque current	~P720

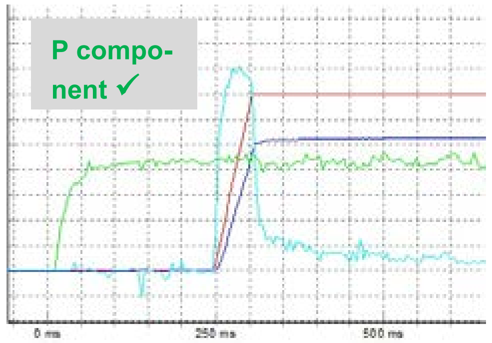
Step	1. "P" scope recording	2. "P" scope recording
Parameter settings	P310 = **50 %** P311 = **5 % / ms**	P310 = **100** % P311 = 5 % / ms



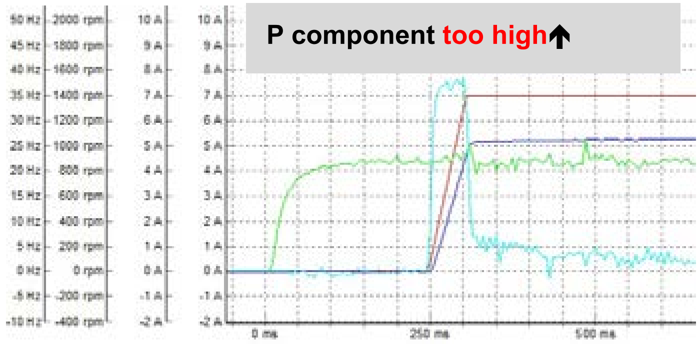


Step	7. "P" scope recording	8. "P" scope recording
Parameter settings	P310 = **350 %** P311 = 5 % / ms	P310 = **400** % P311 = 5 % / ms





Step	9. "P" scope recording	16. "P" scope recording
Parameter settings	P310 **= 450 %** P311 = 5 % / ms	P310 **= 800 %** P311 = 5 % / ms



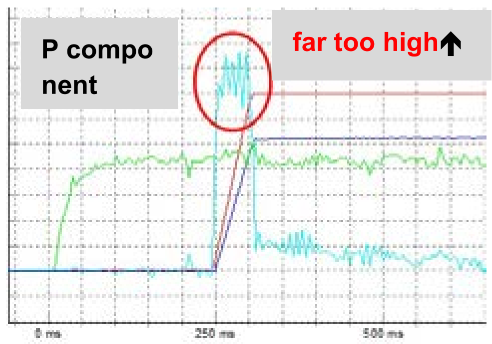
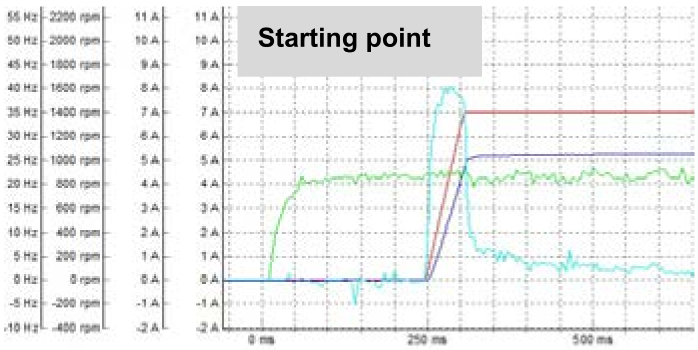


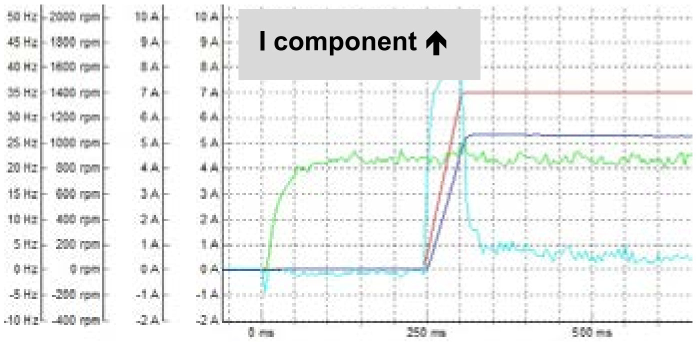
Fig. 38: Curve for the P component of the speed control

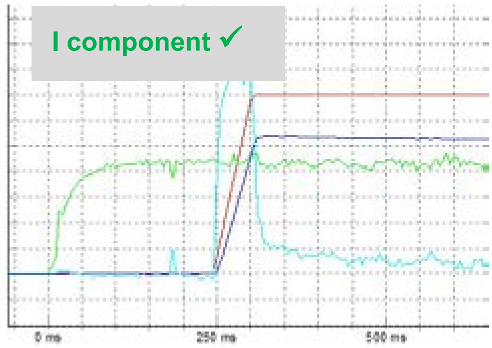
Legend	Set. freq after freq. ramp	~P718[02]	Speed encoder	~P735
	Flux current	~P721	Torque current	~P720

Step	1. "I" scope recording	2. "I" scope recording
Parameter settings	P310 = **400** % P311 = **5 % / ms**	P310 = 400 % P311 = **10 % / ms**



Step	5. "I" scope recording	6. "I" scope recording ✓
Parameter settings	P310 = 400 % P311 = **25 % / ms**	P310 = 400 % P311 = **30 % / ms**





Step	7. "I" scope recording	30. "I" scope recording
Parameter settings	P310 = 400 % P311 = **35 % / ms**	P310 = 400 % P311 = **150 % / ms**

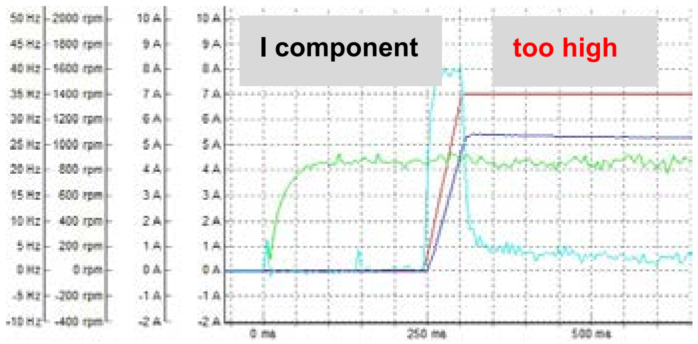


Fig. 39: Curve for the I component of the speed control

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 10.1 "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.

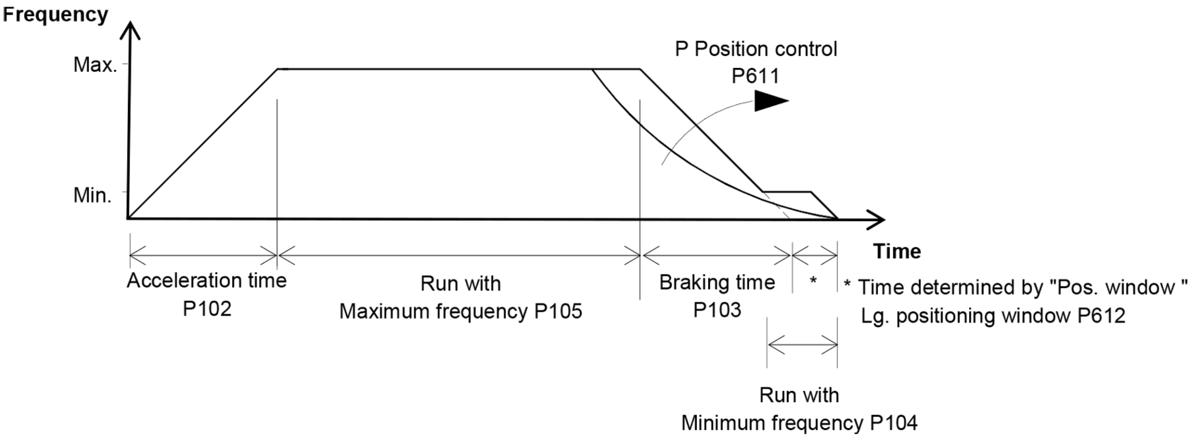


Fig. 40: Position control movement profile

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 🕮 10.1 "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** (50 Hz / 87 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. **45 %** 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 45 % I.e. in this example (frequency inverter 4.0 kW / motor combination 4.0 kW) a setpoint frequency of **22.5 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!

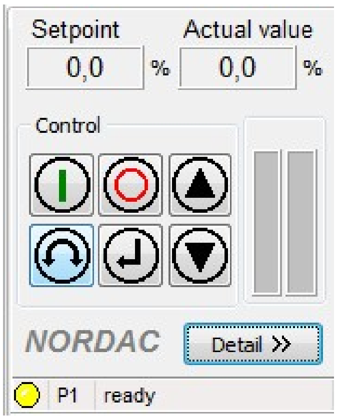
6.2 NORD CON

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. 41: Standard control view

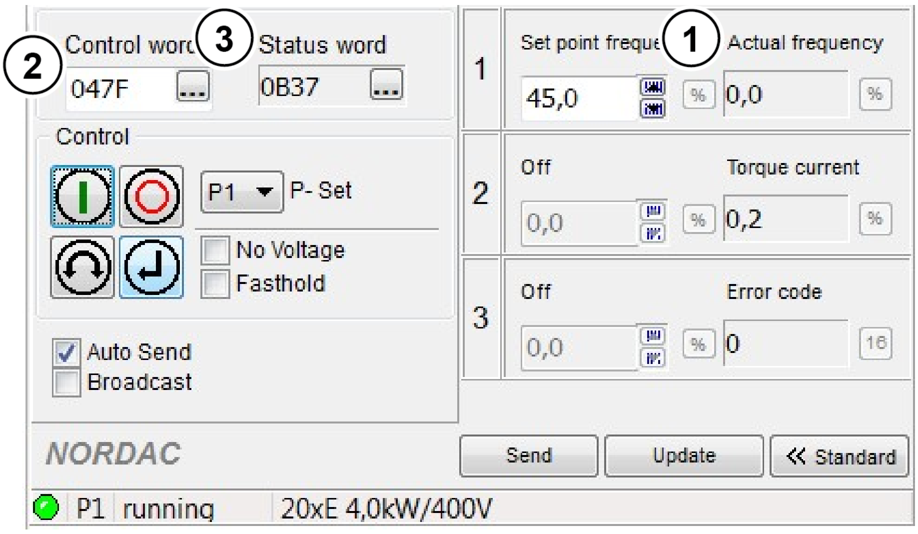


Fig. 42: Control of the speed controller, setpoint and enabling

(1) Set the setpoint to e.g. 45 %, i.e. the setpoint frequency to *22.5 Hz*, using the Value + or Value – button or enter *45 %* directly

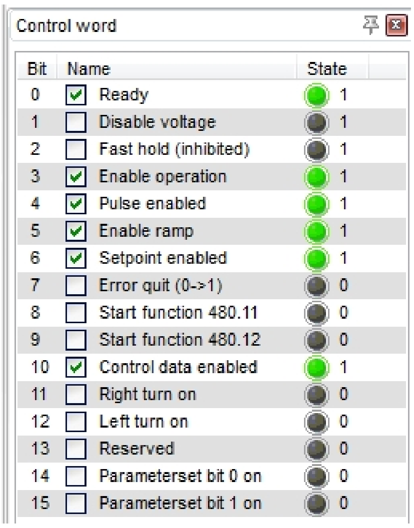
(2) in the control word, enter the value *047F* for *Position 0* or press the Start button or enter the value *057F* for *Position 1*

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*

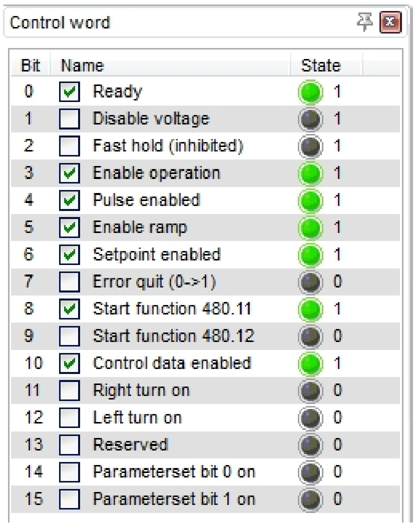
(5) Set Bit 8 ✓ = Specify *Position 1* and then set Bit 3 ✓ = *Enable operation*

(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)

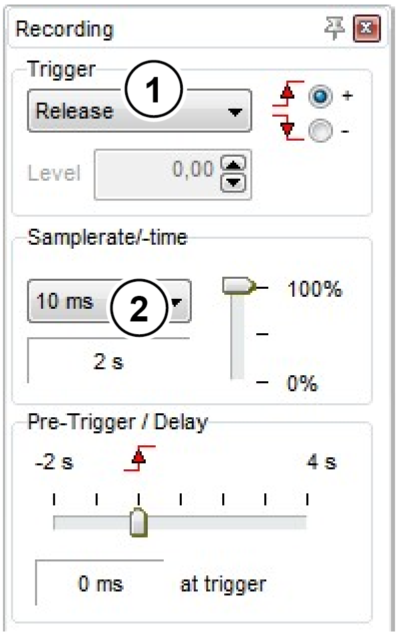

Control word

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. 43: 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. 44: Oscilloscope settings for trigger and scan rate / scan duration

Fig. 45: Resolution settings for the time axis, comment examples

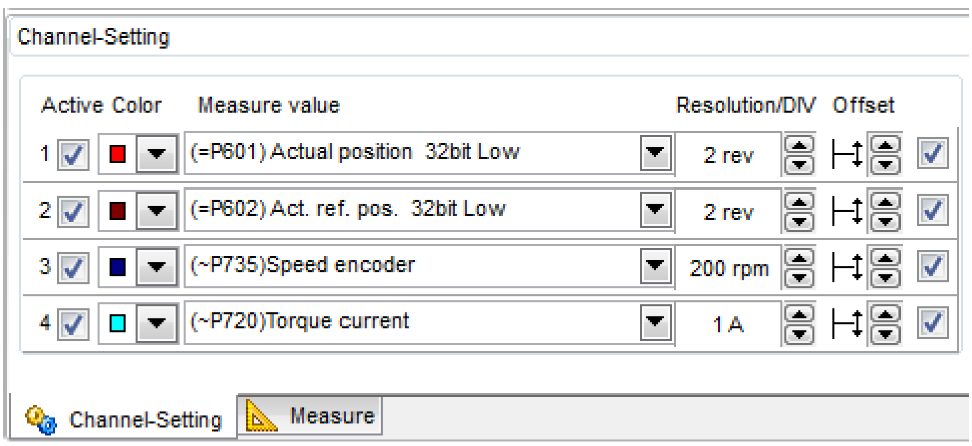
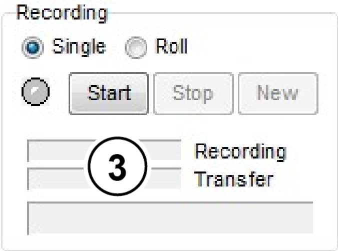


Fig. 46: Oscilloscope channel settings for the four measurement values



3 **Press the Start button**

Note

Note the initialisation phase, see the illustrations in Section 🕮 Fehler! Verweisquelle konnte nicht gefunden werden. **"**Fehler! Verweisquelle konnte nicht gefunden werden.**"**

Fig. 47: 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**

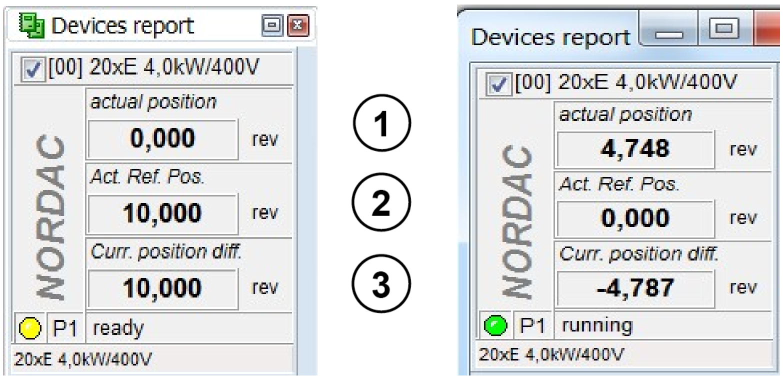


Fig. 48: Position control device overview, display settings

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

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

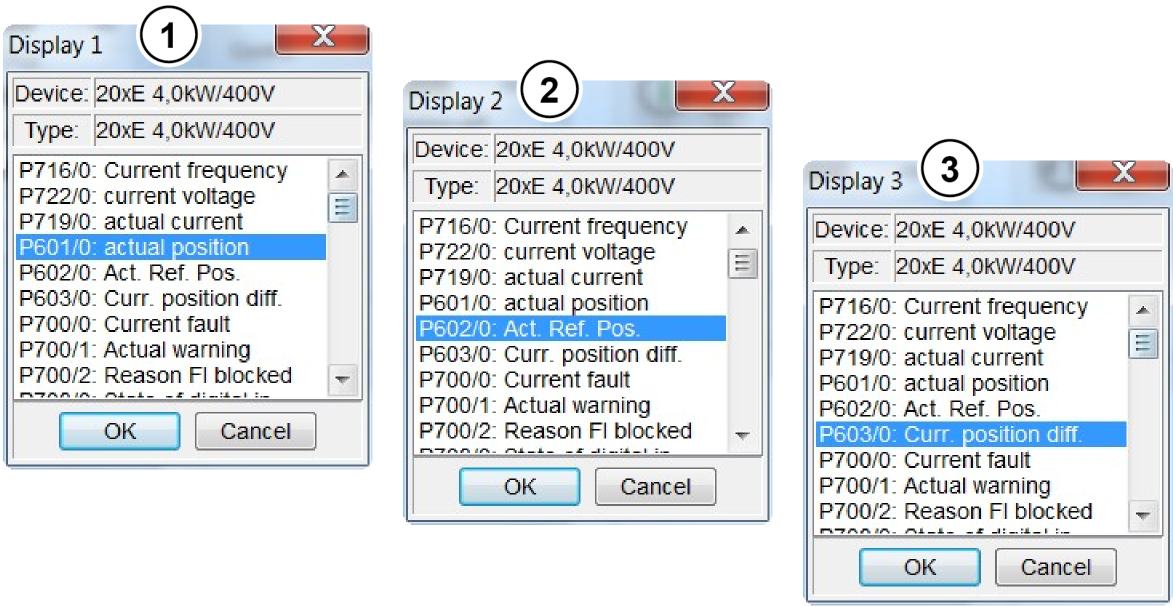


Fig. 49: Overview of position control devices, display selection

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 🕮 10.1 "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.**)}.

② 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.

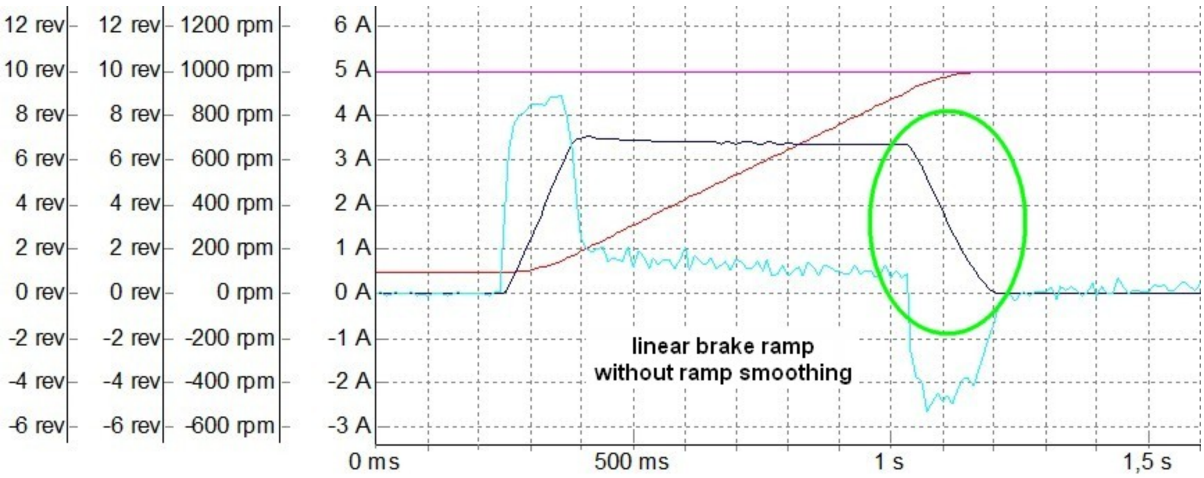


Fig. 50: Example of an optimised position controller curve

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.

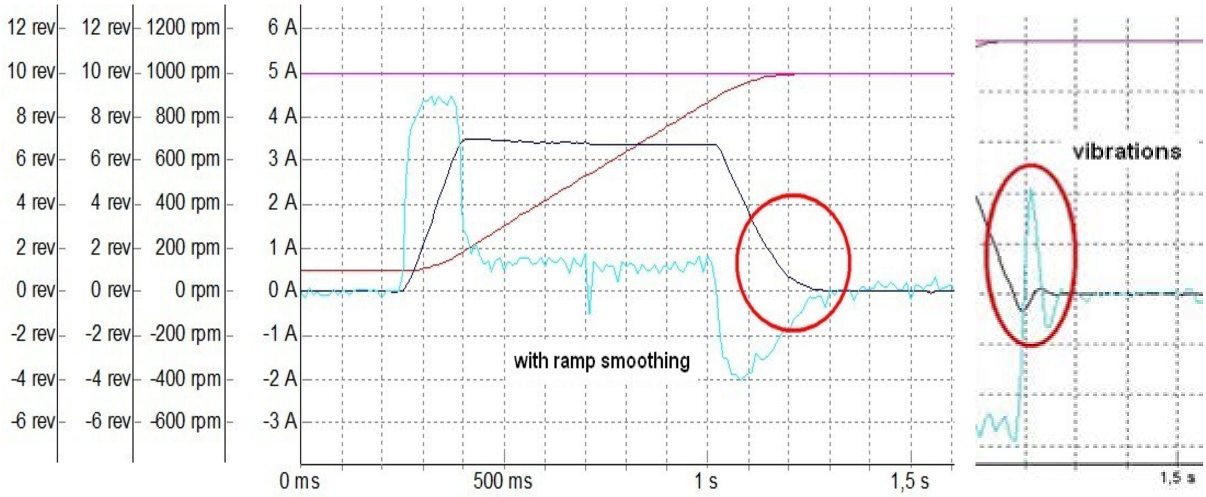


Fig. 51: Example with P component of the position control too small (left) and too high (right)

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 controller using the example of a **4.0 kW asynchronous motor** with efficiency class **IE2** 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

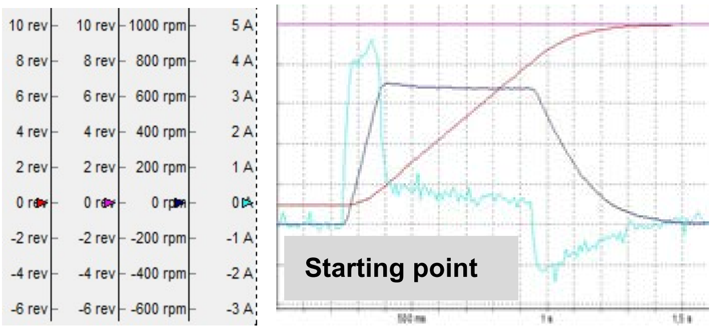
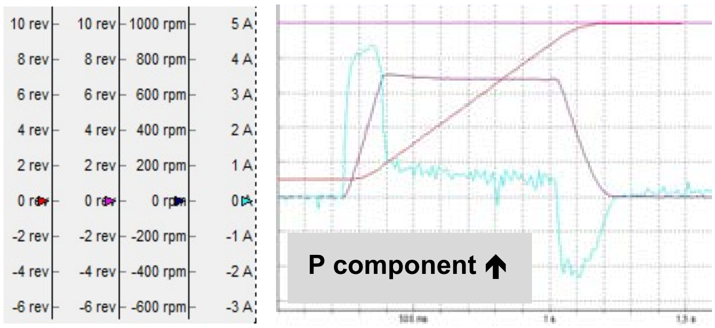
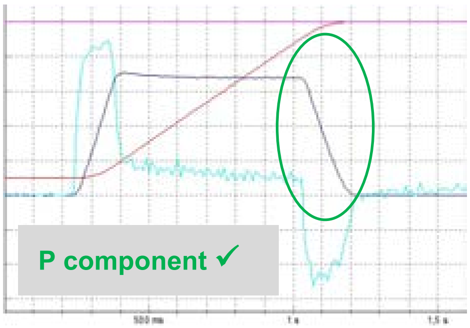
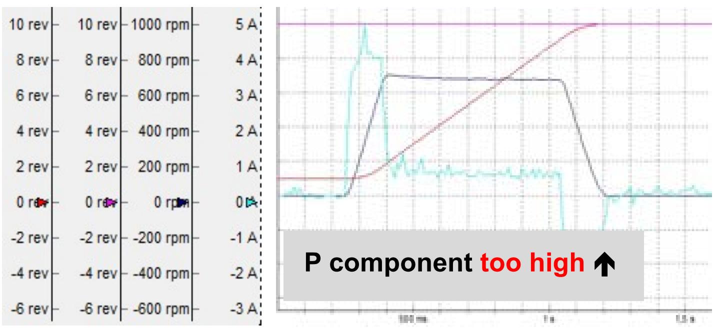
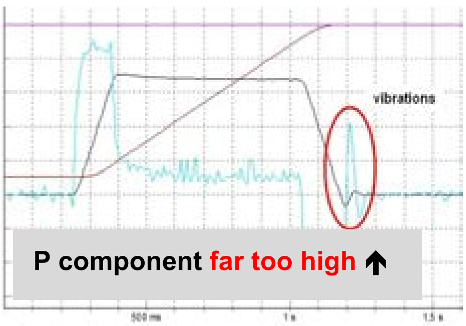
Step / Parameter settings		
Step	**1. "P" scope recording**	**2. "P" scope recording**
Parameter settings	P611 = **5 %**	P611 = **15** %
		
Step	**3. "P" scope recording**	**4. "P" scope recording**
Parameter settings	P611 = **25 %**	P611 = **35** %
		
Step	**5. "P" scope recording**	**9. "P" scope recording**
Parameter settings	P611 = **45 %**	P611 = **85** %
		

Fig. 52: Curve for the P component of the position control

7 Slip compensation

Step 7

Information

Depending on the load, the **Slip compensation P212** changes the output frequency of the frequency inverter and therefore improves the pre-control of the ASM model.

For advance information for the adjustment of the **slip compensation** please refer to Section 🕮 3.3 "Adjusting the slip compensation".

The slip compensation depends on the external temperature and the load on the drive unit. Because of this, setting of the **Slip compensation P212** should always be made at the **operating point** at the **operating temperature** and under the **rated load conditions**.

Note

Optimisation of the **slip compensation** must not be carried out in the **weak field range.** For applications with operation in the weak field range (e.g. ≥ 45 Hz) the weak field should only be optimised after this.

The slip compensation should then only be optimised according to the following procedure after optimisation of the controller has been carried out (see 🕮 Section 4 "Current control", 5 "Speed control" and 6 "Position control").

Overview of optimisation procedure

- Set the **slip compensation** to an **initial value** (e.g. 80 %) and e.g. **increase** in **5 % - 20 % increments** until the **Torque Current ~P720** reaches a **minimum** under the operating and load conditions.

- Optimum adjustment of the **slip compensation** is achieved if no improvement of the shape of the curve can be obtained by increasing the value.
  A curve as shown in 🕮 **Figure 2** or **Figure 3**7.3 "Slip compensation".

- If increasing the value of the slip compensation does not produce a minimisation of the **Torque current ~P720**, the optimisation should be continued with smaller setting values (e.g. < 75 %) until no improvement of the shape of the curve is achieved by reducing the value. Refer to 🕮 **Figure 2** or **3**7.3 "Slip compensation" for further details.

- 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 a minimum Torque current ~P720 under nominal load conditions with the "correct" setting of the slip compensation.**

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

7.1 Further settings

Instructions

For optimisation of the slip compensation, all of the parameters for

- the relevant optimisation of the controller (see 🕮 previous Section) must be optimised
- all other parameters must be set according to the specific requirements for the application.

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**).

For applications with operation in the **weak field range** the weak field controller should always be optimised as the **last** optimisation step of the **weak field controller after** optimisation of the **slip compensation**.

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 → 40.0**

Adjustment of the slip compensation should be carried out using observation of the Torque current =P720) 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 4.0 kW) a setpoint frequency of approx. **40 HZ** must be specified.

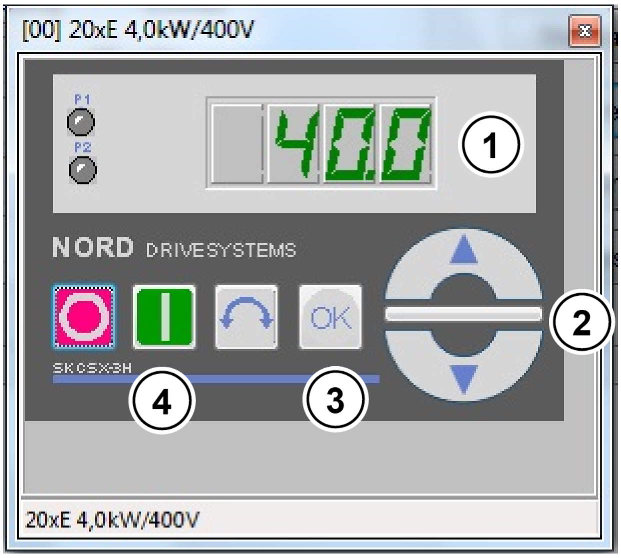
7.2 NORD CON

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 slip compensation before starting the scope recordings.



① **Set the setpoint to 80 %, i.e.set the setpoint frequency to 40 Hz**

② **Use the + value or the - value button**

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

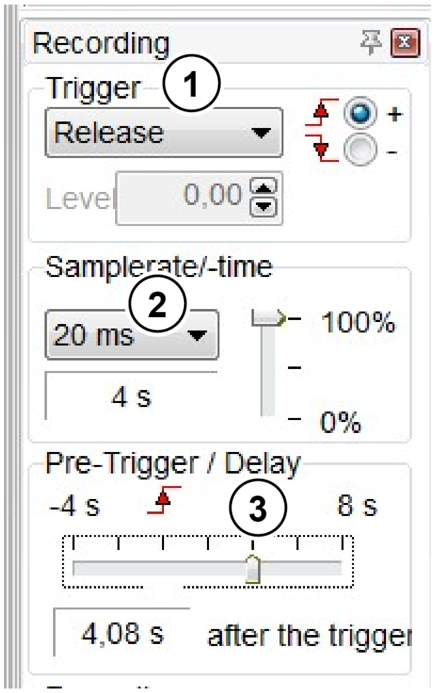
④ **Press the Enable button**

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

Fig. 53: Remote control of slip compensation, setpoint and enabling

7.2.2 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 20 ms**

→ Scan duration 4 s

→ Scan rate depending on the application type which is set

Note

The scan rate should be selected so that it corresponds to the scope recordings in the illustrations in Section 🕮 7.4 "Optimisation procedure"!

3 **Set the start of recording e.g. to 4 sec after the trigger, i.e. for lifting equipment after the acceleration phase and for movement applications during the acceleration phase.**

Fig. 54: Oscilloscope settings for trigger and scan rate / scan duration

Fig. 55: Resolution settings for the time axis, comment examples

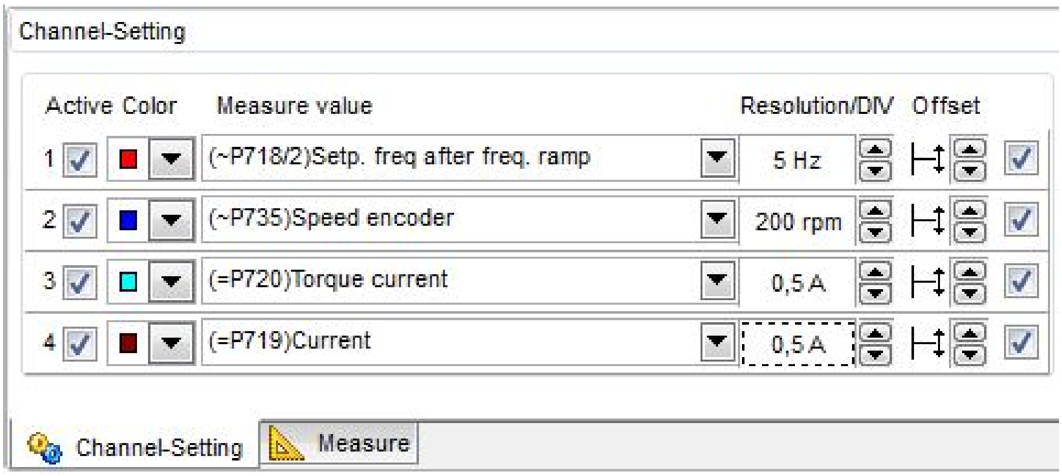
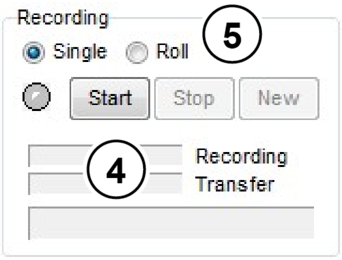


Fig. 56: Oscilloscope channel settings for the four measurement values



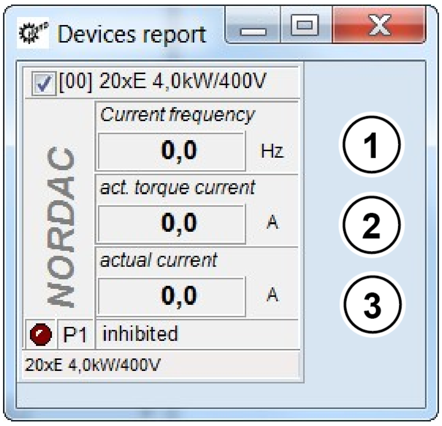
④ **Press the Start button**

⑤ **For certain applications it is advisable to only make one or more rolling recordings instead of individual recordings.**

Fig. 57: Start the scope recording

7.2.3 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. 58: Slip compensation device overview, display settings

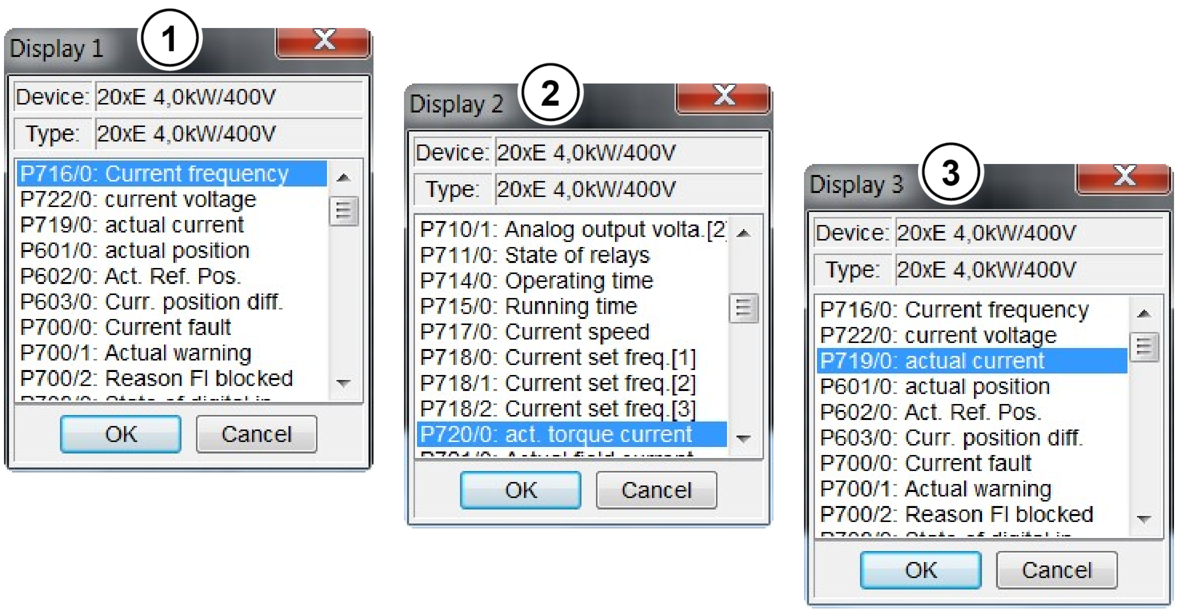


Fig. 59: Slip compensation device overview, display selection

7.3 Slip compensation

Information & instructions

For slip compensation, the slip compensation is changed for the particular optimisation steps.

As the initial for optimisation of the slip compensation, for the **1st optimisation step** the **slip compensation** is set to **80 %** in the parameter **Slip compensation P212**.

Parameter No. [-Array]		Name [Unit]	Factory setting	Setting related to parameter set (P1, ... , P4)
MOTOR DATA/ CHARACTERISTIC CURVE PARAMETERS				
P212	(P)	Slip compensation [%]	100	**80 → optimal**

With constant load, the **Slip compensation P212** must be optimised until the **Torque current ~P720** is at a minimum.

If the **slip compensation is not optimised,** this results in a **higher current consumption** by the **drive unit** for 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 **Slip compensation P212**:

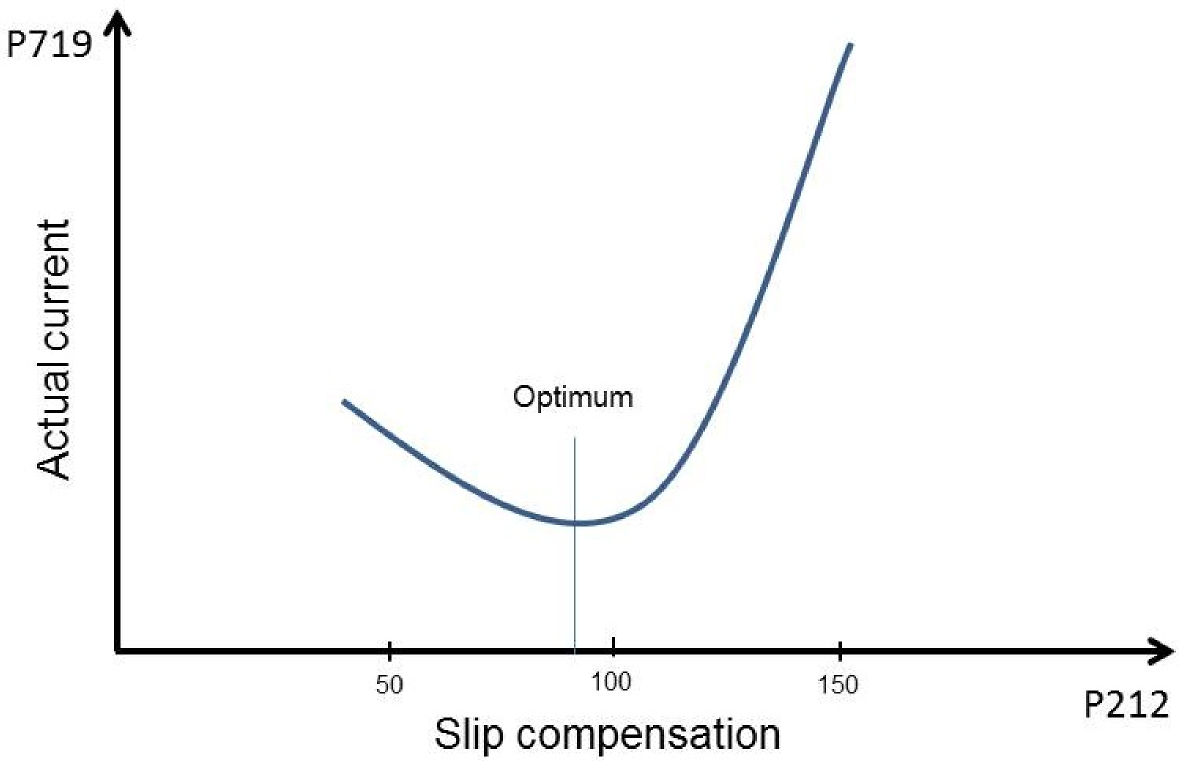


Fig. 60: Diagram for optimum current / slip compensation

The changes to the slip compensation must be checked with the **NORD CON Oscilloscope Function** (📖 4.2 "NORD CON").

In the following illustration, the curve for an **optimally** adjusted slip compensation for a **4.0 kW asynchronous motor** with efficiency class **IE2** is shown as the target.

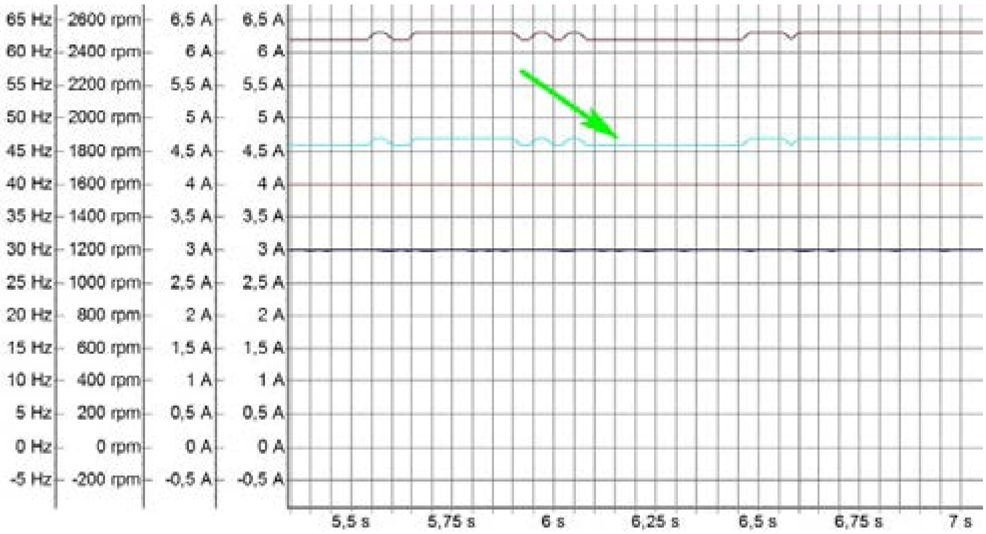


Fig. 61: Example of optimised slip compensation

The **optimum curve** for the **Torque current ~P720** at the operating point for a lifting equipment application under nominal load conditions is illustrated.

The following illustrations show the shape of the curve if the **slip compensation** is set "**too high**" and "**too low**". In the case of a lifting equipment application (lifting a load), a value for the **Slip compensation P212** which is set too high or too low causes and increased Torque current ~P720 or an increase in the current consumption of the motor.

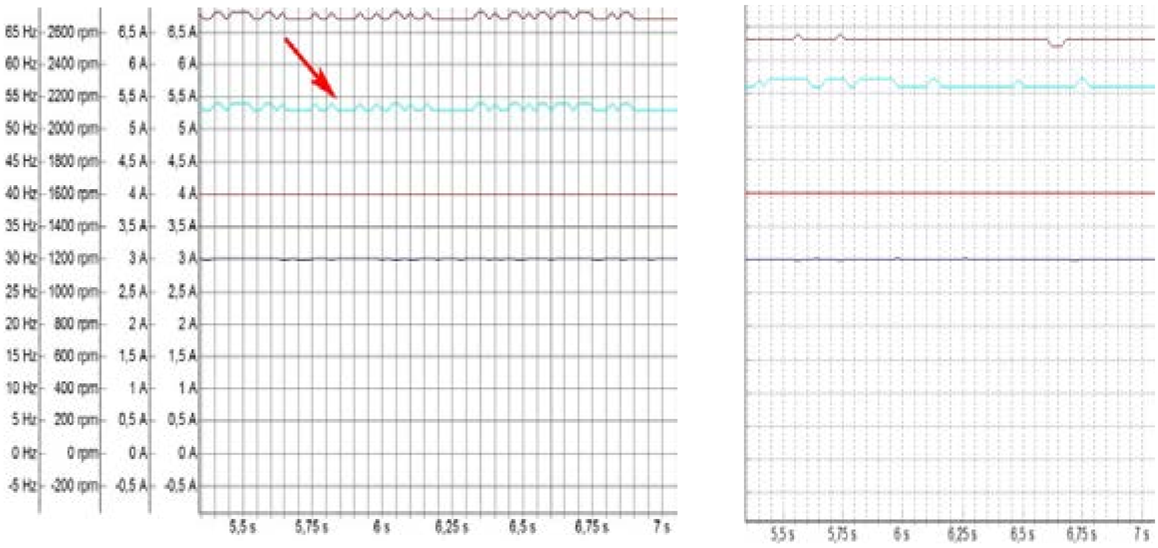


Fig. 62: Example with the slip compensation set too high (right) and too low (left)

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 Slip compensation value

Increase or decrease the parameter for **Slip compensation** in e.g. **5 %, 10 % or 20 % increments** until the **Torque current =P720** during movement applications, or in the case of lifting equipment applications, after the acceleration ramp reaches a **minimum**.

The curve is as illustrated in the first Illustration (🕮 7 "Slip compensation").

The optimum setting of the **Slip compensation P212** is 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 slip compensation:

The objective is to achieve a minimum Torque current ~P720 under nominal load conditions with the "correct" setting of the slip compensation.

- For movement applications, the curve for the **Torque current ~P720** during, or in the case of lifting equipment application, after the acceleration ramp under nominal load should always reach a **minimum**
- The curve for the **Flux current ≈P721** should also be analysed and should not show any abnormalities

Information — **Optimisation steps**

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

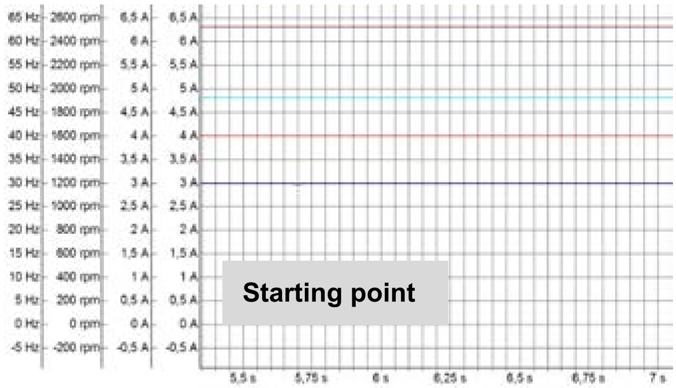
7.4 Optimisation procedure

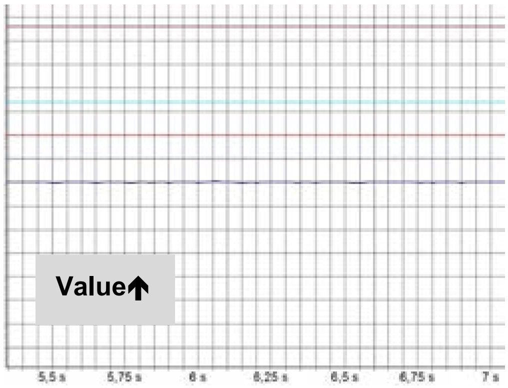
Instructions

The following illustrations show the optimisation process for the slip compensation using the example of a **4.0 kW asynchronous motor** with efficiency class **IE2** on the basis of individual scope recordings.

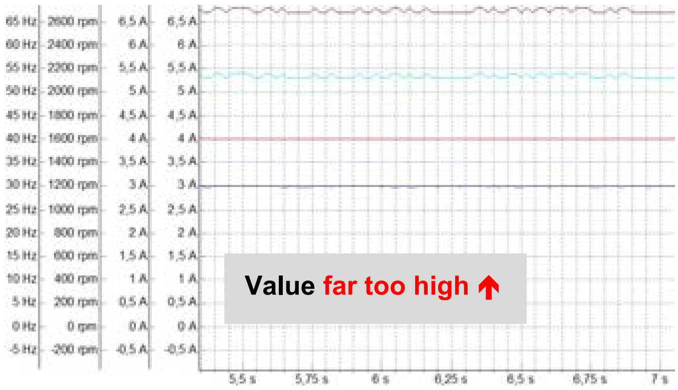
Legend	Set. freq after freq. ramp	~P718[02]	Speed encoder	~P735
	Torque current	~P720	Actual current	=P719

Step	1. Scope recording	2. Scope recording
Parameter settings	P212 = **80 %**	P212 = **100 %**

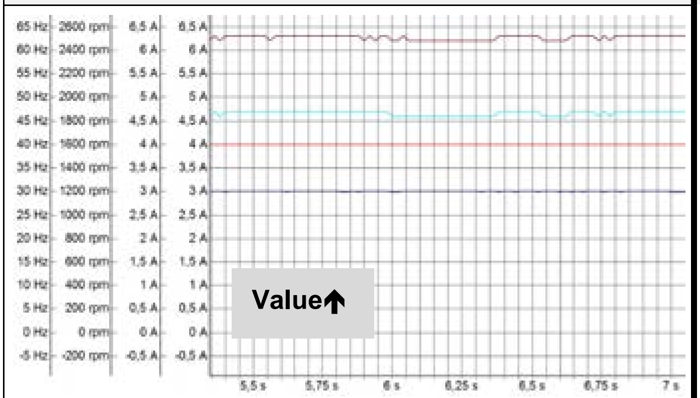




Step	3. Scope recording	4. Scope recording
Parameter settings	P212 = **120 %**	P212 = **60 %**



Step	5. Scope recording	6. Scope recording
Parameter settings	P212 = **90 %**	P212 = **95 %**



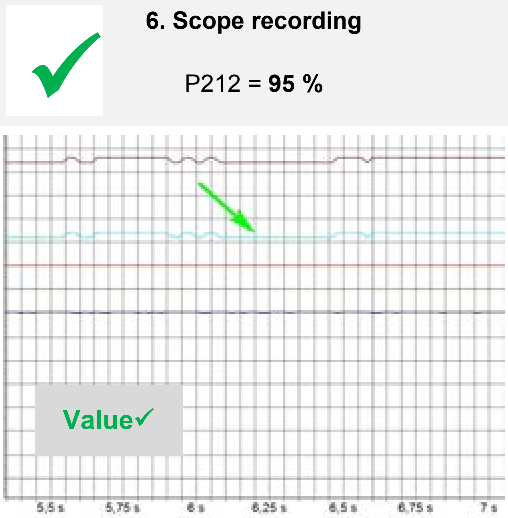


Fig. 63: Slip compensation curve

8 Weak field controller

Step 8

Information

The weak field controller is a **PI controller** and comprises the following three parameters.

- Weak field controller (P318, P319, P320)

The parameter **P-Weak P318** is for the **P component**. The parameter **I-Weak P319** must be used for the **I component**. In addition the "limiting parameter" **Weak Border P320** completes the weak field controller. This parameter is used to specify the speed / voltage range in which the controller weakens the field.

Information — Weak field range

The **weak field range** depends on several factors. These include the:

- Mains voltage
- Motor (type and power)
- Frequency inverter (type and size)
- Load

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 **weak field range** begins at about **≥ 45 Hz**.

IE4 motors should **not** be operated in the **weak field range**!

Field weakening is performed if the voltage can no longer increase proportionally to the speed. In this case the maximum output voltage is reached and the **Voltage components** U_d and U_q are limited. Due to the limitation of the **Voltage component** U_{sd} **~P723** or the parameter **Voltage -d P723** the field is weakened. The **weak field control** is only **effective** in the **weak field range**.

The behaviour of the system in the **transition** to the **weak field range is less favourable** than vice versa, because of which the optimisation must be made when the **speed is increased**.

The following diagrams show several control curves / transient responses which occur after a sudden change of the setpoint for various weak field controllers. Only the various aspects for optimisation of the **Flux current ≈P721** are illustrated.

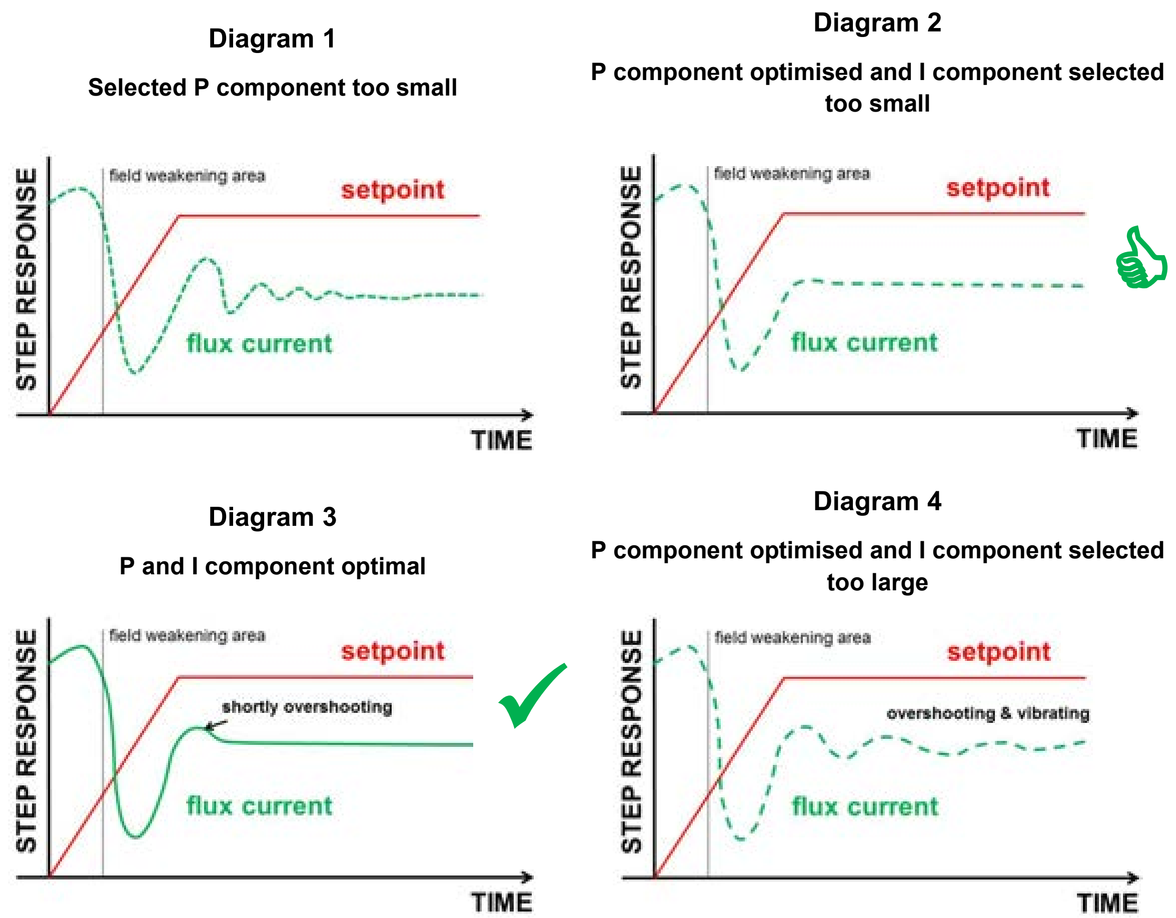


Fig. 64: Control value curves

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.

In the diagrams above, the curves for the control values are shown with short acceleration ramps (**short acceleration times**). For **longer acceleration times**, the curves for the magnetisation current deviate as shown in **Diagram 5**. No curves with severely reducing and then increasing amplitude of the magnetisation current occur.

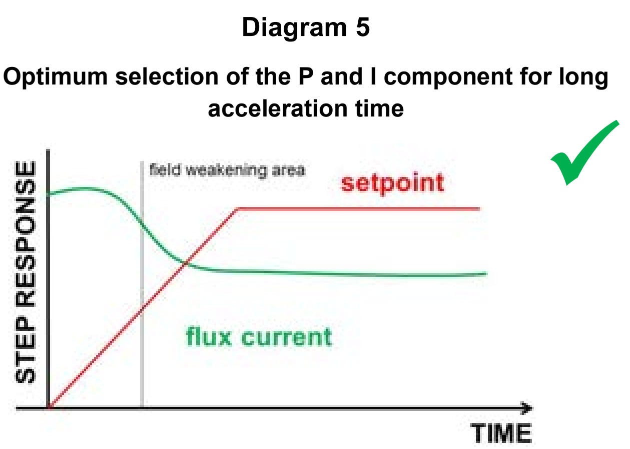


Fig. 65: Control value curves with long acceleration ramp

It is recommended that the following **optimisation steps** are performed to systematically adjust the weak field controller (PI controller):

Overview of optimisation procedure

- Set the **I component** to a **low value**
- Set the **P component** to a **small value** and **increase** it e.g. in **50% increments** until both the **Flux current ≈P721** and the curve for the **Torque current ≈P720** in the **weak field range** have a curve which is as **free from oscillations** as possible.
- Optimum adjustment of the **P component** is achieved if no improvement of the shape of the curve can be obtained by increasing the value. A curve as shown in **Diagram 2** results.
- This is followed by an increase in the **I component** in order to further improve the curve according to the stated criteria.
  Diagram 3 shows the optimised curve, whereby in this diagram, the brief overshoot is slightly exaggerated for clarity. The permissible slight overshoot is caused by the acceleration time which is selected and set.
- If the **I component** is set too large, this can be seen from the **oscillations** in the **Flux current ≈P721** in **Diagram 4**. In this case, the **I component** must be reduced again.
- For the optimisation, the setpoint which is selected for the weak field range must also be taken into account!

Diagram 1 shows the curve if the P components is selected too small. In contrast, **Diagram 5** shows the curve for the actual value with an optimally adjusted P and I component with a long acceleration phase.
For shorter acceleration phases, the curve shown in **Diagram 3** deviates from the curve in Diagram 5 (no overshoot) for the **Flux current ≈P721**.

☞ **The aim is to obtain a curve which as optimal as possible, or which corresponds to the curves for the Flux current ≈P721 as shown in Diagrams 3 and 5, with the "correct" setting for the I and P components.**
A slight overshoot of the Flux current ≈P721 after the setpoint is reached, with a subsequent linear and oscillation-free curve is permissible for short acceleration phases.

The practical implementation for optimisation of a weak field controller is described in Section 🕮 8.4 "Optimisation procedure".

8.1 Further settings

Instructions

For optimisation of the weak field 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)
BASIC PARAMETERS				
P102	(P)	Acceleration time [s]	2.0	**2.0 → 0.3** *
P105	(P)	Maximum frequency [Hz]	50.0 / (60.0)	**50.0 → 100.0** **
P113	(P)	Jog frequency [Hz]	0.0	**0.0 → 75.0**

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

** Note: For testing double the nominal frequency of the motor (see P201)

The ramp time and the maximum frequency must be set under the "**Basic Parameters**" tab in the parameter **Acceleration time P102** and **Maximum frequency P105**.

Information — Application information

The ramp times for the **Acceleration time P102**, the **Maximum frequency P105** and the **setpoint specification** (required speed) result from the **requirements of the application**. When setting the **Acceleration time P102**, care must be taken that the frequency inverter **does not** enter the current limit (Warning **C004** = **Overcurrent measured**).

Information — Setpoint / Weak field range

The **specified setpoint** and the specified **Maximum frequency P105** should correspond to the design range (50 Hz / 87 Hz / 100 Hz **–** characteristic curves).

A setting value which corresponds to the **requirements of the application** should be selected for the **Maximum frequency P105** for optimisation of the weak field controller

The **weak field range** for this application therefore begins above approx **45 Hz** and ends at approx. **100 Hz**.

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

Setting of the **Torque current ≈P720** (**I_{sq}**) and the **Flux current ≈P721** (**I_{sd}**) should be made 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 of e.g. 75 % (with a Maximum frequency P105 of 100 Hz). I.e. in this example (4.0 kW frequency inverter / motor combination) a setpoint frequency of **75 Hz** must be specified.

Information — Optimisation information

To optimise the weak field controller, the **Maximum frequency P105** should be set according to the specific application or the requirements of the application. If this is not defined, for a "pre optimisation"* the maximum frequency should be set to **2x the Nominal frequency P201**!

I.e. for applications with an **extended operating point** (e.g. **100 Hz characteristic curve**) a Maximum frequency P105 of 200 Hz should be set. The **setpoint** (**frequency**) which is to be set should then be e.g. **75 % ≈ 150 Hz**.

The **weak field range** for this application therefore begins above approx. **45 Hz** and ends at approx. **200 Hz**.

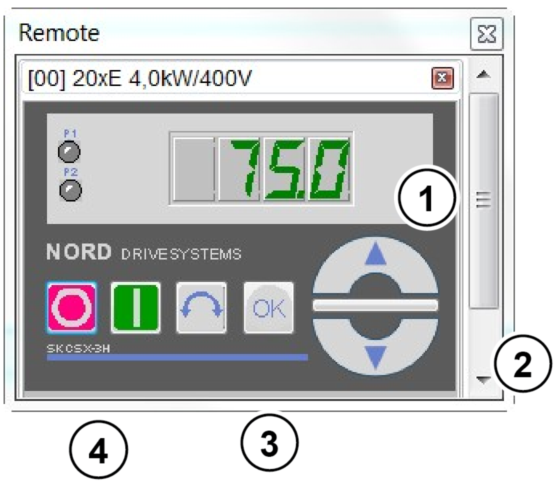
8.2 NORD CON

Information & instructions

Further information about the settings can be obtained from Section 🕮 5.2 "NORD CON" and the following.

8.2.1 Remote control

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



(1) **Set the setpoint to 75 %, i.e.set the setpoint frequency to 75 Hz**

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

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

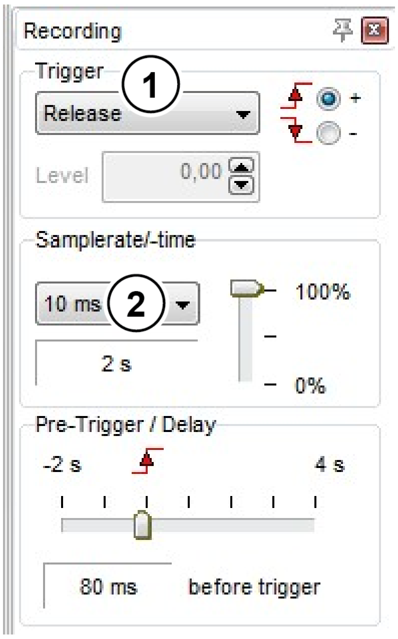
(4) **Press the Enable button**

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

Fig. 66: Remote control of the weak field control, setpoint and enabling

8.2.2 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 🕮 8.4 "Optimisation procedure"!

Fig. 67: Oscilloscope settings for trigger and scan rate / scan duration

Fig. 68: Resolution settings for the time axis, comment examples

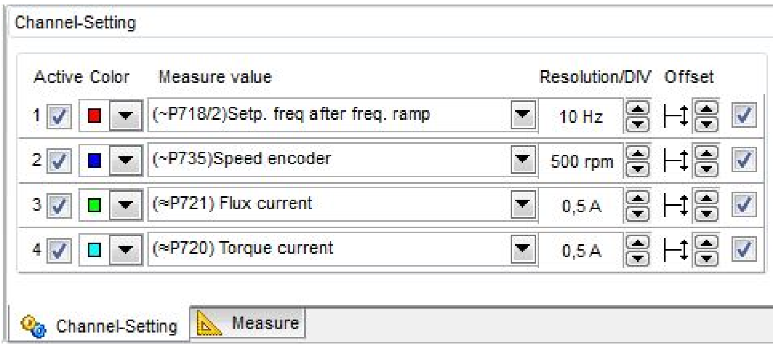
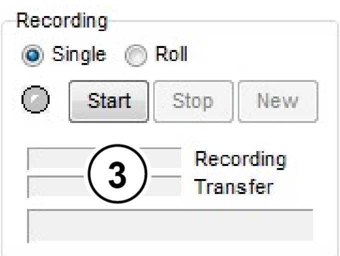


Fig. 69: Oscilloscope channel settings for the four measurement values



③ **Press the Start button**

Fig. 70: Start the scope recording

8.3 Weak field controller

Information & instructions

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

As the initial for optimisation of the weak field controller, for the **1st optimisation step** the **P component** (P318) should be set to **50 %** and the **I component** (P319) should be set to **5 % / ms**.

Parameter No. [-Array]		Name [Unit]	Factory setting	Setting related to parameter set (P1, ... , P4)
Speed control				
P318	(P)	P-Weak [%]	150	**150 → 50**
P319	(P)	I-Weak [%/ms]	20	**20 → 5**

The changes to the control parameters must be checked with the **NORD CON Oscilloscope Function** (8.2.2 "Oscilloscope").

Information — Acceleration time

With large acceleration times, a linearisation of the two currents in the weak field range due to the setting of the weak field controller is clearly apparent. For small run up times, true linearisation of the curves is not possible. Because of this, in this case the oscillations of the current curves recorded with the oscilloscope should be reduced by optimisation of the weak field control parameters.

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

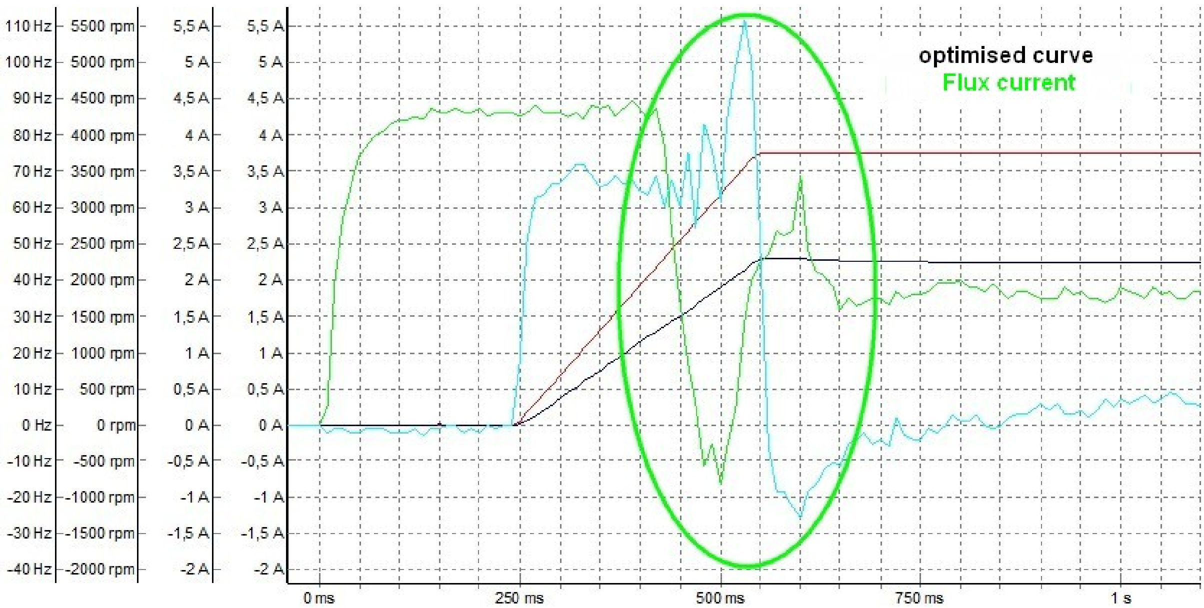


Fig. 71: Example of an optimised weak field controller curve

An almost **oscillation-free curve** for the **Flux current ≈P721** in the weak field range (> 45 Hz) can be seen, with an overshoot after the setpoint has been reached as well as a linear increase of the **Speed encoder ~P735**.

In addition, the influence of the **Flux delay P558** at the start of the scope recording.

The following illustration shows the form of the curve of the **I component** of the weak field control is set **too high**. After the setpoint has been reached, the value of the **I-Weak P319** which is set too high causes oscillation of the **Flux current ≈P721** and the **Torque current ≈P720**.

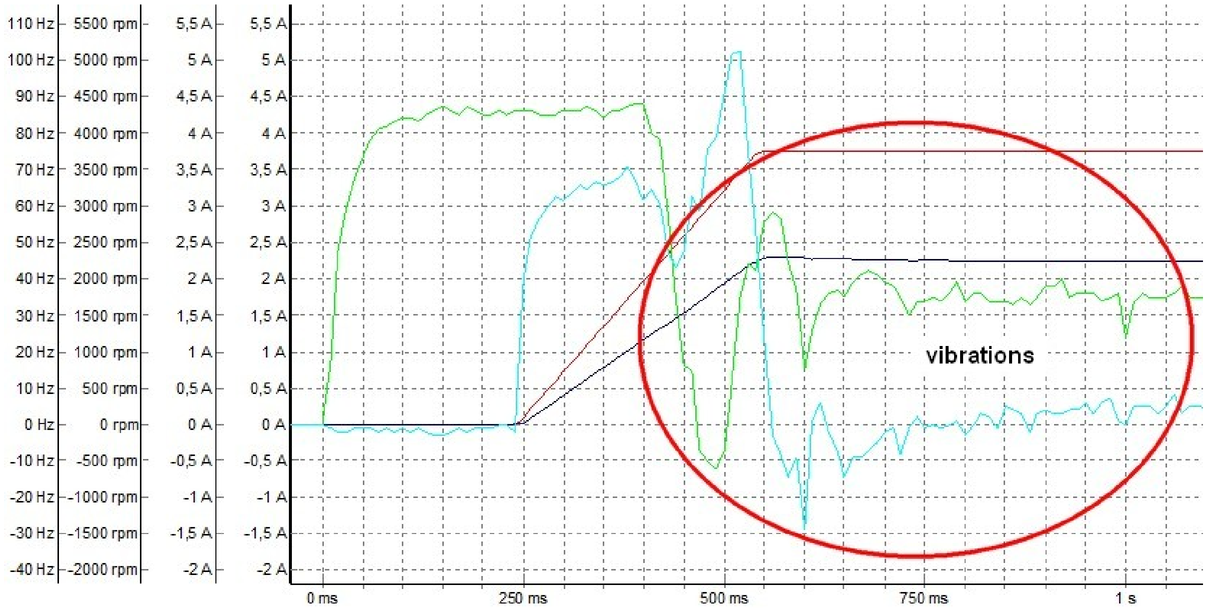


Fig. 72: Example with an excessive I component of the weak field controller

The next optimisation steps and oscilloscope 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.

8.3.1 P component of the weak field controller

Increase the parameter for the **P component** in **50 % increments** until, if possible, from the start of the weak field range (> 45 Hz) the **Flux current ≈P721** initially has a **steeply reducing curve** which rises **steeply again** shortly before the setpoint is reached.

The curve is as illustrated in **Diagram 2** (see 📖 8 "Weak field controller").

The upper adjustment limit of the **P-Weak P318** 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 "low oscillation" current curve). A value of the **P component** which is set "**too high** does not have any further effect on the **Flux current ≈P721**.

If the **P component** for a selected speed (setpoint specification) is set **too high**, this is not visible in the curve for the **Flux current ≈P721** in the transition to the weak field range and after the setpoint has been reached. However, it may be apparent due to an associated **noise**.

As a **guide value** the optimised P component of the **weak field control** should be in the range from **200 %** to **250 %**.

8.3.2 I component of the weak field control

Beginning from the set starting value [5 % / ms] increase the **I component** in small **increments** (e.g. **5 % / ms**) until an approximately **oscillation-free curve** for the **Flux current ≈P721 no longer results**. After the setpoint has been reached, there should only be a single overshoot of the **Flux current ≈P721** after which there should be a **linear** and **oscillation-free curve**.

The curve is as illustrated in **Diagram 3** or **Diagram 5** see 🕮 8 "Weak field controller".

The upper adjustment limit of the **I-Weak P319** is reached, when a further increase of the **I component** results in further oscillations in the **Flux current ≈P721** curve. In this case, the **I component** must be reduced again.

An **I component** which is set "**too high**" may cause oscillations of the **Torque current ≈P720** after the setpoint has been reached.

If the **I component** for a selected speed (setpoint specification) is set **too high**, this is apparent from the oscillation of the **Flux current ≈P721** in the transition to the weak field range and after the setpoint has been reached and possible by the associated production of **noise**.

8.3.3 Criteria

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

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

- In the weak field range, a clear increase in thes **Torque current ≈P720** and a corresponding reduction of the **Flux current ≈P721** should be evident
- The curve for the **Flux current ≈P721** during the acceleration phase should correspond to Diagram 3 or Diagram 5 (🕮 8 "Weak field controller"), depending on the acceleration time
- Oscillation-free curve for the **Torque current ≈P720** and **Flux current ≈P721** in the weak field range after reaching the setpoint value, i.e. only slight oscillations in the two current curves after the acceleration phase; undesirable oscillations are shown in Diagram 4
- No "noise production" in the transition to the weak field range when the drive unit is in operation (if necessary, reduce the P component).

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.

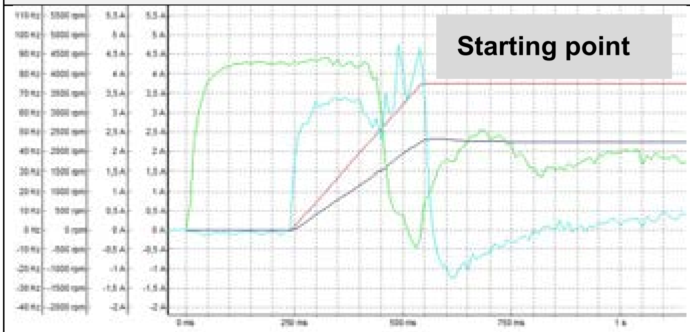
8.4 Optimisation procedure

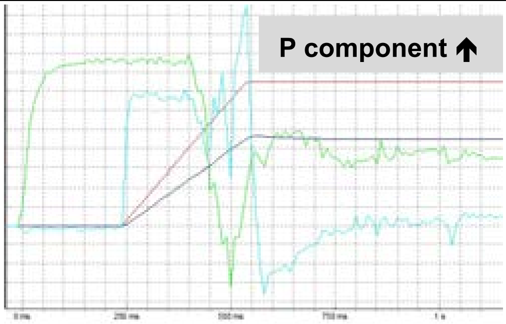
Instructions

The following illustrations show the optimisation process for the weak field controller using the example of a **4.0 kW asynchronous motor** with efficiency class **IE2** on the basis of individual scope recordings.

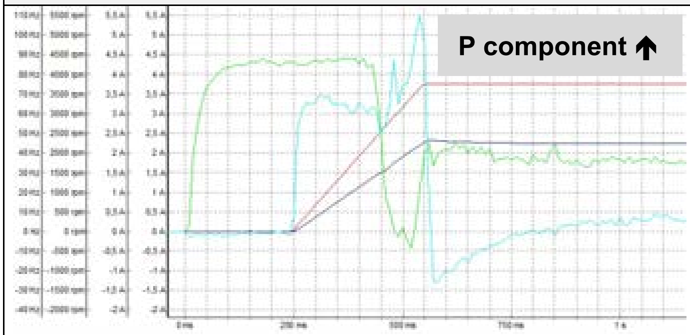
Legend	Setpoint	~P718[02]	Speed encoder	~P735
	Magnetisation current	≈P721	Torque current	≈P720

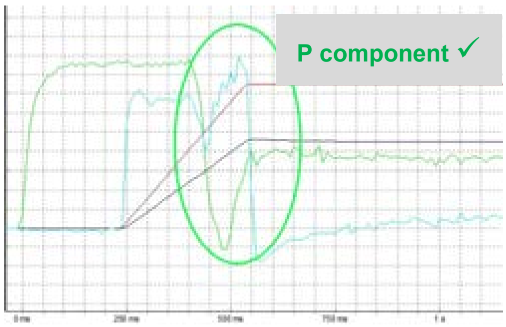
Step	1. "P" scope recording	2. "P" scope recording
Parameter settings	P318 = **50 %** P319 = **5 % / ms**	P318 = **100 %** P319 = 5 % / ms



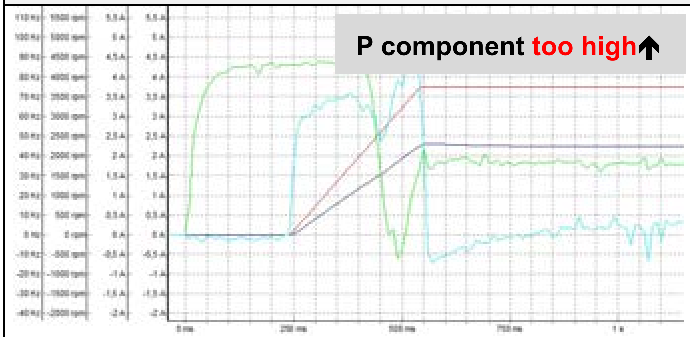


Step	4. "P" scope recording	5. "P" scope recording
Parameter settings	P318 = **200 %** P319 = 5 % / ms	P318 = **250 %** P319 = 5 % / ms





Step	6. "P" scope recording	12. "P" scope recording
Parameter settings	P318 = **300 %** P319 = 5 % / ms	P318 = **600 %** P319 = 5 % / ms



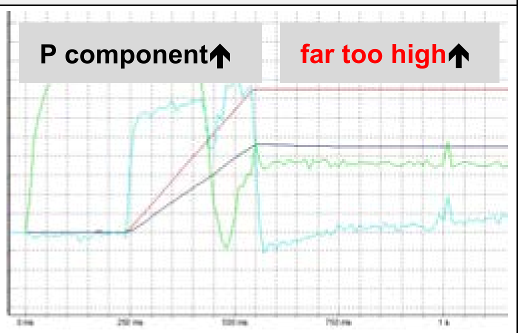


Fig. 73: Curve for the P component of the field weakening control

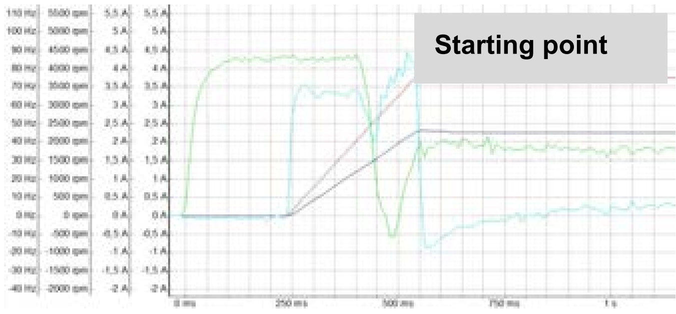
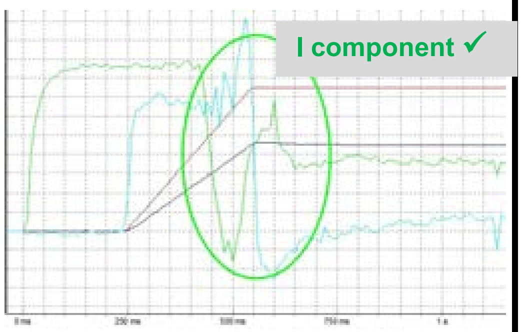
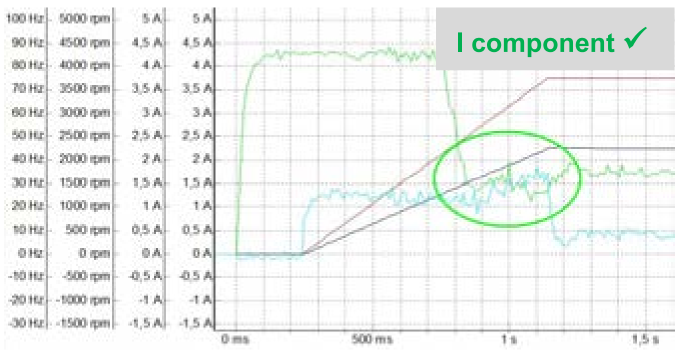
Legend		
	Setpoint ~P718[02] Magnetisation current ≈P721	Speed encoder ~P735 Torque current ≈P720
Step **Parameter settings**	**1. "I" scope recording** P318 = **250 %** P319 = **5 % / ms**	✓ **2. "I" scope recording** P318 = **250 %** P319 = **10 % / ms**
		
Step **Parameter settings**	**3. "I" scope recording** P318 = **250 %** P319 = **15 % / ms**	**6. "I" scope recording** P318 = 250 % P319 = **30 % / ms**
		
The following "I" scope recordings are made with a larger acceleration time (1.2 sec).		
Step **Parameter settings**	✓ **1. "I" scope recording** P318 = **350 %** P319 = **10 % / ms**	**2. "I" scope recording** P318 = **350 %** P319 = **20 % / ms**
		

Fig. 74: Curve for the I component of the weak field control

9 Parameter lists

Information

9.1 Basic Commissioning

Parameter List

Device Name: Offline parameterize
Device Type: 20xE 4,0kW/400V
Database: Base commissioning.ndbx*
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	0,08	2	2	2	s
Motor data							
202	0	Nominal speed	1440	1440	1440	1440	rpm
203	0	Nominal current	8,02	8	8	8	A
206	0	Cos phi	0,83	0,83	0,83	0,83	
208	0	Stator resistance	3,25	3,26	3,26	3,26	Ohm
212	0	Slip compensation	80	100	100	100	%
Speed control							
300	0	Servo Mode	On [1]	Off [0]	Off [0]	Off [0]	
301	0	Incremental encoder	2048 [5]				
Control clamps							
420	1	digit inputs[2]	No function [0]				
420	2	digit inputs[3]	No function [0]				

Parameter Number 12

Legend

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

[ ] The value is invalid

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Fig. 75: Parameter list for basic commissioning

9.2 Current control

Parameter List

Device Name : Offline parameterize
Device Type : 20xE 4,0kW/400V
Database : optimized torque & field controller.ndbx
Filter: release: Off, no standard value: On, Info Parameter: No

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	0,08	2	2	2	s
Motor data							
202	0	Nominal speed	1440	1440	1440	1440	rpm
203	0	Nominal current	8,02	8	8	8	A
206	0	Cos phi	0,83	0,83	0,83	0,83	
208	0	Stator resistance	3,25	3,26	3,26	3,26	Ohm
212	0	Slip compensation	80	100	100	100	%
Speed control							
300	0	Servo Mode	On [1]	Off [0]	Off [0]	Off [0]	
301	0	Incremental encoder	2048 [5]				
312	0	Torque curr. ctrl. P	350	200	200	200	%
313	0	Torque curr. ctrl. I	30	125	125	125	%/ms
315	0	Field curr. ctrl. P	350	200	200	200	%
316	0	Field curr. ctrl. I	30	125	125	125	%/ms
Control clamps							
420	1	digit inputs[2]	No function [0]				
420	2	digit inputs[3]	No function [0]				
Extra functions							
505	0	Absolute mini. freq.	0	2	2	2	Hz
558	0	Flux delay	0	1	1	1	ms

Parameter Number 18

Legend

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

[ ] The value is invalid

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Fig. 76: Parameter list for optimised current control

9.3 Speed control

Parameter List

Device Name : Offline parameterize
Device Type : 20xE 4,0kW/400V
Database : optimized speed controller.ndbx
Filter: release: Off, no standard value: On, Info Parameter: No

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	0,08	2	2	2	s
113	0	Jog frequency	35	0	0	0	Hz
Motor data							
202	0	Nominal speed	1440	1440	1440	1440	rpm
203	0	Nominal current	8,02	8	8	8	A
206	0	Cos phi	0,83	0,83	0,83	0,83	
208	0	Stator resistance	3,25	3,26	3,26	3,26	Ohm
212	0	Slip compensation	80	100	100	100	%
Speed control							
300	0	Servo Mode	On [1]	Off [0]	Off [0]	Off [0]	
301	0	Incremental encoder	2048 [5]				
310	0	Speed Ctrl P	400	100	100	100	%
311	0	Speed Ctrl I	30	20	20	20	%/ms
312	0	Torque curr. ctrl. P	350	200	200	200	%
313	0	Torque curr. ctrl. I	30	125	125	125	%/ms
315	0	Field curr. ctrl. P	350	200	200	200	%
316	0	Field curr. ctrl. I	30	125	125	125	%/ms
Control clamps							
420	1	digit inputs[2]	No function [0]				
420	2	digit inputs[3]	No function [0]				
Extra functions							
505	0	Absolute mini. freq.	0	2	2	2	Hz

Parameter Number 20

Legend

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

[ ] The value is invalid

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Fig. 77: Parameter list for optimised current and speed control

9.4 Position control

Parameter List

Device Name : Offline parameterize
Device Type : 20xE 4,0kW/400V
Database : optimized position controller.ndbx
Filter: release: Off, no standard value: On, Info Parameter: No

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
Motor data							
202	0	Nominal speed	1440	1440	1440	1440	rpm
203	0	Nominal current	8,02	8	8	8	A
206	0	Cos phi	0,83	0,83	0,83	0,83	
208	0	Stator resistance	3,25	3,26	3,26	3,26	Ohm
212	0	Slip compensation	80	100	100	100	%
Speed control							
300	0	Servo Mode	On [1]	Off [0]	Off [0]	Off [0]	
301	0	Incremental encoder	2048 [5]				
310	0	Speed Ctrl P	400	100	100	100	%
311	0	Speed Ctrl I	30	20	20	20	%/ms
312	0	Torque curr. ctrl. P	350	200	200	200	%
313	0	Torque curr. ctrl. I	30	125	125	125	%/ms
315	0	Field curr. ctrl. P	350	200	200	200	%
316	0	Field curr. ctrl. I	30	125	125	125	%/ms
Control clamps							
420	1	digit inputs[2]	No function [0]				
420	2	digit inputs[3]	No function [0]				
480	10	Funct. BusIO In Bits[11]	Bit 0 PosArr / Inc [55]				
Extra functions							
501	0	Inverter name	Regleroptimierung				
505	0	Absolute mini. freq.	0	2	2	2	Hz
509	0	Source Control Word	USS [2]				
Positioning							
600	0	Position Control	lin.ramp (setfreq.) [2]	Off [0]	Off [0]	Off [0]	
611	0	P Pos. Control	35				%
613	0	position[1]	10				rev

Parameter Number 26

Legend

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

[ ] The value is invalid

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Fig. 78: Parameter list for optimised current, speed and position control

9.5 Slip compensation

Parameter List

Device Name : Offline parameterize
Device Type : 20xE 4,0kW/400V
Database : optimized slip compensation.ndbx
Filter: release: Off, no standard value: On, Info Parameter: No

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
113	0	Jog frequency	40	0	0	0	Hz
Motor data							
202	0	Nominal speed	1440	1440	1440	1440	rpm
203	0	Nominal current	8,02	8	8	8	A
206	0	Cos phi	0,83	0,83	0,83	0,83	
208	0	Stator resistance	3,25	3,26	3,26	3,26	Ohm
212	0	Slip compensation	95	100	100	100	%
Speed control							
300	0	Servo Mode	On [1]	Off [0]	Off [0]	Off [0]	
301	0	Incremental encoder	2048 [5]				
310	0	Speed Ctrl P	400	100	100	100	%
311	0	Speed Ctrl I	30	20	20	20	%/ms
312	0	Torque curr. ctrl. P	350	200	200	200	%
313	0	Torque curr. ctrl. I	30	125	125	125	%/ms
315	0	Field curr. ctrl. P	350	200	200	200	%
316	0	Field curr. ctrl. I	30	125	125	125	%/ms
Control clamps							
420	1	digit inputs[2]	No function [0]				
420	2	digit inputs[3]	No function [0]				
Extra functions							
501	0	Inverter name	Regleroptimierung				
505	0	Absolute mini. freq.	0	2	2	2	Hz
Positioning							
600	0	Position Control	lin.ramp (setfreq.) [2]	Off [0]	Off [0]	Off [0]	
611	0	P Pos. Control	35				%
613	0	position[1]	10				rev

Parameter Number 25

Legend

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

[ ] The value is invalid

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Fig. 79: Parameter list for optimised current, speed, position control and slip compensation

9.6 Weak field control

Parameter List

Device Name : Offline parameterize
Device Type : 20xE 4,0kW/400V
Database : optimized weak controller
Filter: release: Off, no standard value: On, Info Parameter: No

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	100	50	50	50	Hz
113	0	Jog frequency	75	0	0	0	Hz
Motor data							
202	0	Nominal speed	1440	1440	1440	1440	rpm
203	0	Nominal current	8,02	8	8	8	A
206	0	Cos phi	0,83	0,83	0,83	0,83	
208	0	Stator resistance	3,25	3,26	3,26	3,26	Ohm
212	0	Slip compensation	95	100	100	100	%
Speed control							
300	0	Servo Mode	On [1]	Off [0]	Off [0]	Off [0]	
301	0	Incremental encoder	2048 [5]				
310	0	Speed Ctrl P	400	100	100	100	%
311	0	Speed Ctrl I	30	20	20	20	%/ms
312	0	Torque curr. ctrl. P	350	200	200	200	%
313	0	Torque curr. ctrl. I	30	125	125	125	%/ms
315	0	Field curr. ctrl. P	350	200	200	200	%
316	0	Field curr. ctrl. I	30	125	125	125	%/ms
318	0	P-Weak	250	150	150	150	%
319	0	I-Weak	10	20	20	20	%/ms
Control clamps							
420	1	digit inputs[2]	No function [0]				
420	2	digit inputs[3]	No function [0]				
480	10	Funct. BusIO In Bits[11]	Bit 0 PosArr / Inc [55]				
Extra functions							
501	0	Inverter name	Regleroptimierung				
505	0	Absolute mini. freq.	0	2	2	2	Hz
Positioning							
600	0	Position Control	lin.ramp (setfreq.) [2]	Off [0]	Off [0]	Off [0]	
611	0	P Pos. Control	35				%
613	0	position[1]	10				rev

Parameter Number 28

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Fig. 80: Parameter list for all optimised controllers, plus weak field controller

10 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.

10.1 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

10.2 Technical Information / Data Sheets

10.2.1 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_8.5820.0H10.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_8.5820.0H30.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_8.5820.0H40.XXXX.5093.XXXX.pc

Table 8: TIs – Incremental encoder (IG)

10.2.2 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_8.5888.0452.2102.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_8.5888.0400.2102.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 9: TIs - CANopen absolute encoder (AG)

10.2.3 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 10: Options and accessory components

11 Appendix

11.1 Abbreviations

AG	Absolute encoder	**IG**	Incremental encoder
ASM	Asynchronous machine / motors	**IO**	Input / Output
BG	Size	**PI controller**	Proportional-integral controller
CFC	Current Flux Control	**POSICON**	Positioning control
DIN	Digital input	**P**	Parameter
ENC	Special encoder extension	**SK**	Schlicht & Küchenmeister
SCD	Schematic circuit diagram	**SSI**	Synchronous Serial Interface
FI	Frequency inverter	**TI**	Technical Information / Data Sheet (Data sheet for NORD accessories)
HTL	High Transistor Logic		
IE1	Efficiency class of standard motors	**TTL**	Transistor-Transistor Logic
IE2	Efficiency class of motors with higher efficiency	**VFC**	Voltage Flux Control
IE3	Efficiency class of motors with even higher efficiency, Premium		
IE4	Efficiency class of motors with even higher efficiency, e.g. synchronous motors		

Notes

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