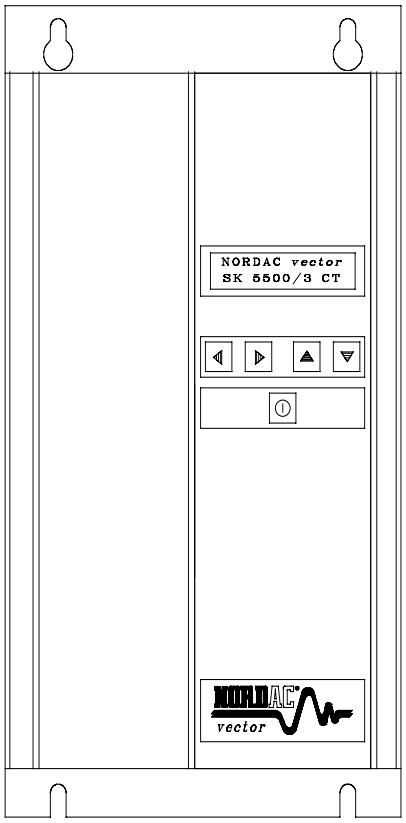
Supplementary Operating Instructions

NORDAC *vector* Frequency Inverter

With Positioning Card



BU 4010/00 GB
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Getriebebau NORD

GmbH & Co.KG

Rudolf-Diesel-Str. 1 · 22941 Bargteheide
P.O. Box 12 62 · 22934 Bargteheide
Phone: 04532/401 - 0 · Telex: 261505 · Fax : 04532/401 - 555

NORDAC *vector* Frequency Inverter

Instructions for the safety and use of converters feeding drives

(as provided in the 73/23/EEC low-voltage directive)

1. General

Depending on their type of enclosure, driving current converters may have live, bare, in some cases even moving or rotating parts as well as hot surfaces during operation.

Inadmissibly removing the required covers, improper use, incorrect installation or handling can be dangerous and may lead to serious damage to persons or to property.

See the documentation for more detailed information.

Any transport, installation, starting-up or maintenance work shall be performed by properly qualified, skilled and competent personnel (IEC 364 or CENELEC HD 384 respectively or DIN VDE 0100 and IEC 664 or DIN VDE 0110 and national accident prevention regulations to be observed).

Qualified, skilled personnel as mentioned in these basic safety instructions is understood to refer to persons who are familiar with the installation, assembly, setting-up and operation of the product and who have the qualifications required for the job of which they are in charge.

2. Intended use

Driving current converters are components designed to be integrated into electrical installations or machinery.

If the converters are installed in machines, they must not be put into operation (in other words, operation as intended by the manufacturer must not begin) until it has been established that the machine in question actually meets the requirements mentioned in the EC directive 89/392/EEC (Directive For Machines); EN 60204 is to be observed.

The device must not be put into operation (i.e. operation as intended by the manufacturer must not be started) unless the stipulations of the EMC directive (89/336/EEC) are fulfilled.

Driving current converters meet the requirements stated in the low-voltage directive 73/23/EEC. Likewise the accorded standards of the series prEN 50178/DIN VDE 0160 in conjunction with EN 60439-1/ VDE 0660 Part 500 and EN 60146/ VDE 0558 are applied to the driving current converters.

Refer to the rating plate and the documentation for details on technical data and connecting requirements and do not fail to observe them and to follow instructions.

3. Transport, storage

Follow the instructions for transport, storage, and proper handling.

Ensure climatic conditions as specified in prEN 50178.

4. Installation

The devices must be installed and cooled as directed in the relevant documentation.

The driving current converters must be protected against inadmissible stress. Special care should be taken not to bend components or to change the spacing of insulation during transport and handling. Do not touch electronic components and contacts.

Driving current converters contain electrostatically sensitive components which are easily damaged through improper handling. Electrical components must not be damaged or destroyed mechanically (potential health risks!).

5. Electrical connection

Follow the applicable national accident prevention rules (e.g. VBG 4) when working on driving current converters while they are live.

Electrical installation is to be performed in accordance with applicable rules and regulations (e.g. regarding conductor cross sections, fusing, PE connection). Apart from these, more instructions may be mentioned in the documentation.

Recommendations for meeting EMC standards in installation - for instance with regard to screening, earthing, filter arrangement and the routing of lines - are found in the converter documentation. CE-marked driving current converters are always subject to such instructions as well. It is the responsibility of the machine or plant manufacturer to ensure that the limit values stipulated by EMC legislation are duly met.

6. Operation

It may be necessary to provide facilities in which driving current converters are installed with additional monitoring and protecting devices to satisfy the applicable safety regulations, e.g. the law on technical working materials, accident prevention regulations etc. Modifications of the driving current converters by means of the operating software are allowed.

Do not touch live parts of the device or power terminals right after the converter has been disconnected from the supply voltage as capacitors may still be charged. The information plates on the driving current converter will give you precise details on the subject.

Keep all covers closed during operation.

7. Service and maintenance

As described in the manufacturer's documentation.

Do keep these Safety Instructions for future reference!

Please note: Validity of these Supplementary Operating Instructions is contingent on the complementary use of the basic Operating Instructions for the NORDAC vector frequency inverter which are also enclosed with the unit delivered.

1 General

NORDAC *vector* frequency inverters are voltage source d.c. link inverters with microprocessor electronics designed to control the speed of three-phase motors.

Providing an **incremental encoder** on the motor and/or an **absolute encoder** on the output shaft along with using the ***posicon*** positioning card will enhance the standard components so as to constitute a drive system capable of performing positioning tasks in a highly precise manner.

- 252 positions can be programmed to be approached by the unit controlled
- Position control in the destination window; the unit controlled will retain the desired position even with substantial fluctuations of the load.
- Distance calculation ensures that the driven assembly is moved into the destination position accurately and within the shortest possible time
- Control options not only provide for setting positions but also for presetting the step widths required for moving from one position to the next (position increments)
- Also possible: transmission of setpoint positions via the RS485 interface.

Designed to be plugged into the control board, the add-on positioning card fits into the standard housing of the frequency inverter so that the overall size of the device is not increased.

The positioning card is equipped with a processor of its own which will determine the speed setpoint the inverter will have to ensure.

The parameters which are required for distance calculation are inserted into the existing inverter menu structure as an additional menu group.

The position setpoints can be applied to the six digital inputs which are additionally provided on the positioning card, or transmitted via the USS protocol or another bus system respectively. Setpoints can also be fed to the system using the synchronous serial interface.

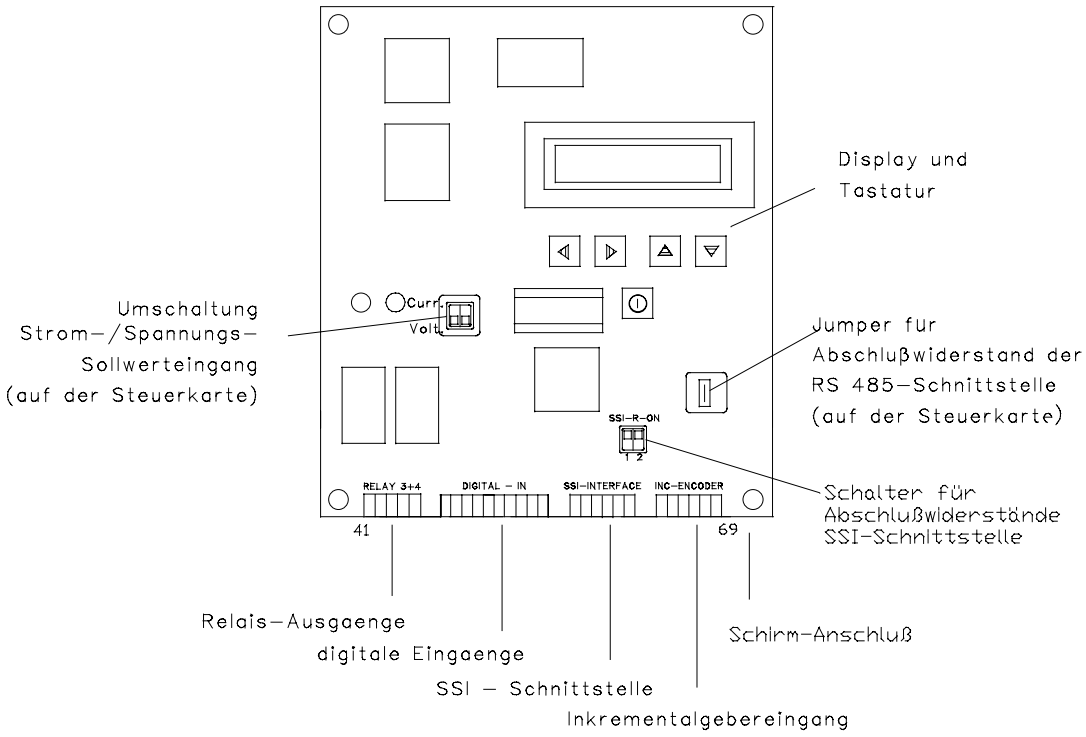
By switching from one parameter set to another, the operator may quit speed control in order to access distance calculation or position control, or vice versa.

2 Installation procedure

2.1 Position control card

Connect control lines to: - the 29-pin Posicon card terminal strip which is subdivided into 4 blocks

Display and operating buttons: - are permanently soldered onto the Posicon card



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2.2 Connection

To connect the electrical lines the device must be opened. The housing cover is attached to the housing with four screws. Be sure to observe the safety and installation instructions while you are working.

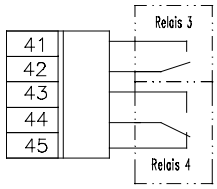
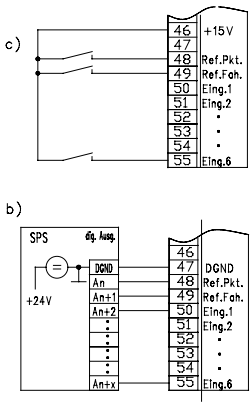
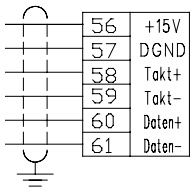
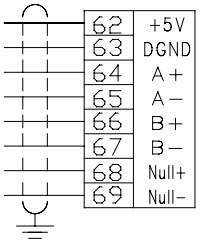
The connection lines are fed into the device from below and then connected to the power and control terminal strip. To facilitate connection the cable entry plate which is secured with a screw may be removed altogether. Please remember to fit the plate back into place, otherwise the specified degree of protection will no longer apply.

Important note: Always provide an output choke when using the Posicon positioning card!

Control, power, and motor lines should be taken through separate openings in the cover plate. Cable grips which are inserted into the cable entry plate will relieve the pull on the cables. For EMC limit values to be ensured, the motor and power cables should be shielded and suspended on the entry plate with metal cable clamp screws. Installation of the mains leads must be carried out in accordance with local regulations for the installation of electrical systems.

The connection cross section should be 1.5 mm^2 for the digital inputs and outputs and 2.5 mm^2 for the relay outputs. Control lines and motor leads are laid separately. Use screened cables to connect incremental or absolute encoders. **Plug the encoder cable screen into the rectangular connector on the right mounting screw of the Posicon card – <u>do not</u> connect it to the cable entry plate**. The encoder cables should preferably be laid without any additional clamping**.**

2.3 Posicon terminal strip

Terminal	Function	Technical information	Circuit layout/ Suggested circuit
(41) (42) (43) (44) (45)	Multifunction relay 3 output 0 (make contact) Multifunction relay 3 output 1 Multifunction relay 4 output 0 (make contact) Multifunction relay 4 output 1 Multifunction relay 4 output 2 (break contact)	110V~ / 60V= 0.8A max.	
(46) (47)	Digital input supply voltage Reference potential for digital inputs (GND-D)	+15V 50mA max.	
	Potentials are identical with those of the standard control board, terminal (13, +15V) and (15, GND)		
(48) (49) (50) (51) (52) (53) (54) (55)	Reference point Reference point tracking operation / Reset Position setpoint via digital input 1 (→ bit 5) "MSB“ Position setpoint via digital input 2 (→ bit 4) .. Position setpoint via digital input 3 (→ bit 3) .. Position setpoint via digital input 4 (→ bit 2) .. Position setpoint via digital input 5 (→ bit 1) .. Position setpoint via digital input 6 (→ bit 0) "LSB“	low level: 0...3V high level: 13...30V positive logic input resistance approx. 5.7kΩ	
(56) (57) (58) (59) (60) (61)	Absolute encoder supply voltage Ref. potential for absolut encoder (GND-A) Clock rate + Clock rate - Data + Data -	+15V 250mA max. SSI interface Configurable to betw. 8 and 24 bits TTL-compatible signals for drivers as per EIA RS485/422	
(62) (63) (64) (65) (66) (67) (68) (69)	Incremental encoder supply voltage Ref. potential for incremental encoder (GND-I) Track A + Track A - Track B + Track B - Zero + Zero -	+5V 250mA max. TTL-compatible signals for drivers as per EIA RS 422	

<u>NOTE</u>: As the GND terminals of the control board and those of the positioning card are interconnected, the <u>same</u> potential must be applied to them all!

2.4 Incremental encoder connection

Input for an incremental encoder with two tracks and a zero track, with TTL-compatible signals for drivers according to EIA RS 422. Maximum current input to the incremental encoder must not exceed 250mA. Supply voltage for the encoder is 5V.

The number of graduation marks per revolution may amount to either 512, 1024, 2048 or 4096 increments. A menu item is provided where the respective number can be adjusted (cf. Additional Functions, Operating Instructions of the basic unit).

If very long cables are used, or if the motor speed exceeds 1500 1/min, the encoder should not have more than 2048 graduation lines/revolution.

With more than average cable lengths the cross sectional area must be large enough to ensure that voltage won't drop too much from one end of the cable to the other. This is especially important with regard to the supply cables where the cross section can be enlarged for instance by connecting several wires in parallel. Alternatively incremental encoders with a higher supply voltage requirement could be used. In that case the voltage for the incremental encoder should come from a separate source however.

The screen of the encoder cable is connected to the rectangular connector (AMP-type) on the Posicon card.

Function		Colour (with incremental encoder 660)	Input terminals on the NORDAC *vector* Posicon
5 V supply	+5V	Red	62
0 V supply	DGND	Blue	63
Track A	A+	White	64
Track A inverse	A-	Brown	65
Track B	B+	Pink	66
Track B inverse	B-	Black	67
Track 0	ZERO+	Violet	68
Track 0 inverse	ZERO-	Yellow	69
Screen		Screen	Flat cable connector

2.5 Absolute encoder connection

Input for absolute encoder with Gray code and SSI interface. Signals are TTL-compatible in accordance with EIA RS 422. The inverter will provide the encoder with a supply voltage of 15V. The resolution per revolution, the maximum number of revolutions or alternatively the length of the transmitted word (8 – 24 bits) can be set in the corresponding menu parameters.

The absolute encoder should be installed on the shaft so that the scale zero of the encoder is in the correct position. The mark treated as zero point by the inverter can be set by defining an offset value.

Multiplication and reduction parameters allow for a transmission ratio to be ensured between motor and absolute encoder.

The sense of rotation of motor and absolute encoder need not necessarily be the same. If the sense of rotation is different, a negative transmission ratio must be set.

With the 100kHz clock frequency used, cable lengths of up to 80m are allowed. The cables should be twisted-pair and screened.

Absolute encoders may include break-of-wire checking provided that an extra voltage monitoring bit has been assigned for that purpose.

Two DIP switches are provided on the Posicon card to operate the terminating resistors of the SSI interface. With absolute encoders connected, switch 1 is set to "Off“ and switch 2 to "On“.

Connect the screen to the flat cable (AMP) connector on the Posicon card.

3 Functional characteristics

3.1 Introduction

The Posicon positioning card is extremely versatile in carrying out positioning and position controlling tasks. To make it easier for you to decide which configuration will be most suitable for the application at hand, a description of the various ways of setpoint setting and actual value recognition is provided below.

Setpoints can be fed to the control system as either absolute or relative position values. Absolute position setpoints are mainly used in applications where the same positions are approached over and over again, as e.g. with shifting trolleys, elevators, shelf operating equipment etc. Relative position setpoints are obviously more suitable where axles perate in an intermittent fashion, especially endless ones driving turntables or clock-controlled metering belts. Setpoints can also be transmitted over the bus (Profibus or USS interface). In that case the position is translated into an encoded value or into a bit combination representing the number of a position or a position increment.

If the operator wishes to quit the positioning mode and activate speed setting instead, he can do so by switching parameter sets. While in one parameter set the position control parameter must be set to "On", an "Off" setting will be required in the other. Switching between parameter sets is possible any time.

Position recognition can be handled using either an incremental or an absolute encoder. With rotary axles turning in one direction most of the time, only an increment encoder can be used, since with absolute encoders the range of values is limited to ±50000 revolutions. Using an incremental encoder implies that a reference point will be needed.

3.2 Actual position recognition

3.2.1 Position recognition with an incremental encoder

The actual position is determined by the Posicon card processor. This calculation presupposes a reference point which is used to define the zero position of the axle. The position recognition function will be active as long as the frequency inverter is supplied with a voltage. The pulses generated by the incremental encoder are counted in the inverter and added to the actual position value. When the inverter supply voltage is switched on, "0" will be read out as the actual position (if the reference point tracking parameter was set to "ON"), or else the value which was read out last before the inverter was switched off (if the reference point tracking parameter was set to "Save pos. ON"). Changes of position which take place while the frequency inverter is disconnected have no effect on actual position indication. That is why a search for the reference point is usually required whenever the frequency inverter is connected to the mains.

With rotary axles turning in one direction most of the time the parameters for reduction have to be 1. With other values the position set point must be in the limits of –50000 and 50000. In this applications the encoder has to be mounted on the motor shaft.

3.2.1.1 Tracking the point of reference

Reference point tracking is activated via the terminal 49 input. An enable left or enable right signal is applied to define the direction in which the search for the reference point is to be performed. The rate of reference point tracking can be set in the "Ref. Point Frequ." parameter. When the axle has turned so far as to trigger the reference point switch (change 0 → 1 at terminal 48 input) the inverter awaits the next zero pulse transmitted by the incremental encoder. The moment the zero pulse is received, the current position is set to the value of parameter “offset” and reference point tracking is completed. At this stage, the program activates position

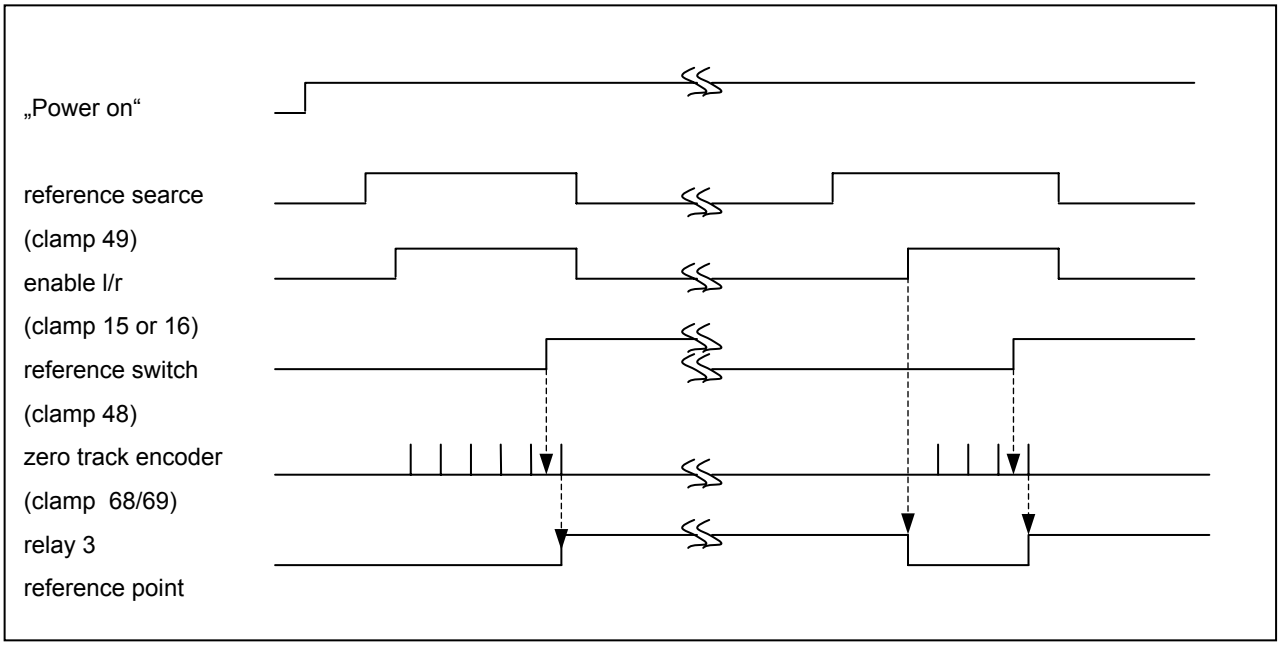
control and makes the controlled unit move to the selected position. This is when in the digital mode 2 (relative positioning) the setpoint position will be set to 0 which makes the axle rotate up to the point of reference. If parameterised accordingly, the frequency inverter will use relay 3 to signal the end of reference point tracking.

Should the input which is used for reference point tracking (terminal 49) be de-energized before the point of reference was found, the inverter will signal a "reference point" error.

When the frequency inverter is switched on, either "zero" or the position held at the moment the inverter was last switched off is reported to be the actual position, depending on how the reference point parameter was set.

While the display is reading out the "Reference point" relay signal, reference point tracking is in progress, and the point of reference has not yet been found. As soon as it is found though the relay will pick up. Important: Switching the inverter on will energize the relay as well. Whether or not reference point tracking will be necessary should be determined within the scope of overall system control.

sequence diagram reference point searce



3.2.1.2 Reset position function

Instead of being used for reference point tracking and being active temporarily only, input 49 can be assigned a reset switch function. In that mode the input is active all the time and will set the actual position to the value of parameter “offset” instantly as soon as the signal changes from 0 → 1, whether position control is ON or OFF. The setpoint position in the digital mode 2 (position increments) is set to zero.

The repetition accuracy of referencing by means of the reset function falls short of the precision obtained by reference point tracking as described above – it depends on the tolerance of the reference point switch and the rate at which the operating threshold of the switch is approached. For many applications it is sufficient though. Besides referencing can be carried out without interrupting position control.

3.2.2 Position recognition with an absolute encoder

The absolute encoder transfers the actual position value to the frequency inverter via the serial SSI interface in Gray code. As the complete position information is stored in the absolute encoder all the time, it is still available even if the axle has been moved while the inverter was off. That is why in this case the program need not search for the reference point again.

If an absolute encoder is connected, the "Position recognition" parameter must be set to "absolute" and the "SSC mode parameter" to "SSI master".

If the absolute encoder is not mounted on the motor shaft, the transmission ratio between motor and absolute encoder must be specified in the relevant parameter. The inverter will convert the absolute revolutions to revolutions of the motor by means of the multiplication and devision parameters.

$n_M = n_E * mul / dev$

n_M: number of revolutions of motor
n_E: number of revolutions of absolute encoder
mul: multiplication
dem: devision

Example: The absolute encoder is installed on the output face of the gearbox, the gear ratio of the gearbox is i = 26,34. The following values are parameterised:
multiplication 2634; demultiplication : 100

The zero point (point of origin) of the axle can be corrected by providing an offset value in the relevant parameter. This offset value is added to the value obtained after the absolute encoder revolutions have been converted into revolutions of the motor shaft. That is why a new offset value must be entered any time the multiplication or demultiplication ratio has been changed.

The maximum allowable position range is ±50000, a complete turn is not allowed. With continuous axles rotating in the same direction most of the time, incremental encoders must be used.

3.2.3 Encoder monitoring

When an incremental encoder is used for position recognition, correction and monitoring of its functions are activated in the "Abs. Pos. Check“ parameter. The zero track of the encoder is used for this purpose. If the number of pulses transmitted between two zero pulses is different from the number of graduation marks of the encoder, the value is corrected and the difference added in an error counter. If the added values registered by the difference pulse counter excede the total amount of 8 revolutions, an "Encoder Error" signal is put out. The error counter is set to zero with every power-on of the inverter and after each reference point tracking or position reset.

When an absolute encoder is used for position recognition, monitoring is ensured by activating the voltage monitoring bit in the "Abs. Pos. Check" parameter. The absolute encoder must feature the corresponding option. If the bit succeeding the last data bit is not equal to 0, the value will be ignored. If no value has been read by the end of a 50 ms period, the inverter puts out a "encoder error".

When the motor is operated in the servo mode, the incremental encoder can additionally be monitored for rpm lags (see basic documentation, section relay parameters).

With the parameter “pos supervision” a tracking of the position control loop is activated. If either the motor turns in opposite direction while the output frequency is more then 5Hz or if for more then 100ms no changes

at the actual position are recognized with an output frequency higher than 1Hz, an error message is generated.

With the "minimum position" and "maximum position" parameters, limits for the allowable operating range can be set. When either the setpoint position or the actual position is found to have exceded these limits, the system indicates a "encoder error". The monitoring function is neither available in the "Digital mode 2" setpoint mode (displacement increments) nor in the mode for incremental position recognition.

3.3 Setpoint setting

Essentially four methods of setpoint setting are available. Setpoints can be fed to the system via digital inputs as absolute or as relative position values, or they can be transmitted via a bus or the SSI interface. The way the actual position is ascertained is irrelevant for setpoint setting. Absolute, relative and bus setpoints can be defined whether an absolute encoder or an incremental encoder is used to determine the actual position.

3.3.1 Digital mode 1 – Absolute setpoint position via digital inputs

In the digital mode 1, up to 63 positions per parameter set can be selected via the digital inputs 1 through 6. The position numbers result from the binary value of the inputs (input terminal 55 = 2^0, input terminal 50 = 2^5). For each position number one position setpoint can be parameterised. The position setpoint is either entered via the control panel (by reading the current position and saving it as the setpoint in the inverter's memory) or be made permanent by "teach-in" programming which implies that the operator will "demonstrate" to the system how to make the driven assembly adopt the various positions.

3.3.2 Digital mode 2 – Relative setpoint position via digital inputs

The digital mode 2 is especially suitable for rotary shafts. A value can be assigned to each of the 6 digital inputs (terminals 50 to 55) in the relevant parameters. This value will be added to the setpoint position when the signal changes from 0 → 1 . As both positive and negative values can be used, control also allows for returning to the original position. The addition is made with any positive signal edge whether the inverter is enabled or not. By applying several pulses to one input, the multiple of the parameterised increment can be preset. The pulse width as well as the width of the pulse intervals must be 10 ms minimum.

3.3.3 16-bit bus mode

With the 16-bit bus mode, the absolute setpoint position is fed to the control system as a percentage value. The setpoint is transmitted via the RS485 interface or the Profibus activation circuit, presuming that 100% is equal to 4000_{16} . The "Bus setpoint 100%" parameter is used to scale the percentage value into revolutions. Transmission of setpoints via the serial interface is enabled in the "Interface" parameter included in the "Additional Functions" menu group. For detailed information regarding bus setpoints see the relevant supplemetary operating instructions.

3.3.4 32-bit bus mode

In the 32-bit bus mode the absolute setpoint position is transmitted via the serial interface in terms of revolutions. The 1/1000 revolution ratio corresponds to the way the setpoint is represented in the display.

3.3.5 Digital bus mode 1

The digital bus mode 1 is basically comparable to the digital mode 1, with the exception that functions of the inputs 49 – 55 are assigned to the bits 6 to 0 of the setpoint received from the serial interface. Reference point tracking is activated via bit 6, while the reference point switch is still directly connected to terminal 48.

3.3.6 Digital bus mode 2

Basically the digital bus mode 2 is used in the same way as the digital mode 2. As with the digital bus mode 1, bits 6 to 0 of the serial interface setpoint are analysed rather than the digital inputs 49 – 55.

2.2.1 Setpoint transmission via the SSI interface

Setpoints can also be transmitted via the SSI interface. The setpoints must be set in accordance with the format defined in the "SSI-resol./rev“ and "SSI-max.revol.“ parameters.

3.4 Teach–in programming

The programming of position setpoints (digital modus 1) can be done direct in the parameter section in teach in mode. The teach in is activated and controlled via control clamps or with the parameter “position control”.

If the teach in is controlled by control clamps two inputs on the control board have to be programmed as “teach in” and “quit teach in” signals (input DIN2 ... DIN6, clamp 16...20). With a “1” signal on “teach in” the teach in mode is activated and stays active until the signal is switched to “0” again. If the “quit teach in” signal changes from “0” to “1” the actual position is stored as setpoint at the selected position number (selected with input clamp 50 ... 55). If the selected position number is “0” the position is generated with an internal counter. The counter starts with 1 and is increased with every “quit teach in” signal. With selecting a position at the digital inputs the counter immediately is set to the selected position number.

It is also possible to control the teach in via keyboard. To activate teach in via keyboard the parameter position control mußt be set to “teach in”. After this the position counter is set to “1”. When the enter key is pressed, the actual position is stored at this number and the counter is increased. It is not allowed to mix the teach in via keyboard operating and control clamps.

As long as teach in is active, the position control loop is switched off and the setpoint is interpreted as frequency setpoint.

The Posicon positioning card affords a teach-in function which is activated or inactivated in the position control menu (Teach–In/ON/OFF). It is not possible to toggle between the teach-in and the position control mode via control signals. In the teach-in mode, positions 1 to 63 are successively filled with the current actual value. Afterwards the input is confirmed by operating the Enter key or by activating the Acknowledge/Teach-In signal.

3.5 Position control

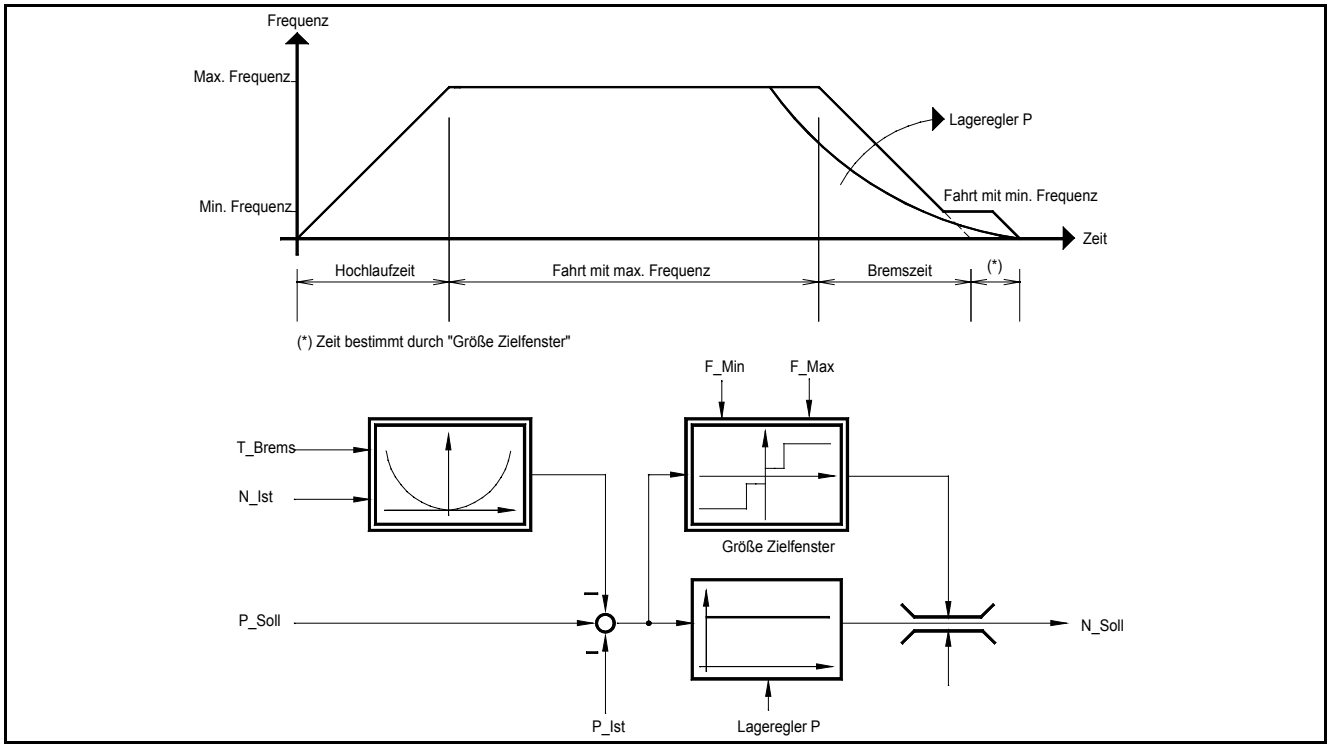
Position control is configured as a P control loop. Setpoint and actual position are constantly compared. The setpoint frequency is calculated by multiplication of the position error with the value set in the "Position controller P" parameter. Afterwards a maximum limit is determined which the setpoint frequency must not exceed.

If the distance calculation function is activated, a derivative with respect to distance is calculated based on the programmed braking time and the current speed. With braking time not being taken into account by distance calculation, the speed would very probably be reduced too late, and the position be overshot. However braking time is not a factor considered with highly dynamical systems where acceleration and deceleration periods are extremely short, or with systems for which only very small displacement increments are defined.

Another parameter allows for the provision of settings for a destination window. In the destination window the setpoint frequency is limited to minimum frequency. In applications with varying loads and without speed control, this parameter can be used to program a distance to be covered in crawling motion.

The destination window parameter does not affect the "Final position" relay signal.

Synoptical position control diagram



3.6 Relay signals

The Posicon positioning card is endowed with two multi-function relays, each of which can be assigned one function in a parameter. It is not possible to establish AND or OR circuits between any of these functions. The following functions are available on both relays:

- **Final position**

  The inverter will use this function to indicate that the setpoint position has been reached. The relay picks up when the amount by which the actual position deviates from the setpoint position is smaller than the value set in the "Relay hyst." parameter. The relay signal is not dependent on the enable signal or on the current speed.

- **Position**

  The relay will close the circuit when the actual position is greater than or equal to the value defined in the "Relay position" parameter. The relay will be released again when the actual position value becomes less than "Relay position" – "Relay hyst". The sign is taken into account.

- **Abs. position**

  The "Abs. position" function is basically similar to the "Position" function, it is different however in that the actual position is processed as an absolute (unsigned) value. The relay is operated when the actual position excedes the parameterised value or drops below the value of the same but negative amount.

Apart from the functions mentioned above, relay 3 and relay 4 are equipped with one more function each:

- **Reference point (only relay 3)**

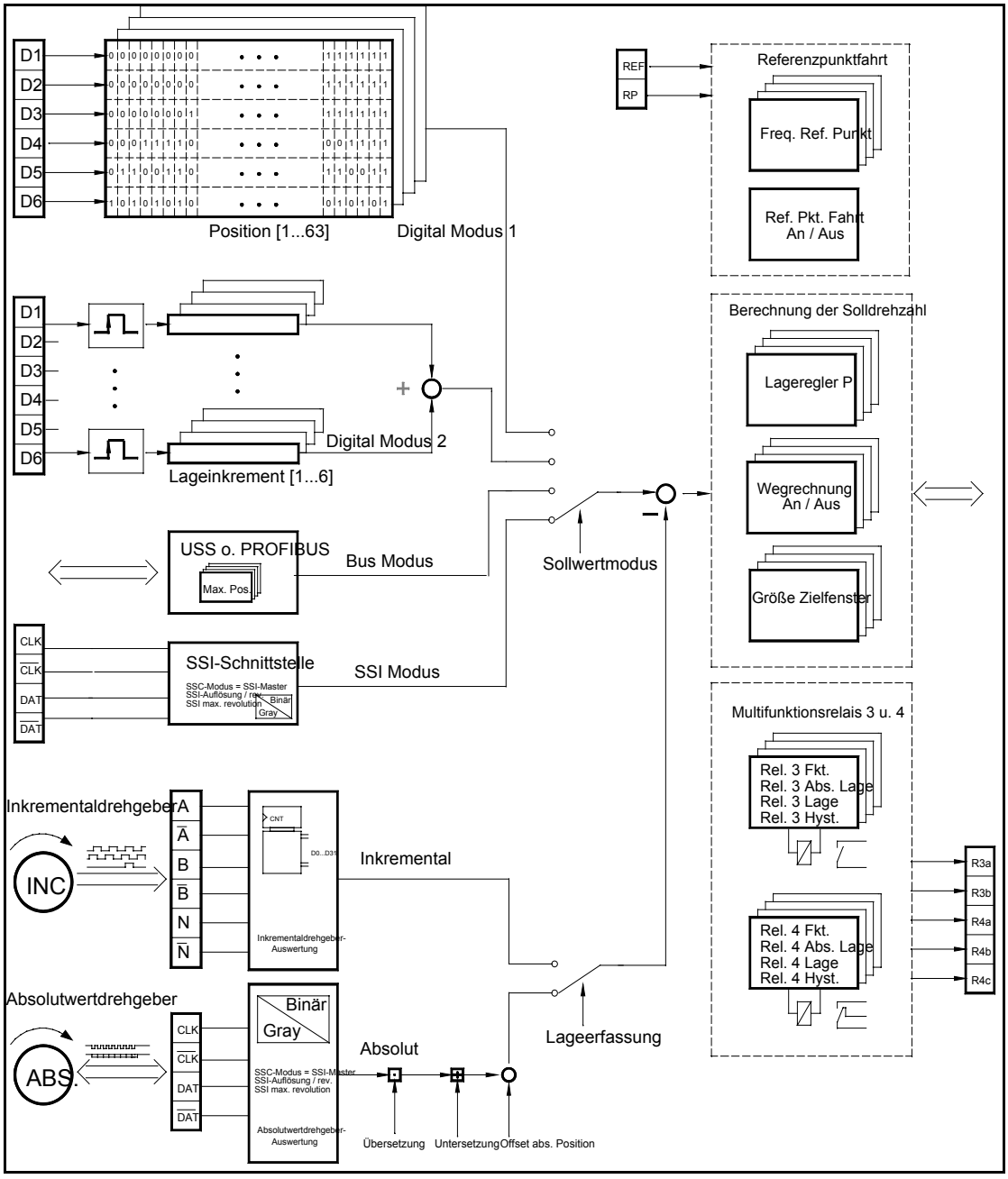
  The relay signals that the search for a reference point is still in progress. The relay drops out when reference point tracking is started. As soon as the reference point is found the relay pulls up. Whenever the inverter supply voltage is switched on, the relay is energized too.

- **Pos. array (only relay 4)**

  The relay picks up whenever any of the positions parameterised between 1 and 63 is either reached or overshot. This function is available even if the "Digital mode 1" was not selected as setpoint mode. Activation of this setpoint mode is required however to parameterise the values directly on the inverter because otherwise the position parameters are inaccessible to viewing.

All relay functions are available whether or not the system is operated in the position control mode.

3.7 Signal-flow diagram



4 Table of menu items

To edit the various menu items, select the menu group and operate the Enter key when you have finished the settings. When the two field keys are operated simultaneously the display switches back to the menu group annular structure and to reading out the operating values.
The field keys can also be used to go from one menu item of a group to another. The menu items are arranged in an annular structure as well. To quit this level the field keys must be pressed at the same time. The values contained in any individual menu item are varied with the value keys and made permanent by operating the Enter key.
In the "Type" column of the table, menu items which can be varied on-line are marked "O" while those parameters which can be set differently in the two parameter sets are marked "P".
The shaded areas of the table contain those menu items which presuppose a certain configuration to be accessible to viewing.

Type	Function Comment	Display shows:	Range of values Resolution	Default setting
	Current position Indicates the current position sensed, and whether the selected position has been reached (Pr = position reached)	**"Current pos. Pr"**	-50000.000 to 50000.000 0.001rev 0/1	-
P	Position control[1]	**"Position control"**	Off On Teach – In	Off
	On: Position control is active as defined in the parameters mentioned below. Teach-In: With position setpoint = digital mode 1, the standard inverter function (enable/setpoint) enables the controlled assembly to approach up to 63 positions which will be stored one by one. Tech in also can be activated by control clamps. To do this one input of the contol board must be programmed as “teach in” function and an other input as “quit teach in” functon			
	Mode of the synchronous serial interface	**"SSC mode"**	Off SSI master SSI slave SCI master SCI slave	Off
	Off: if the SSI input is not required SSI master: for evaluation of the actual position value transmitted by an absolute encoder or a control device SSI slave: to put out an actual position value to a control device SCI master: for the master inverter in cascade control SCI slave: for servo driving in cascade control			
	Mode of the SCI interface [2]	**"SCI mode"**	32-bit [cascade] 32-bit [pos ref] 32-bit [pos]	32-bit [cascade]

[1] all of the parameters described below are visible only with position control = ON or Teach-In activated

[2] not available for display unless "SCI master" or "SCI slave" has been programmed as serial interface mode

Type	Function Comment	Display shows:	Range of values Resolution	Default setting
	32-bit [cascade]: actual speed and actual position are transmitted 32-bit [pos ref]: setpoint position is transmitted 32-bit [pos] actual position is transmitted Make sure that the same SCI mode is set in both the master and the slave inverter			
	Position setpoint mode[3]	**"Setpoint mode"**	Digital mode 1 Digital mode 2 Bus mode 16 bits [4] Bus mode 32 bits [4] Dig. bus mode 1 [4] Dig. bus mode 2 [4] SSI mode [5] Cascade control[5]	Digital mode 1
	Digital mode 1: allows for programming up to 63 absolute positions to be approached Digital mode 2: A definite path increment can be programmed for each of the 6 digital inputs. When a pulse is applied to one or more digital inputs, the current position is increased by the corresponding increments. 16-bit bus mode[4]: The absolute position desired is transmitted to the inverter via the bus interface as a percentage value. Select the "bus" interface in the "Additional functions" group first! 32-bit bus mode[4]: (Only with interface selection = bus) The absolute position desired is transmitted via the bus interface. Resolution is 1/1000 motor shaft revolutions. Dig. bus mode 1 [4]: (Only with interface selection = bus) This mode is essentially comparable to digital mode 1; position control via the corresponding bits in the bus setpoint. Dig. bus mode 2 [4]: (Only with interface selection = bus) This mode performs in much the same way as digital mode 2; position control via the corresponding bits in the bus setpoint. SSI mode[5]: The setpoint is applied via the SSI interface. Cascade[5]: Cascade control, the setpoint supplied by the master is read via the SSI interface.			
P	Maximum position[6]	**"Bus 100% Pos“**	0...50000 rev 2 rev	2 rev
	With this setting the number of revolutions the maximum setpoint transmitted (100%) will be equivalent to in the 16-bit bus mode is specified.			
	Position recognition	**"Pos. recognition"**	Incremental mode Absolute mode	Incremental
	Incremental: Position control by an incremental encoder Absolute mode 1: Position control by an absolute encoder.			
	Resolution per rev. SSI interface[7]	**"SSI resol. /rev"**	64 / 128 / 256 / 512 / 1024 / 2048 / 4096	4096

[3] setting options vary according to the serial interface mode and the interface setting (bus mode)

[4] only with the following setting of additional function: USS mode = slave, and interface = USS

[5] only with SSI interface ON

[6] only provided that the bus mode = setpoint mode

Type	Function Comment	Display shows:	Range of values Resolution	Default setting
	Number of pulses per revolution transmitted by the absolute encoder			
	Number of revolutions SSI interface [7]	**"SSI max. revol."**	1 / 16 / 256 / 4096	4096
	Maximum number of absolute encoder revolutions			
O	Offset absolute encoder [7]	**"Abs. pos. offset"**	0...±50000 rev 0.001 rev	0
	The amount by which the program will shift the zero point of positions			
	Supervision actual position (see chapter 3.2.3)	**"Check act. pos."**	ON / OFF	OFF
	Supervision control loop (see chapter 3.2.3)	**"Pos. supervision"**	ON / OFF	OFF
O	Encoder demultiplication **"Demultiplication"** Fehler! Textmarke nicht definiert.		-1000...10000 1	1
O	Encoder multiplication **"Multiplication"** Fehler! Textmarke nicht definiert.		-1000...10000 1	1
	Multiplication and demultiplication determine the speed ratio between encoder and motor, and thus the reduction of a gearbox or different senses of rotation of motor and encoder, as the case may be.			
	Reference point tracking[8]	**"Ref. pt. track."**	OFF ON ON Save position Reset position	OFF
PO	Frequency ref. point tracking[9]	**"Frequ.ref. pt."**	0...2 * F_{nom} or 0.1 Hz analogue	5 Hz
	The digital inputs to which this function is assigned (term. 49 + 48) are used to locate the point of reference (zero point), with one input (term. 49) triggering the search for the point of reference, and the other (term. 48) communicating the position of the reference point to the inverter. A reference point is not required unless the position is determined by means of an incremental encoder. In that case it is correlated with the zero track. The frequency for point-of-reference tracking can be preset as a fixed value, or else be applied as an analogue setpoint (set the "Frequ.ref.pt." parameter to "analogue) .			
PO	Position 1- 63 [10] for digital mode 1	**"Position [01...63]"**	0...±50000 rev 0.001 rev	0 rev
PO	Position interval digital inputs 1 to 6 [11] for digital mode 2	**"Position increment" [1...6]**	0... ±50000 rev 0.001 rev	0 rev

[7] SSI interface to be ON to ensure this parameter function

[8] displayed only with position recognition set to "Incremental"

[9] displayed only with "reference point tracking" activated

[10] only with position setpoint control in "Digital mode 1"

Type	Function Comment	Display shows:	Range of values Resolution	Default setting
PO	Position controller P control gain	**"Pos. controller P“**	0...100% 0.1%	5%
	Distance calculation	**"Distance calculation"**	On/Off	On
PO	Size of destination window	**"Destin. window size"**	0....1000rev 0.001 rev	0 rev
P	Multifunction relay 3 function (see section 3.6)	**"Relay 3 fct."**	Final position: Position: Abs. position: Reference:	Reference
P	Reference position MFR 3 Only with the "Position" function activated	**"Relay 3 pos."**	0...±50000 rev 0,001 rev	0 rev
P	Amount of ref. pos. MFR 3 Only with "Abs. pos." function activated	**"Rel. 3 abs. pos."**	0...50000 rev 0.001	0 rev
P	MFR 3 hysteresis	**"Relay 3 hyst.“**	0...50 rev 0.01 rev	1 rev
P	Multifunction relay 4 function (see section 0)	**"Relay 4 fct.“**	Final position Position Abs. position Pos. array	Final position
P	MFR 4 Ref. position Only with "Position" function	**"Pos. relay 4"**	0...±50000 rev 0.001 rev	0 rev
P	MFR 4 Amount of ref. pos. Only with "Abs. position" function	**"Rel. 4 abs. pos."**	0...50000 rev 0.001	0 rev
P	MFR 4 Hysteresis	**"Relay 4 hyst."**	0...50 rev 0.001 rev	1 rev
	Software version	**"Po. Softw.-Ver.→"**	e.g. "5021 0005 “	-
	Minimum position	**Minimum pos.**	-50000 rev ... max. pos. 0.001 rev	-50000 rev
	Maximum position	**Maximum pos.**	Min. pos ... 50000 rev 0.001 rev	50000 rev
	The minimum and maximum position parameters are provided to set limits for the allowable working range. Whenever a position setpoint or actual position value is not within this range, the inverter will generate an "encoder error" signal.			

[11] displayed only with position setpoint selected in "Digital mode 2"

Type	Function Comment	Display shows:	Range of values Resolution	Default setting
	Current setpoint position **"Current setpoint pos. Pr“** The position value selected via the digital inputs is displayed, and a "Pr" (Position reached) message is read out when the selected position has been reached.		- 0.001 rev 0 / 1	-

5 System start-up

When setting up Posicon control for an application it is advisable to carry out the individual steps in the order described below. For errors that may occur during this stage see also Section 7, Fault clearance.

1st step: Putting the axle into operation without control

After all parameter settings have been entered as required, begin by putting the axle into operation without position or speed control. Accordingly switch off position control in the "Positioning" parameter group, and the servo mode in the "Additional functions" parameter group.

Important note: Make sure that emergency stop and safety circuits are operative!

With lifting gear applications take precautions before turning on the power for the first time to ensure that the load will not suddenly drop or sag.

In speed-controlled lifting gear, set the speed controller before you optimise the moment the load is taken up (setpoint delay parameter).

2nd step: Putting the speed controller into operation

If no speed control is desired or no incremental encoder provided, disregard this step, otherwise set the servo mode to ON. For operation in the servo mode, enter the exact motor data and the correct number of encoder graduation marks.

If after the servo mode has been activated the motor runs at low speed while the current input is high, this is caused in all probability by a wiring error or by a parameterisation error concerning the connection of the incremental encoder. Very often the above condition results from a discrepancy between the sense of rotation of the motor and the counting direction of the encoder, see also Chapter 7.2, table 1. Preferably the speed controller is not optimised until the position controller is put into operation, because the behaviour of the position control loop can be manipulated by varying the parameters relating to the speed controller.

3rd step: Putting the position controller into operation

Check first whether the actual position is recognized correctly. The actual position is read out in the "Current position" parameter. The value is supposed to be stable, and to increase when the motor is activated with the "enable right" command. If the value does not change when the axle is rotated, check on the parameter settings and the encoder connection. The same checking should be performed if the actual position value read out is erratic although the shaft does not move.

After that a setpoint position should be parameterised next to the current position. If the axle moves away from that position rather than towards it when the motor has been enabled, the sense of rotation of the motor does not match the sense of rotation of the encoder. When absolute encoders are used, the sign of the demultiplication factor must be exchanged, whereas with incremental encoders it is the tracks that will have to be exchanged, e.g. A for Ā.

When actual position recognition is working correctly, the position controller can be optimised. As a rule the axle will respond more "rigidly" as the P gain is increased, in other words there will be less deviation from the setpoint position than with minor gain values.

The maximum P gain of the position controller that can reasonably be set depends on the dynamical behaviour of the total system. As a rule the following principle is true: The greater the masses involved in the system and the less the friction, the more it is prone to oscillation, and the less is the maximum allowable P gain value. To determine the critical value, the gain is gradually increased until the drive oscillates around the position (departing from it for an instant and returning to it again). After that set the gain to between 0.5 and 0.7 times the criticial value.

As the default setting will probably not be adequate for positioning applications with cascaded controller (servo mode) involving heavy loads, a different setting should be preferred, e.g. a value between 3% and 5% for the I gain of the speed controller, and a value between 100% and 150% as the P gain.

6 Settings after system start-up

In the table below all relevant settings found to be adequate on system start-up should be documented. Please remember that some menu items are visible only in connection with certain setting configurations (shaded items). A continuous line without column markings refers to those menu items the settings of which are valid in all parameter sets alike.

Menu item	Factory setting	Parameter set 1	Parameter set 2	Parameter set 3	Parameter set 4
Position control	Off				
SSC mode	Off				
SCI interface resolution	16 bits				
Setpoint mode	Digital mode 1				
Maximum position	4096 revs				
Position recognition	Incremental				
Abs. pos. offset	0				
Current pos. check	Off				
Pos. supervision	Off				
SSI resol./rev	4096				
SSI max. revol.	4096				
Demultiplication	1				
Multiplication	1				
Ref. pt tracking	Off				
Ref. pt frequ.	5 Hz				
Position [01...63]	0 rev				
Pos. increment 1	0 rev				
Pos. increment 2	0 rev				
Pos. increment 3	0 rev				
Pos. increment 4	0 rev				
Pos. increment 5	0 rev				
Pos. increment 6	0 rev				
Pos. controller P	10 %				
Distance calculation	On				
Destin. window size	0 rev				
Relay 3 fct.	Ref. pt. found				
Relay 3 ref. pos.	0 rev				
Relay 3 amount	0 rev				
Relay 3 hyst.	1 rev				
Relais 4 fct.	Pos. reached				
Relay 4 ref. pos.	0 rev				
Relay 4 amount	0 rev				
Relay 4 hyst.	1 rev				
Minimum pos.	-50000.000 rev				
Maximum pos.	50000.000 rev				

7 Fault clearance

7.1 Error messages

The majority of the frequency inverter functions and operational information is continuously monitored and compared to limit values. Detecting a deviation the inverter will put out a warning or an error message.

For fundamental information on this subject kindly refer to the Operating Instructions for the basic unit.

The table below contains all of those faults which can be attributed to the Posicon function. The inverter display will read them out as clear text messages:

Faults	Cause	Remedy
Reference point error	• Reference point tracking was interrupted without a reference point having been found	• Check reference point switch and the zero track of the incremental encoder, check the selection circuit too
Encoder error	• Incremental encoder missed pulses • Absolute encoder monitoring bit • EMC measures inadequate • Minimum or maximum position limit was reached or exceded	Provide output choke, check parameter settings
System error 12, **System error 13**	Internal program flow error	

7.2 Table of errors / possible causes

In the table below the most frequent error sources are listed along with the characteristic symptoms. For trouble shooting best proceed in the same order as when starting up the system, that is check first whether the shaft runs correctly without being controlled, and only then go on to testing the speed and the position controller.

1. Error sources while the system is operated in the servo mode (without position control)

Symptom	Additional checking	Possible cause
Motor speed very low, motor runs jerkily	Exchange incremental encoder tracks (A for Ā, terminal 64 for terminal 65)	Motor sense of rotation and incremental encoder counting direction do not match
	Exchanging encoder tracks has no effect	Inappropriate incremental encoder type (no RS422 outputs) Interruption of encoder cable No power is supplied to the encoder The number of graduation marks parameterised was wrong Motor parameters are not correct Encoder lacks one track
Motor speed is basically o.k., however there is some jerking at low speeds Overcurrent release at high speeds	Problems disappear when the servo mode is switched off	Incremental encoder was not installed correctly Encoder signals disturbed Failure to install an output choke
Overcurrent tripping during deceleration	Motor in field weakening range	With field weakening operation in the servo mode, the torque limit must not excede 200%

2. General error sources

Symptom	Additional testing	Probable cause
Overshooting of position		Distance calculation OFF Speed controller setting (servo mode) inadequate (set I gain to approx. 3%/ms, P gain to approx. 120%)
Drive oscillates about position		Too high a value set for P gain of position controller
Drive moves into wrong direction (away from setpoint position)		Sense of rotation of the absolute encoder does not correspond to the sense of rotation of the motor => set a negative multiplication value in the relevant parameter
Load sagging after the enable signal is invalidated (lifting gear)		No setpoint delay was set (control parameter); With the servo mode = "OFF" the controller must be disabled immediately when the event "Final position reached" has occurred

3. Typical error sources in position control with incremental position recognition (without absolute encoder)

Symptom	Additional testing:	Possible cause
"encoder error"	Was the minimum or maximum position parameter changed?	Actual position value or setpoint position value excedes minimum or maximum position
	“Abs. pos. check” parameter ON?	Disturbing pulses on the encoder lines
	“Pos. supervision” Parameter ON?	Direction of rotation between encoder and motor is different, or encoder value does not change
"Reference point" error		Reference point tracking completed but failed
Position drifts away		Encoder cable affected by interference pulses Output choke should have been installed
No repetitive accuracy when moving into identical positions several times	even at low speed (n < 1000 1/min))	Encoder cable affected by interference pulses Failure to provide output choke
	at high speed only (n > 1000 1/min)	Number of graduation marks too high considering the length of encoder cable / the cable type (pulse frequency too high)

4. Typical error sources in position control with absolute encoder

Symptom	Additional testing:	Possible cause
The same actual position value is signalled over and over again and remains steady afterwards		Encoder connection is not correct
Current position is displayed as an erratic ("jumping") value although the shaft does not move		Encoder cables are affected by interference pulses. No output choke has been provided.
"encoder error"	Was the minimum or the maximum position parameter modified?	Actual position value or setpoint position value excedes the minimum or maximum position
	"Abs. Pos. Check" parameter ON?	Absolute encoder does not supply a voltage monitoring bit, encoder cables are affected by interference
	"Pos. supervision” parameter ON?	Direction of rotation between encoder and motor is different, or encoder value does not change
Recognition function supplies varying information on the same position; sometimes the axle seems to jump to and fro	Is there any mechanical irregularity?	Axle is tight, getting jammed or does not move smoothly for any other reason
Position value is not in accordance with amount of encoder rotation or is erratic => shaft encoder is defective	Check absolute encoder (detach it, set multiplication and demultiplication parameters to 1, turn encoder by hand: the position indicated must be in accordance with the encoder revolutions)	Encoder defective

Business establishments & sales offices in Germany:

Getriebebau NORD
GmbH & Co.KG
Niederlassung NORD
Rudolf-Diesel-Str. 1
22941 Bargteheide

Getriebebau NORD
GmbH & Co.KG
Niederlassung West
Forststr. 27 - 29
40721 Hilden

Getriebebau NORD
GmbH & Co.KG
Vertriebsbüro Berlin
Roedernstr. 8
12549 Berlin

Getriebebau NORD
GmbH & Co.KG
Vertriebsbüro Nürnberg
Schillerstr. 3
90547 Stein

Getriebebau NORD
GmbH & Co.KG
Vertriebsbüro Bremen
Wohlers Feld 16
27211 Bassum

Getriebebau NORD
GmbH & Co.KG
Vertriebsbüro Butzbach
Marie-Curie-Str. 2
35510 Butzbach

Getriebebau NORD
GmbH & Co.KG
Niederlassung Süd
Lise-Meitner-Str. 11
70794 Filderstadt-Plattenhardt

Getriebebau NORD
GmbH & Co.KG
Vertriebsbüro Hannover
Weberstraße 4
30629 Hannover

Getriebebau NORD
GmbH & Co.KG
Niederlassung Ost
Leipziger Str. 58
09113 Chemnitz

Getriebebau NORD
GmbH & Co.KG
Vertriebsbüro München
Untere Bahnhofstr. 38a
82110 Germering

Representation in Germany:
Hans-Hermann Wohlers
Handelsgesellschaft mbH
Ellerbuscher Str. 177a
32584 Löhne

International subsidiaries:

Belgium
NORD Aandrijvingen N.V. /
Transmission S.A.
Boutersemdreef 24
B – 2240 Zandhoven

Danmark
NORD Gear Danmark A/S
Kiplev Erhvervspark 28 – Kiplev
DK – 6200 Abenraa

Great-Britain / England
NORD Gear Limited
1, Blacklnds Way,
Abingdon Business Park
GB - Abingdon, Oxford OX 14 1DY22

Canada
NORD Gear Limited
41, West Drive
CDN - Brampton, ON L6T 4A1

Norway
Nord Gear Norge A/S
Vestre Haugen 21
N – 1001 Oslo

Sweden
NORD Drivsystem AB
Ryttargatan 277 / Box 2097
S – 19402 Upplands Väsby

Slowakia
Nord Pohony, s.r.o
Stromovva 13
SK 81101 Bratislava

Turkey
NORD-Remas Redüktör
San. ve Tic. Ltd. Sti.
Tepeören Köyü
TR - 81700 Tuzla – Istandbul

Brazil
NORD-Motoredutores do Brasil Ltda.
Rua Elias Gannam 83
02552 - 040 São Paulo

Finland
NORD Gear Oy
Aunankorvenkatu 7
FIN 33840 Tampere

Indonesia
Getriebebau NORD Indonesia
Komplex Ruko BSD
Sektor 7 Block R.O.No. 71
RI Bumi Serpong Damai

Kroatia
NORD Pogoni d.o.o
Obrtnicka 9
HR 48260 Krizevci

Austria
Getriebebau NORD GmbH
Schärdinger Str. 7
A - 4061 Pasching bei Linz

Switzerland
Getriebebau NORD AG
Bächingenstr. 18
CH – 9212 Arnegg

Spain
NORD Motorreductores
Ctra. de Sabadell a Prats de Llucanès
Aptdo. de Correos 166
E - 08200 Sabadell

Hungary
NORD Hajtastechnika Kft.
Törökkö u. 5-7
H - 1037 Budapest

China
Getriebebau NORD
Beijing Representative Office
#207 Catic Plaza
18 Beichendoglu Chaoyangqu
Beijing 100101

France
NORD Réducteurs sarl.
17-19 Avenue Georges Clémenceau
F - 93421 Villepinte Cedex

Italy
NORD Motoriduttori s.r.l.
Via Modena 14
I – 40019 Sant' Agata Bolognese (BO)

Netherlands
NORD Aandrijvingen Nederland B.V.
Voltstraat 12
NL - 2181 HA Hillegom

Poland
Nord Napedy Sp.z.o.o.
Ul. Grottgera 30
PL 32-020 Wieliczka

Singapore
NORD Gear Pte. Ltd.
33 Kian Teck Drive, Jurong
SGP-Singapore 628850

Czechia
NORD Pohánèci Technika s.r.o
Palackeho 359
CZ – 500 02 Hradec Králové

USA
NORD Gear Corporation
800 Nord Drive / P.O. Box 367
USA - Waunakee, WI 53597-0367