Intelligent Drivesystems, Worldwide Services

GB

BU 0050

USS Bus modules and MODBUS RTU

Supplementary manual for NORD frequency inverters

NORD DRIVESYSTEMS

N O R D Frequency inverters

Safety and operating instructions for drive power converters

(as per: Low Voltage Directive 2006/95/EEC)

1. General

During operation, drive power converters may, depending on their protection class, have live, bare, moving or rotating parts or hot surfaces.

Unauthorised removal of covers, improper use, incorrect installation or operation causes a risk of serious personal injury or material damage.

Further information can be found in this documentation.

All transportation, installation, initialisation and maintenance work must be carried out by **qualified personnel** (compliant with IEC 364, CENELEC HD 384, DIN VDE 0100, IEC 664 or DIN VDE 0110, and national accident prevention regulations).

For the purposes of these basic safety instructions, qualified personnel are persons who are familiar with the assembly, installation, commissioning and operation of this product and who have the relevant qualifications for their work.

2. Proper use in Europe

Drive power converters are components intended for installation in electrical systems or machines.

When installed in machines, the drive power converter cannot be commissioned (i.e. commencement of the proper use) until it has been ensured that the machine meets the provisions of the EC Directive 2006/42/EEC (Machine Directive); EN 60204 must also be complied with.

Commissioning (i.e. implementation of the proper use) is only permitted if the EMC Directive (2004/108/EEC) is complied with.

Drive power converters with the CE mark meet the requirements of the Low Voltage Directive 2006/95/EEC. The harmonized standards stated in the Declaration of Conformity are used for the drive power converters.

Technical data and information for connection conditions can be found on the name plate and in the documentation, and must be complied with.

The drive power converters may only be used for the safety functions which are described and for which they have been explicitly approved.

3. Transport, storage

Information regarding transport, storage and correct handling must be complied with.

4. Installation

The installation and cooling of the equipment must be implemented according to the regulations in the corresponding documentation.

The drive power converters must be protected against impermissible loads. Especially during transport and handling, components must not be deformed and/or insulation distances must not be changed. Touching of electronic components and contacts must be avoided.

Drive power converters have electrostatically sensitive components, which can be easily damaged by incorrect handling. Electrical components must not be mechanically damaged or destroyed (this may cause a health hazard!).

5. Electrical connections

When working on live drive power converters, the applicable national accident prevention regulations must be complied with (e.g. VBG A3, formerly VBG 4).

The electrical installation must be implemented according to the applicable regulations (e.g. cable cross-section, fuses, ground lead connections). Further information is contained in the documentation.

Information about EMC-compliant installation – such as shielding, earthing, location of filters and installation of cables can be found in the drive power converter documentation. These instructions must be complied with even with CE marked drive power converters. Compliance with the limiting values specified in the EMC regulations is the responsibility of the manufacturer of the system or machine.

6. Operation

Where necessary, systems where drive power converters are installed must be equipped with additional monitoring and protective equipment according to the applicable safety requirements, e.g. legislation concerning technical equipment, accident prevention regulations, etc.

The parameterisation and configuration of the drive power converter must be selected so that no hazards can occur.

All covers must be kept closed during operation.

7. Maintenance and repairs

After the drive power converter is disconnected from the power supply, live equipment components and power connections should not be touched immediately, because of possible charged capacitors. Observe the relevant information signs located on the drive power converter.

Further information can be found in this documentation.

These safety instructions must be kept in a safe place!

Documentation

Designation: BU 0050 GB
Part No.: 607 05 01
Device series: **USS** for SK 300E, SK 500E (entire series), SK 700E, SK 750E
Modbus RTU for SK 540E and SK 545E

Version list

Designation of previous issues	Software Version	Comments
BU 0500 GB, December 2004 Part No. 607 0502 / 5204		Latest version
BU 0050 GB, August 2011 Part No. 607 0502 / 3111		• Deletion of option "DevicenNet mc" for FI series "vector mc" • Inclusion of SK 500E series frequency inverters • Implementation of Modbus RTU (for SK 500E)

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NOTE

This supplementary operating manual is only valid in conjunction with the operating manual supplied for the respective frequency inverter.

Intended use of the frequency inverter

Compliance with the operating instructions is **necessary for fault-free operation** and the acceptance of any warranty claims. **These operating instructions must be read** before working with the device!

These operating instructions contain **important information about servicing.** They must therefore **be kept close to the** device.

The described optional modules can only be used for the specifically defined frequency inverter series, use across series is only possible with the SK TU2-… module with SK 300E and SK 750E. The use of these modules with other devices is not permitted and can lead to their destruction.

The described optional modules and the corresponding frequency inverters are devices for stationary installation in control cabinets or decentralised structures. All details regarding technical data and permissible conditions at the installation site must be complied with.

Commissioning (commencement of the intended use) is not permitted until it has been ensured that the machine complies with the EMC Directive 204/108/EEC and that the conformity of the end product meets the Machinery Directive 2006/42/EEC (observe EN 60204).

Foreword

This supplementary documentation is valid for the SK 300E, SK 500E, SK 700E series and for the SK 750E. It describes the setup of communication via RS485.

For this, the main emphasis is on communication according to the **USS protocol**. Corresponding optional modules are available for the SK 700E and SK 750E series. The SK 300E and SK 500E series have an appropriate interface integrated as standard.

In addition, the requirements of **Modbus** communication (SK 540E and higher) will be considered.

1 USS

1.1 General information

1.1.1 The USS Protocol

With the aid of the USS protocol, a user can set up a serial bus coupling between a higher level Master and several slave systems. Master systems can for example be memory programmable control units (SPS) or PCs.

The USS protocol allows the user to implement automation tasks with conveying according to time-cycled telegram traffic (⇒ fixed telegram length required), as well as visualisation tasks.

The USS protocol is a simple, serial transfer protocol defined by Siemens, which if fully tailored to the needs of drive technology.

1.1.2 Features

Support of a multiple point coupling, e.g. EIA RS 485 hardware or a point-to-point coupling, e.g. EIA RS 232.

- Master / Slave access procedure
- Single Master System
- Maximum 32 participants (maximum 31 slaves)
- Simple, secure telegram framework
- Same physical bus design as PROFIBUS (DIN 19245 Part 1)
- The data interface to the basic device is according to the PROFILE for variable speed drives.
  This means that with USS, the information to the drive unit is transferred in the same way as with the PROFIBUS-DP.
- Can be used for commissioning, service and automation
- Service tools on PC (NORD CON)
- Simple to implement in customer-specific systems-

1.1.3 Delivery

Check the equipment **immediately** after delivery/unpacking for transport damage such as deformation or loose parts.

If there is any damage, contact the carrier immediately and carry out a thorough assessment.

Important! This also applies even if the packaging is undamaged.

1.1.4 Scope of supply

SK TU1-RS232*	for frequency inverter SK 700E	IP20	or
SK CU1-STD	for frequency inverter SK 700E, SK 750E	IP20	or
SK CU1-USS	for frequency inverter SK 700E, SK 750E *incl. screw for optional fixing to the FI	IP20	or

1.1.5 Certifications

1.1.5.1 European EMC Directive

If NORD frequency inverters or their options are installed according to the recommendations in this instruction manual, it meets all EMC directive requirements, as per the EMC product standard for motor-operated systems EN 61800-3.

1.1.5.2 RoHS compliance

The bus options described here are designed to be RoHS compliant according to Directive 2002/95/EEC

1.1.6 Identification System

SK TU1-RS2

Bus system:	AS1 = AS-Interface, CAN = CAN, CAO = CANopen, **RS2** = **RS232**, USS = USS, etc.
Device series:	**SK TU1** / SK TU2 / SK TU3

1.2 Modules

1.2.1 SK 500E

1.2.1.1 General

By the use of various modules for display, control and parameterisation, the SK 5xxE can be easily adapted to various requirements.

Alphanumerical display and operating modules can be used for simple commissioning. For more complex tasks, various connections to a PC or an automation system can be selected.

The technology unit (Technology Unit, SK TU3-…) is connected externally to the frequency inverter and is therefore easy to access and replace at any time.

As delivered, without the technology unit, 2 LEDs (green/red) are visible externally. These indicate the actual device status.

The green LED indicates that the mains voltage is present and operational, while a flashing code that increases in speed shows the degree of overload at the frequency inverter output.

The red LED signals actual error by flashing with a frequency which corresponds to the number code of the error (Manual BU 0500 Section 6).

WARNING

Modules should not be inserted or removed unless the device is free of voltage. The slots may only be used for the intended modules.

Installation of a technology unit separate from the frequency inverter is not possible. It must be connected directly to the frequency inverter.

NOTE

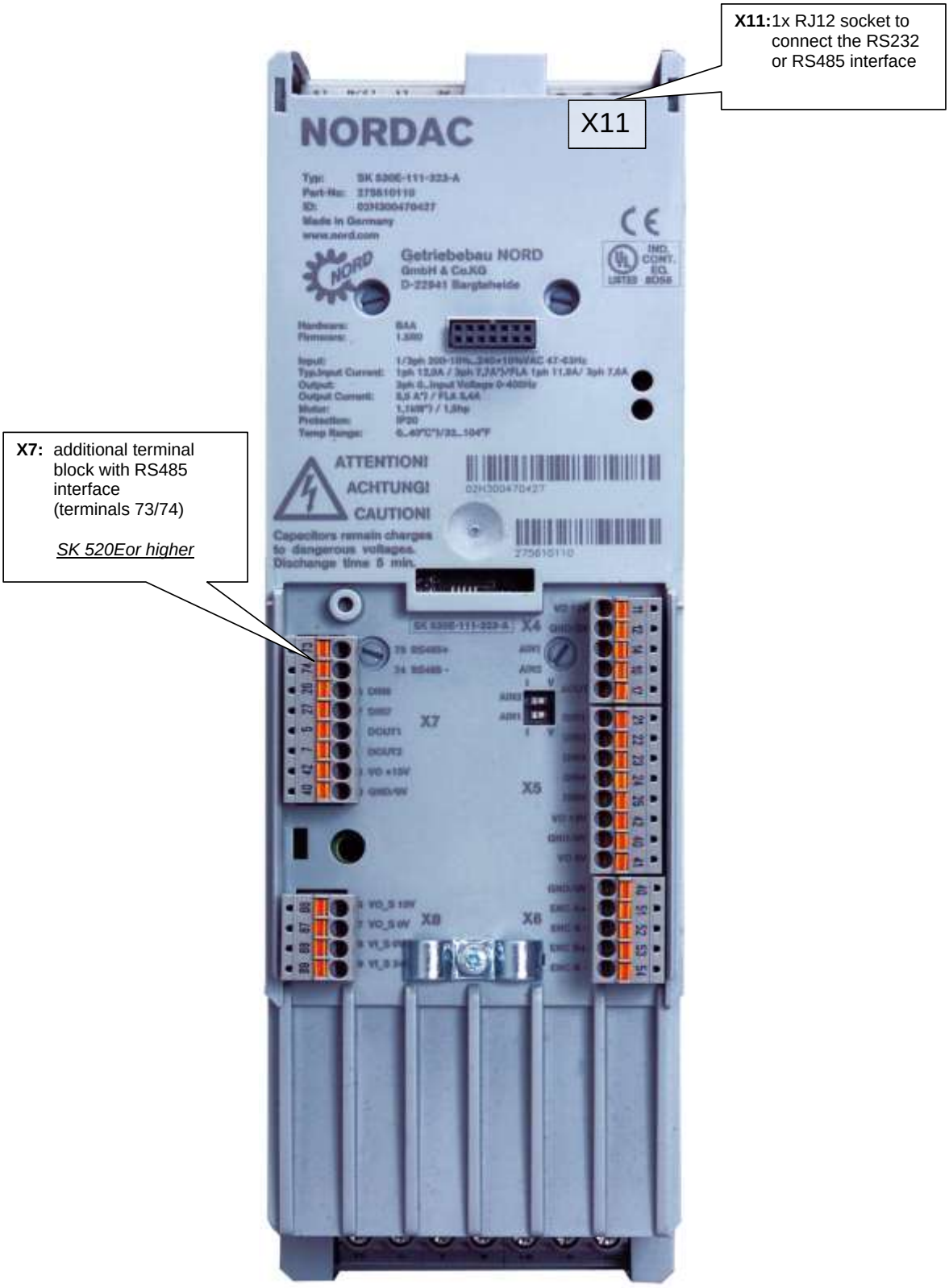
1.2.1.2 RS 485 interface

As standard, all devices in the SK 500E series have an integrated interface for USS bus communication.

According the version of the Fi, the following interfces are available:

X11 RJ12 socket (available for the entire series)

X7:73/74 RS485 + / - terminal connection (available for SK 520E or higher)

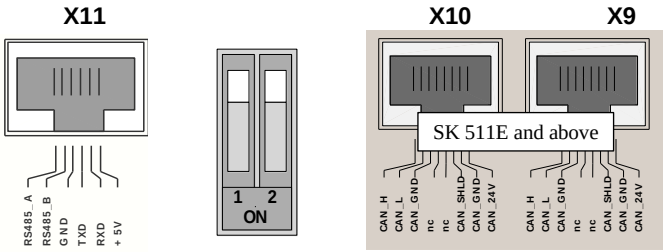


RJ 12 socket (X11)

In addition to the RS485 interface, the RJ12 socket also provides an interface for communication via RS 232. However, the RS232 interface is only intended for connecting a PC.

If a network is to be set up with several participants which communicate via USS (frequency inverters), it must be noted that communication must be via RS 485.

The RS232 interface (contacts X11:TXD and X11:RXD) cannot be deactivated on the frequency inverter. In order to prevent a short circuit of these data cables and therefore the destruction of the RS232 driver, the **contacts TXD, RXD and +5V must not have a common connection to several frequency inverters**.

Contact	Function	Data	Description / wiring suggestion
DIP switch 1/2 (top side of frequency inverter)			
DIP-1	Termination resistor for RS485 interface (RJ12); ON = switched in [Default = "OFF"] For RS232 communication DIP1 to "**OFF**"		 RS232/485 DIP CAN/CANopen
DIP-2	Termination resistor for CAN/CANopen interface (RJ12); ON = switched in [Default = "OFF"]		

Terminal connection (X7:73/74)

Above configuration level SK520E the frequency inverters are equipped with an additional terminal block (X7). This provides the possibility of setting up the RS485 bus communication via contacts 73 and 74.

Terminal	Function	Data	Description / wiring suggestion
X7:73	Data cable RS485	Baud rate 9600…38400Baud Termination resistor R=120Ω	BUS connection parallel to RS485 on RJ12 plug **NOTE:** The termination resistance of DIP switch 1 (see RJ12/RJ45) can also be used for contacts 73/74.
X7:74			

NOTE

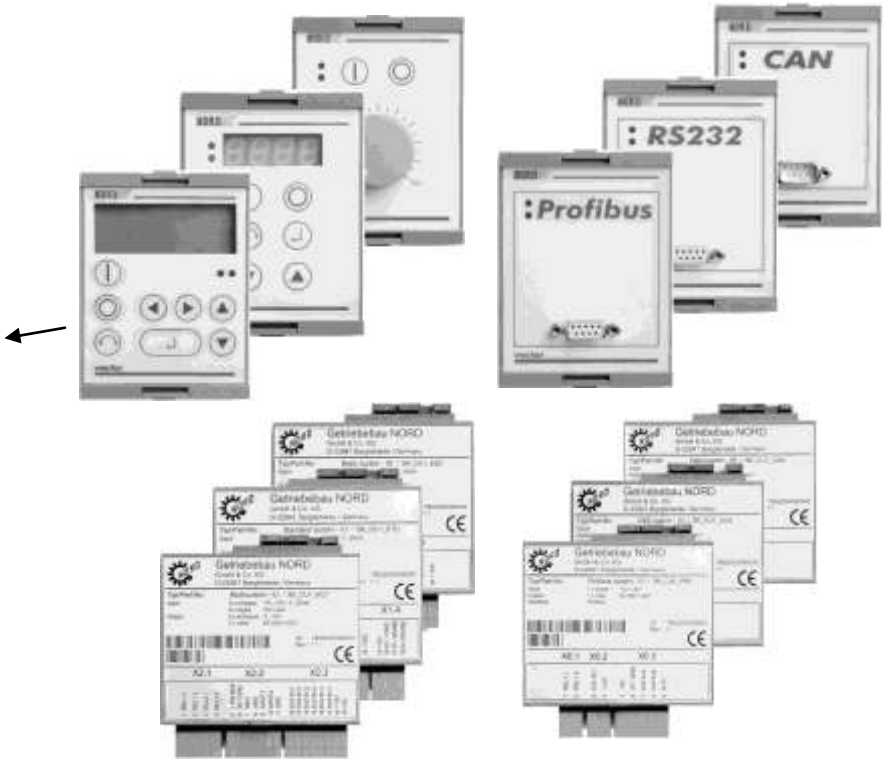
To ensure reliable communication, a termination resistor (DIP switch DIP1) must be set at both ends of the bus.

1.2.2 SK 700E

1.2.2.1 General

With the combination of modules for display, **technology units** and modules with digital and analog inputs and interfaces, **customer interfaces** or **special extensions,** the SK 700E can be easily extended to cater for the requirements of a wide range of applications.

Technology units (**T**echnology **U**nits) are modules which can be inserted from above for display, parameterisation and control of the inverter.



Customer interfaces (**C**ustomer **U**nits) are modules which are inserted into the upper slot inside the inverter. They are used for control and communication using digital/analog signals or bus interfaces.

Special extensions (E**X**tension **U**nits) are inserted into the lower slot of the inverter. Such an extension unit is required if the speed is to be controlled or positioning is to be carried out by an incremental (absolute) encoder.

WARNING

NOTE

Modules must not be inserted or removed unless the device is **free of voltage**. The slots may only be used for the intended modules. The slots are coded to prevent them from being incorrectly connected.

Installation of a technology unit separate from the frequency inverter is not possible. It must be connected directly to the frequency inverter.

1.2.2.2 Technology Box RS232

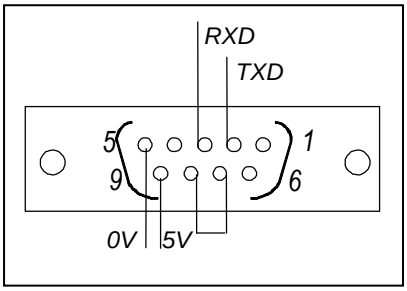
(SK TU1-RS2, Option)

The Technology Box (**T**echnology **U**nit) is clipped to the outside of the inverter.

The RS232 interface enables simple connection of an SK 700E to a PC with a serial interface.

Communication between PC and frequency inverter can be set up using the NORD CON Software (Windows). This is used for the control, parameterisation and display of operating values of the frequency inverter.

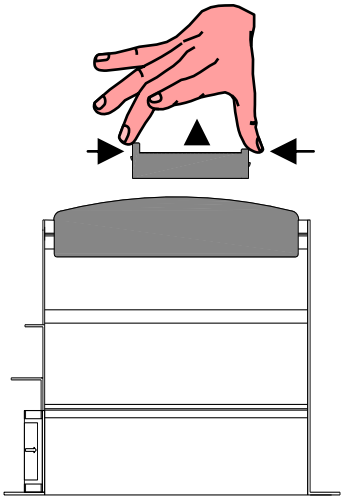
This allows a simple functional test of the inverter to be carried out and, following successful parameterisation, the data set can be saved as a file.



1.2.2.3 Installation of the SK TU1 technology unit

Installation of the technology units must be carried out as follows:

1. Switch off the mains voltage, observe the waiting period.
2. Remove the dummy cover by actuating the unlocking device on the top and bottom edge.
3. Allow the technology unit to engage audibly by pressing lightly on the mounting surface.



WARNING

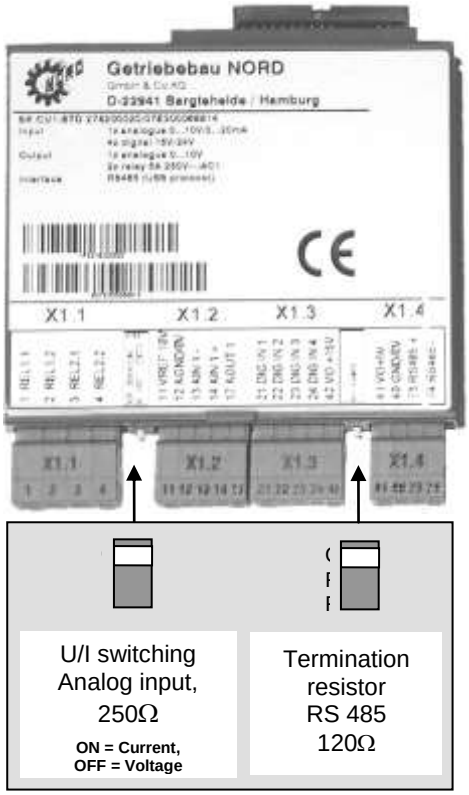
Modules must not be inserted or removed unless the device is free of voltage. The slots may only be used for the intended modules.

Installation of a technology unit separate from the frequency inverter is not possible. It must be connected directly to the frequency inverter.

NOTE

1.2.2.4 Customer unit Standard I/O

(SK CU1-STD, Option)



The standard I/O of the customer interface(**C**ustomer **U**nit) provides sufficient control terminals for most applications and it is fully terminal-compatible with NORDAC *vector mc*..

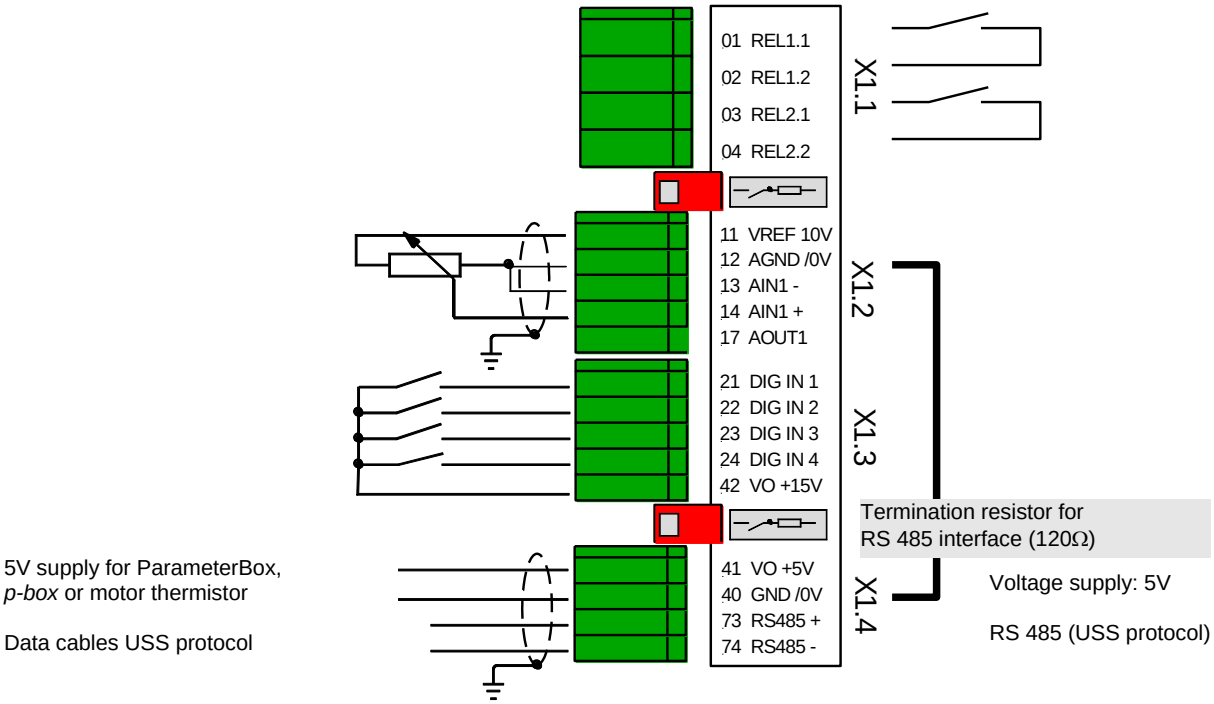
1 analog differential input, 4 digital inputs and 1 analog output are available for control of the frequency inverter.

Readiness for operation is shown via the 2 relay contacts and a mechanical motor brake is activated at the correct time.

The connected frequency inverter can be accessed via the **RS485 interface**. In addition to the entire range of control functions, parameterisation is also possible.

The**NORD CON software** can be used to carry out a simple function test of the serial interface and the parameterisation of the inverter. For this, an interface converter (e.g. SK IC1-232/485) must be used between the PC and the inverter. Following successful parameterisation, the complete data set can be stored as a file by means of NORD CON.

Connector	Functions	Maximum cross-section	Parameter
X1.1	Output relay	1,5 mm^2	P434 ... P443
X1.2	Analog signals IN / OUT	1,0 mm^2	P400 ... P419
X1.3	Digital inputs	1,0 mm^2	P420 ... P423
X1.4	Bus signals / power supply	1,0 mm^2	P503 ... P548



NOTE: All control voltages are based on a common reference potential!
Potentials AGND /0V and GND /0V are internally linked in the device.
The maximum total current 5/15V is 300mA!

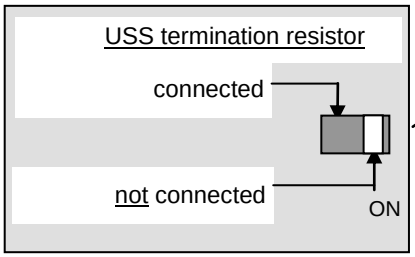
1.2.2.5 USS Customer Interface

(SK CU1-USS, Option)

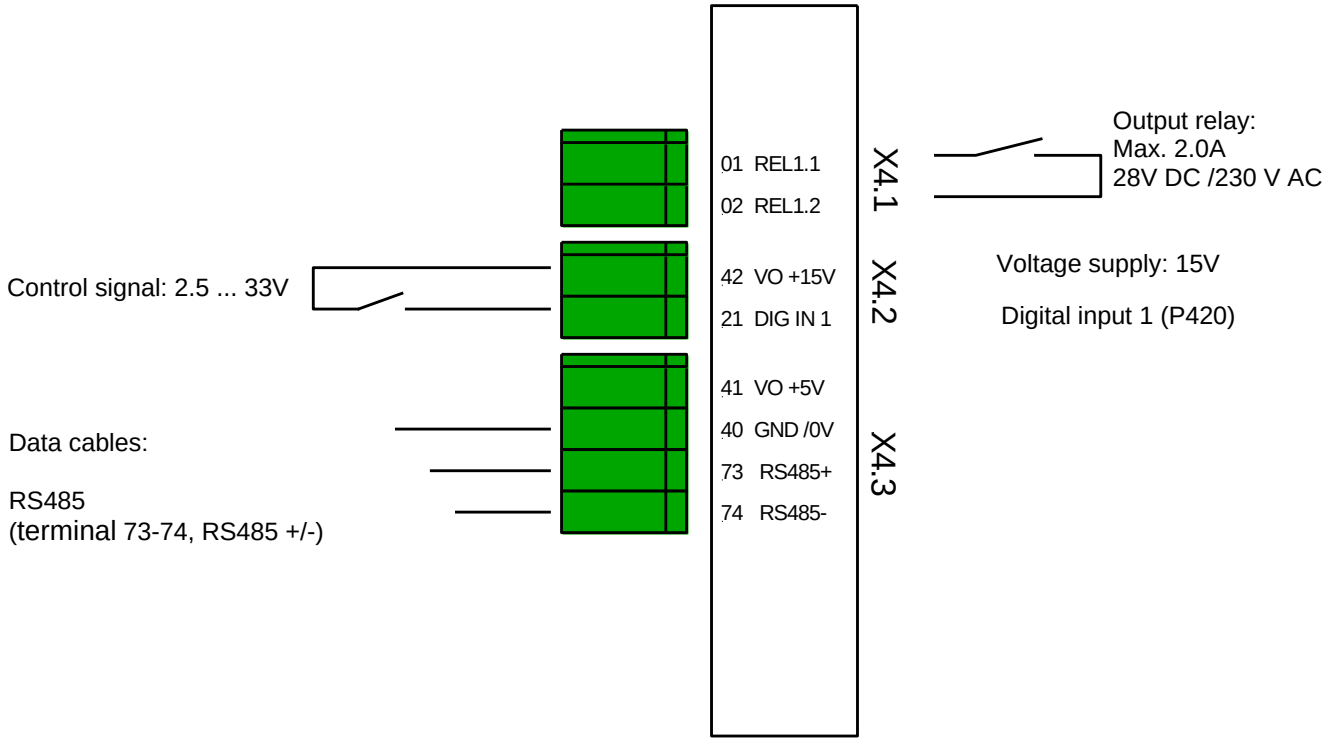
In addition to data connections, the USS customer units are also equipped with conventional digital inputs and outputs.

Via the existing relay contacts, a mechanical motor brake can be controlled or readiness for operation can be communicated to a higher level system.

The digital input has a 2.5V switching threshold for the evaluation of the temperature sensor. The input can, however, also be used for an emergency stop function.



Connector	Functions	Maximum cross-section	Parameter
X4.1	Output relay	1,5 mm^2	P434 ... P436
X4.2	Digital input	1,5 mm^2	P420
X4.3	Data cables	1,5 mm^2	P503 ... P548



NOTE: All control voltages are based on a common reference potential!
Potentials AGND /0V and GND /0V are internally linked in the device.
The maximum total current 5/15V is 300mA!

1.2.2.6 Installation of customer units

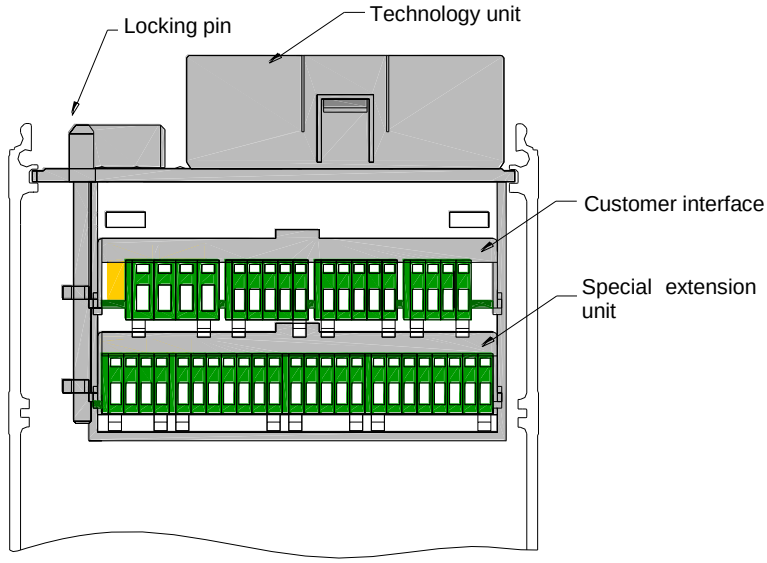
WARNING

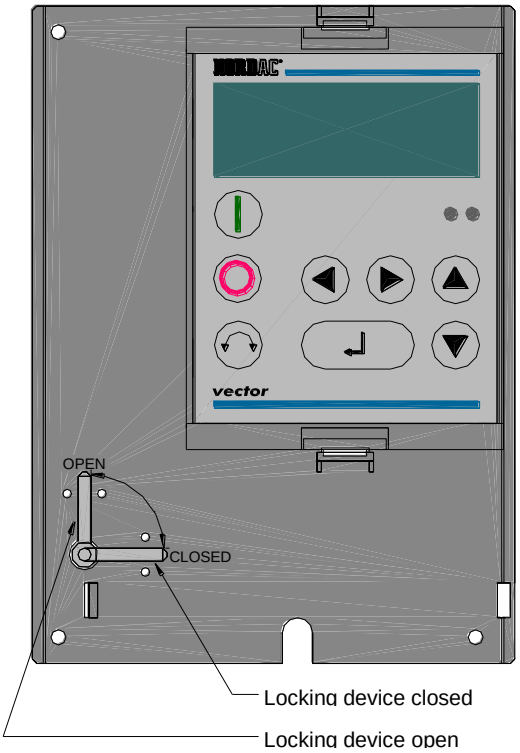
Installation must be carried out by qualified personnel only, paying particular attention to safety and warning instructions.

A customer interface must not be replaced while it is carrying voltage.

NOTE

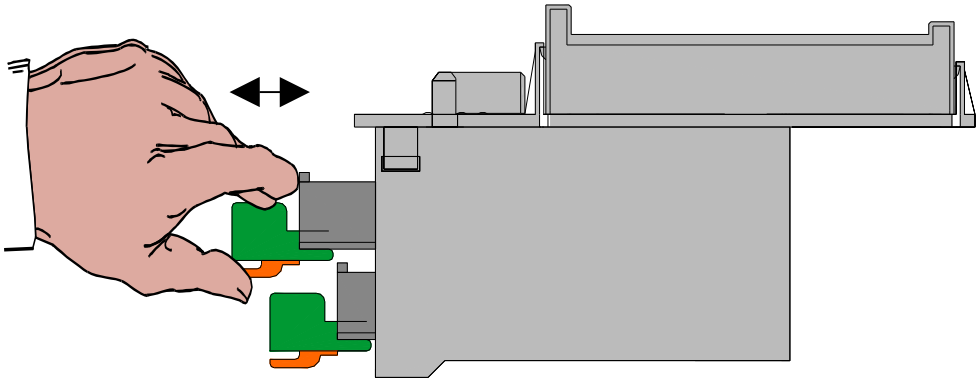
1. Switch off the mains voltage, observe the waiting period.
2. Remove the cover grid from the connection area by loosening the 2 screws and levering out the device cover (slot) or simply pull it out.
3. Locking lever in the "**open**" position.
4. Using light pressure push the customer unit into the upper guide rail until it engages.
5. Move the locking lever to the "**closed**" position.
6. Remove the connector by pressing the releases then make the necessary connections. Then insert the connectors until they engage.
7. Replace all covers.





Removing customer units:

1. Switch off the mains voltage, observe the waiting period.
2. Remove the cover grid from the connection area by loosening the 2 screws and levering out the device cover (slot) or simply pull it out.
3. Locking lever in the "**open**" position.
4. Using a screwdriver (as shown), lever the customer unit out of its engaged position and then remove it by hand.
5. Move the locking lever to the "**closed**" position.
6. Replace all covers.



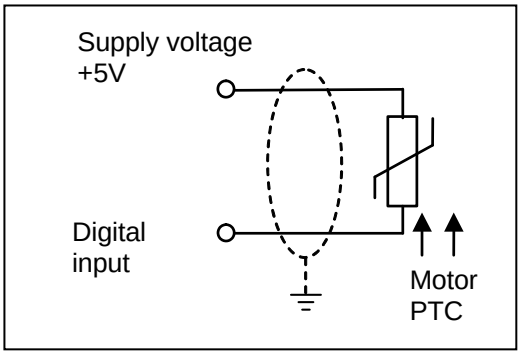
Motor temperature protection **applies for all customer units!**

For secure protection against motor overheating, a **temperature sensor (thermistor, PTC)** can be connected to any digital input.

The appropriate parameters (P420 ... P425, depending on option) must be set to a value of 13 (PTC thermistor input) for this purpose.

The supply voltage varies dependent upon the customer unit. The lowest voltage possible should be chosen.

Internal switching in the inverter prevents excessive PTC voltage.



The cable routing should always be separate from the motor cable and with shielded cables.

1.2.3 SK 300E

Technology units and customer interfaces

Through the combination of modules for the display, (technology units) and modules with digital and analog inputs, as well as interfaces, (customer units) or bus interfaces, the SK 300E can be easily adapted to the requirements of a wide range of applications.

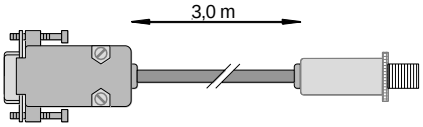
The **NORD CON software** can be used to carry out a simple function test of the serial interface and parameterisation of the inverter. For this, an interface converter (e.g. SK IC1-232/485) must be used between the PC and the inverter. Following successful parameterisation, the complete data set can be stored as a file by means of NORD CON.

Further details can be found in Manual BU 0300.

USS interface (RS485)

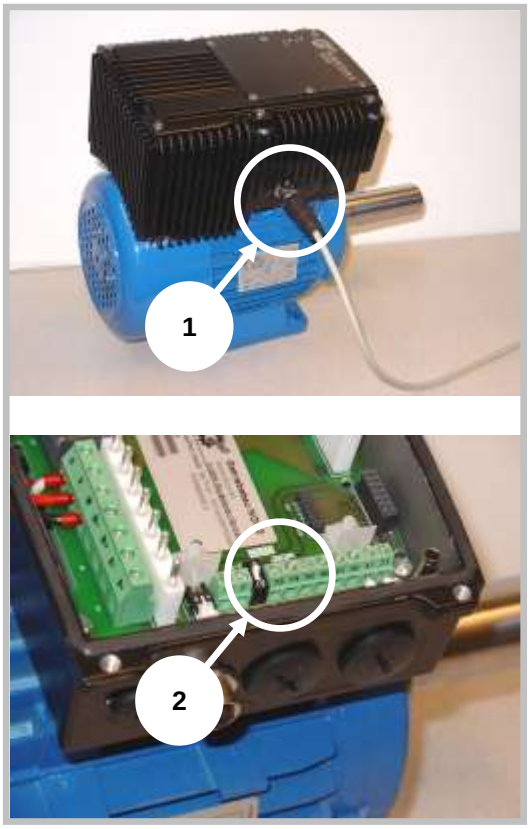
With the SK 300E, an RS485 interface is lead out to a 4-pin M12 round connector (Detail 1) as standard. In addition to being used for external control (ParameterBox) it can also be used as a bus interface.

If required an M12 → SUB D9 (Part No.. 278910060) connecting cable is available.



Parallel to the external M12 connection, in the connection unit (*trio* interface, removed from FI) terminals 73/74 are also available for connection.

The RS485 termination resistor (Detail 2) can be switched in or out using the DIP switch in the connection unit.



M12 connector *(Detail 1)*	Terminal *(Detail 2)*	Functions	Maximum cross-section
4 (black)	73	RS485 +	1,5 mm^2
3 (blue)	74	RS485 -	1,5 mm^2
2 (white)	41	+5V	1,5 mm^2
1 (brown)	40	0V, GND	1,5 mm^2

1.3 USS Protocol Specification

1.3.1 General information

The USS protocol defines an access procedure according to the Master/Slave principle for communication via a serial bus. A sub-set of this also includes point-to-point connection. A master and a maximum of 31 slaves can be connected to a bus. The individual slaves are accessed by the master via an address character in the telegram. Direct exchange of messages between the individual slaves is not possible. Communication is carried out in semi-duplex mode. The master function cannot be transferred (single master system).

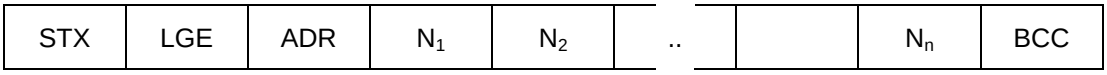
Data transfer via the two-cable bus is carried out by individual characters in the format:
1 start bit, 8 data bits 1 even parity bit and 1 stop bit (**8E1**) - This results in a character frame of 11 bits.

The direction of the data on the bus (transmit or receive) is specified by the master.

1.3.2 Telegram Structure

Each telegram starts with the start character STX (= 02 Hex), followed by the length (LGE) and the address byte (ADR). This is followed by the information characters. The telegram

is concluded by the data saving character BCC (Block Check Character).



For word information (16 Bit) in the information data block (= information character block) the High Byte (first character) is always transmitted first, followed by the Low Byte (second character). The same applies for double-word information:

First the High Word is transmitted, followed by the Low Word.

1.3.3 Data Coding

STX	(Start of Text): ASCII character: 02 Hex The start character forms the first character in the telegram and together with the start pause it is used for reliable detection of the start of the telegram.
LGE	(Telegram length): 1 Byte, contains the length of the telegram. The telegram length is located in the 2nd byte of the telegram and indicates the length of the telegram from the 3rd byte onwards. Specification of the length enables differentiation between the various types of telegram. The data recipient can use the length byte to check the number of characters to be received.
ADR	(Address byte): 1 byte, also contains the slave address. *Bit7 Bit6 Bit5 Bit4 Bit3 Bit2 Bit1 Bit0* 0 M BC | Address (0..30) | The USS address is located in the 3rd byte (data bits 0 to 4) of the telegram. The slave device which is to transmit or receive data is identified via the USS address. Therefore, a maximum of one slave device can be represented by each of the 31 possible addresses For this, the appropriate address must be set in the slave device. Bit 5 and Bit 6 have a special meaning. Bit 5 Broadcast: A so-called broadcast telegram can be triggered by setting this bit. In a broadcast telegram, address bits 0 to 4 are ignored by the connected slaves, i.e. the transmitted telegram is processed by all of the slaves. However, in contrast to standard addressing, the slaves do not transmit a response telegram as this would result in bus conflicts. Bit 6 Echo: By setting the 6th bit, the inverter returns a telegram which is identical to the one which it has received (for commissioning).
N_1... N_n	Information characters: each one byte, content depending on task
BCC	1 byte, data saving character (Block Check Character) The check-sum BCC is formed byte-wise over the entire telegram as an Exclusive OR link. The result after the last net character is then the BCC. BCC = STX XOR LGE XOR ADR XOR N_1 XOR....N_N

1.3.4 Character Frame

Each transmitted character begins with a start bit (logical 0) and end with a stop bit (logical 1). 8 bits (1 byte) are transmitted. Saving is performed by a parity bit (even parity). Therefore 11 bits are transmitted for each character.

1.3.5 Transfer Procedure

The USS protocol functions according to the master/slave principle, whereby the master is the control device (PC, SPS etc) and the slaves are the frequency inverters

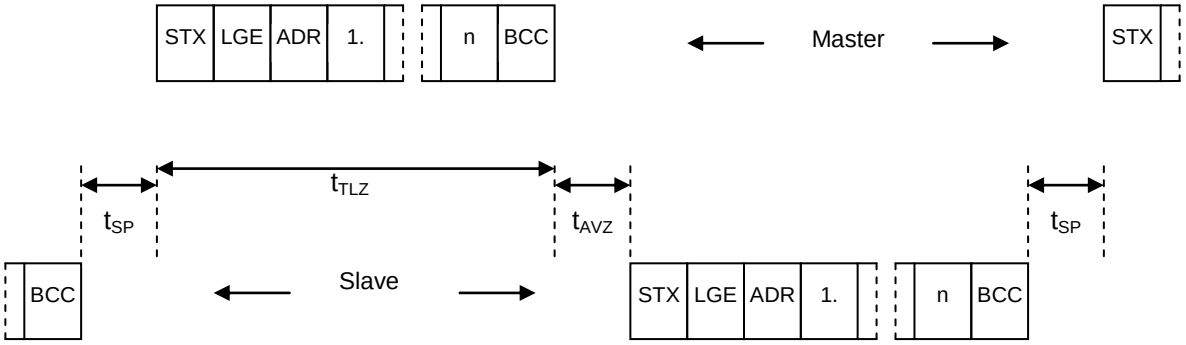
Only one slave can be addressed with each telegram (exception: broadcast telegram without response by the slaves).

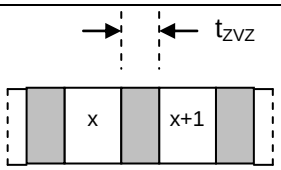
In order to ensure reliable detection of the start of the telegram by the slave, the master must observe a so-called **start pause** between the receipt of the slave telegram and transmission of the next telegram. The master starts to transmit a telegram. After the data package has been sent, the master switches the bus data direction from transmission to reception. The slave addressed in the telegram must respond within a specified **response time**.

The lengths of the master and slave telegrams are the same, i.e. the master telegram determines the length of the response by the slave.

Telegram traffic can be cyclical a acyclical.

The following time definitions must be observed:





Time	Size	Meaning
t_{SP}	Minimum 2 character durations*	Start pause time
t_{AVZ}	Maximum 20 ms	Response Delay Time
t_{TLZ}	1.5 x consecutive telegram duration = 1,5 x (n+4) x character duration	Max. residual telegram duration
t_{ZVZ}	Smallest start pause time	Character delay time
	*Character duration = 11 x (1/Baud rate)	

1.3.6 Start Pause Time

The start character STX (= 02 Hex) on its own is not sufficient to enable the slaves to uniquely identify the start of a telegram, because the bit combination 02/Hex may also occur in the information characters. Therefore, in advance of the STX a start pause time t_{SP} where no characters are sent for at least the duration of 2 characters is specified for the master. The start pause time is a component of the order telegram. A valid telegram is only identified by an STX with a preceding start pause.

The exchange of data is always performed according to the pattern described above (semi-duplex operation):

The minimum start pause time which is to be observed for the various baud rates can be found in the Master Telegram Time table in the Additional Information section.

1.3.7 Response Delay Time

The time interval between the last character of the order telegram (BCC) and the start of the response telegram (STX) is called the **response delay time** t_{AVZ}. The maximum permissible response delay time is **20ms, however, it must not be smaller than the start pause**. If the addressed participant does not respond within the maximum permissible response delay time, an error message is saved in the master. The master then sends the telegram which is intended for the next slave.

The minimum response delay time which is to be observed for the various baud rates can be found in the Master Telegram Time table in the Additional Information section.

1.4 Bus Configuration

1.4.1 General information

The basis for the physical interface of the USS protocol is the 'Recommended Standard RS-485'

For point-to-point connections, a sub-set of EIA RS-232 (CCITT V.24), TTY (20mA current loop) or optic fibre cable can be used as the physical interface.

SK 300E and SK 500E series inverters are always configured with an RS485 interface on the terminal connection bar or connector. For SK 700E series devices, the customer interface standard or USS must be selected.

For the SK 700E series, RS 232 technology modules can be used for communication (only point-to-point communication possible)

1.4.2 Topology

The USS bus is based on a linear topology without spur cables. Both ends of the lines end at a participant and must be terminated there with bus termination networks.

The maximum cable length and the maximum distance between the master and the last slave is restricted by the properties of the cable, the ambient conditions and the transfer rate. With a transfer rate < 100kbit/s, a maximum **length of 1200m** is possible.

[EIA Standard RS-422-A December 1978, Appendix, Page 14]

The number of participants is restricted to 32 (1 master, 31 slaves).

1.4.3 Transfer Method

Transfer is by the half-duplex method, i.e. alternation between transmission and reception, and must be controlled by the software. The half-duplex method allows the use of the same cables for both transfer directions.

This enables simple and low-cost bus wiring, operation in environments where there is interference as well as a high data transfer rate.

1.4.4 Installation of the Bus System

In an industrial environment the correct installation of the bus system is particularly important in order to reduce potential interference. The following points are designed to help prevent interference and problems right from the start.

The installation guidelines are not complete and applicable safety and accident prevention guidelines must be complied with.

1.4.4.1 Cable material

The frequency inverter is usually connected to the USS bus system by a twisted, shielded two-wire cable.

The guaranteed transfer speeds or transfer distances can only be achieved without errors if the specified cable parameters are complied with.

Structural Details:

Cable diameter :	2 ×0,5 mm^2
Flexible strand:	≥16 ×0,2 mm
Twisting:	≥20 twists / m
Total shielding:	Mesh, tinned copper wire, ∅1.1 mm^2, 85 % visual covering
Total diameter:	≥5 mm
External sheath:	according to requirements for flammability, combustion residues, etc.

Thermal / Electrical Properties:

Conductor resistance (20°C):	≤40 W/km
Insulation resistance (20°C):	≥200 MW/km
Operating voltage (20°C):	≥300 V
Test voltage (20°C):	≥1500 V
Temperature range:	-40 °C ≤T ≥80 °C
Load capacity:	≥5 A
Capacitance:	≤120 pF/m

1.4.4.2 Cable runs / Shielding (EMC)

If EMC measures are not in place, high-frequency interference which is principally brought about by switch procedures or lightning often causes electronic components in the Bus participants to become faulty and error-free operation can no longer be ensured.

Proper shielding of the bus cable reduces the electrical interference which can arise in an industrial environment. Best shielding characteristics can be achieved with the following measures

- Connect the Bus participants with the shortest amount of cable possible.
- The shielding of the Bus cable must be applied completely and to a wide area on both sides. *
- Avoid using spur lines to connect field devices to the Bus.
- Avoid extending the Bus lines using plug connectors.

Bus lines should be laid with a minimum spacing of 20cm to other lines which carry a voltage higher than 60V. This applies to lines laid inside and outside of control cabinets.

***)Note:** If earthing potential values are different, transient currents may flow through shielding which is connected on both sides. This may be a danger to electronic components. Differences in potential must be reduced using adequate potential equalisation.

1.4.4.3 Bus termination

The bus lines be terminated at both ends.

For this, a resistance of 120Ω must be connected between the data signal lines RS485 + and RS485 - on the first and last participant.

With some modules, the termination resistor can be switched in with DIP switches. As delivered, the bus termination resistor is not activated.

If the bus termination resistor is not integrated into the module, it must be installed in the module or the connector housing.

1.5 Data transmission

1.5.1 Structure of reference data

This section describes the cyclic data traffic between the master and the frequency inverter.

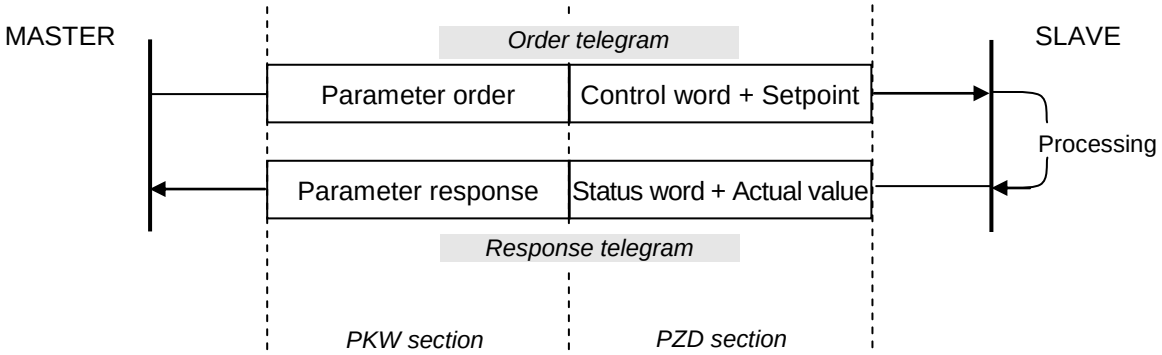
The reference data is divided into two sections:

- PKW section (Parameterisation; **P**arameter **I**dentification- **V**alue)
- PZD section (**P**ro**c**ess**d**ata)

Parameter values can be read and written via the PKW section of the reference data. All tasks which are carried out via the PKW interface are essentially tasks for configuration, monitoring or diagnosis.

The PZD section serves to control the frequency inverter. The control word or status word as well as the setpoint and actual values are transferred in the process data.

Access always consists of an order and a response telegram. In the order telegram, the reference data is transferred to the slave. In the response telegram, the reference data is transferred from the slave to the master. The structure of both telegrams is identical.



Telegram traffic / structure of reference data area

Processing of the process data is carried out immediately in the FI (high priority), in order to ensure a rapid reaction to control commands or a change in status can be transmitted to the master without delay.

On the other hand, the processing speed of the PKW data has a lower priority, so that processing may take considerably longer.

1.5.2 PPO types

For cyclic data traffic, the Parameter- Process data Object (PPO) with which the process data (PZD) and parameters (PKW) are transferred from the master to the frequency inverter is defined. The frequency inverter can process PPO types 1, 2, 3 or 4.

Type	Task
PPO1	extended parameter data telegram with 32 bit parameter values and process data
PPO2	Telegram with extended process data (main and two auxiliary setpoint values) and 32 bit parameter value
PPO3	Process data telegram with main setpoint value without parameter data
PPO4	extended process data telegram with main and auxiliary setpoint values without parameter data

PPO3 and PPO4 are purely process data objects for applications which do not require parameter processing.

Abbreviations used:

PPO	Parameter Process data Object
PKW	Parameter identifier Value
PZD	Process data
PKE	Parameter identifier
IND	Index
PWE	Parameter Value

STW	Control word
ZSW	Status word
SW1..3	Setpoints 1-3
IW1..3	Actual values 1-3

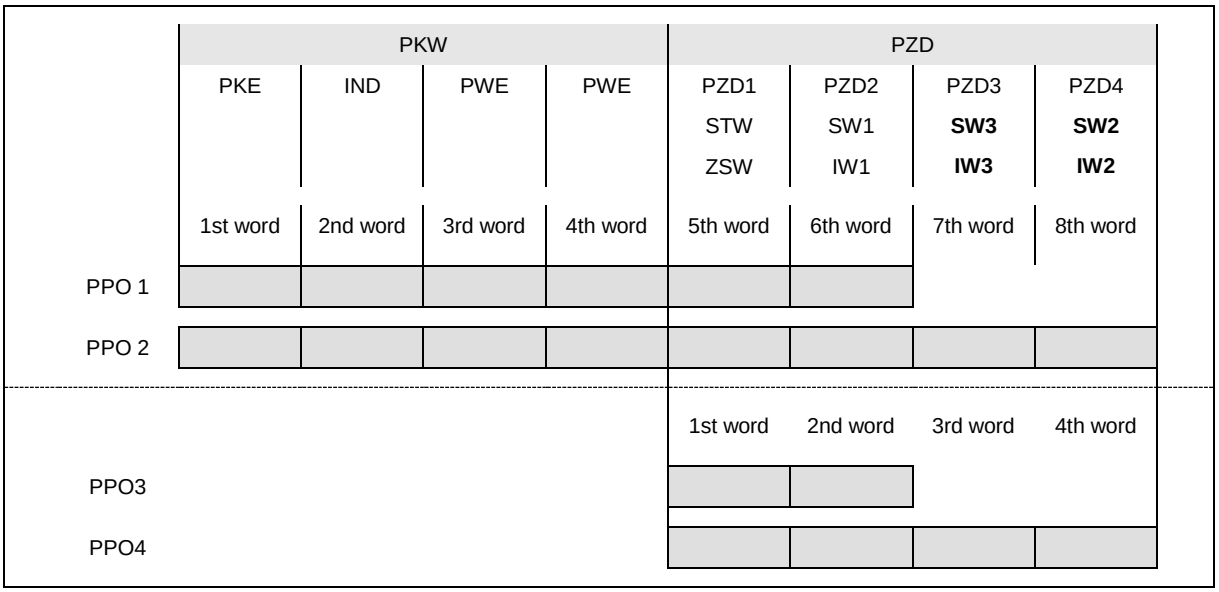
Note:: An SPS can normally only consistently transfer double words by means of I/O memory access. For longer data formats (PKW channel always / PZD data with PPO2 or PPO4) system functions (e.g. SFC 14, consistent data reading / SFC15, consistent data writing) must be used.

NOTE

Because of the protocol specification, for **PPO types 2 and 4 6 words must be reserved** for the address area of the process data (PZD). The two last words are not used for the process data telegrams and are therefore merely reserve areas.

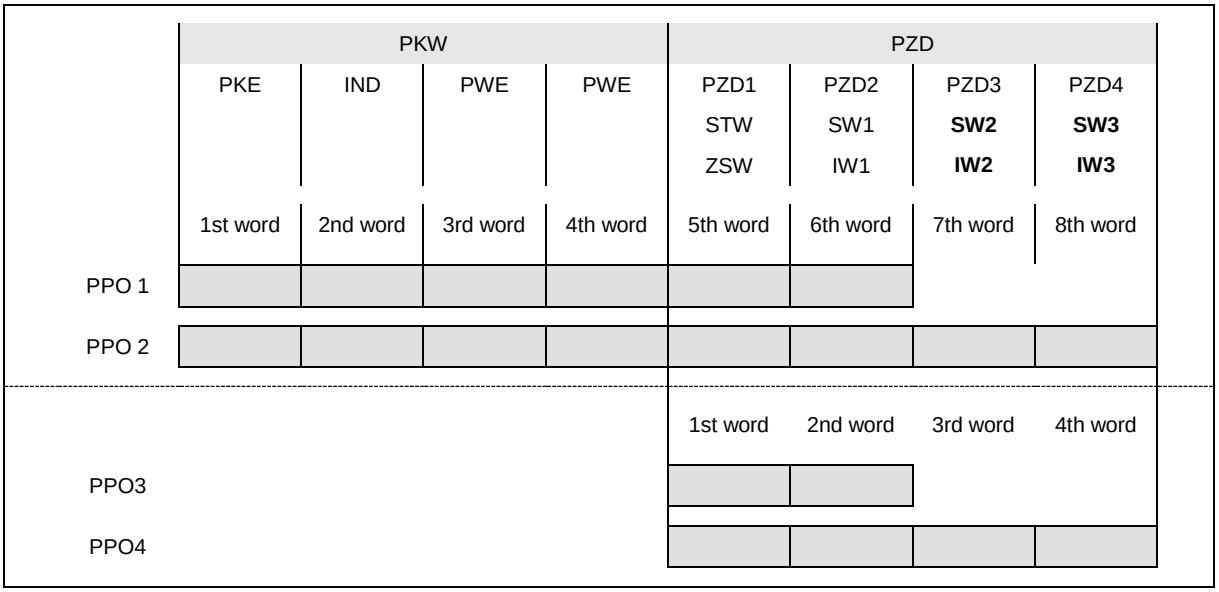
1.5.2.1 PPO types SK 300E/700E/750E

The following diagram shows an overview of the supported PPO types.



1.5.2.2 PPO types for SK 500E series

The following diagram shows an overview of the supported PPO types. Please not the arrangement of SW2/SW3 and IW2/IW3



1.5.3 Process data (PZD)

In the process data area PZD, control words and setpoints are transferred from the master to the slave (frequency inverter) and in return, status words and actual values are sent from the slave to the master. The structure of the PZD area is always the same in terms of the sequence of its elements (words), however, dependent upon direction of data Master ⇒ Slave / Slave ⇒ Master, it is designated differently

The process data area of the reference data has the following structure:

- STW: **C**ontrol**w**ord; length 16 Bit, order telegram
  contains control bits (e.g. enable, quick stop, error acknowledgement)
- ZSW: **S**tatus**w**ord; length 16 Bit, response telegram
  contains status bits (e.g. FI running, error)
- SW1..3: **S**etpoint**v**alues; maximum of 3 possible, 16 or 32Bit, order telegram
  e.g. frequency setpoint value, position setpoint value, torque setpoint value
- IW1..3: **A**ctual**v**alues; maximum of 3 possible, 16 or 32Bit, response telegram
  e.g. actual frequency value, actual position value, actual torque value

1.5.3.1 Process data for SK 300E/700E/750E

	1st word	2nd word	3rd word	4th word
PZD area with 1x16 bit setpoint	STW ZSW	SW1 IW1		
PZD area with up to 3 16 bit setpoints	STW ZSW	SW1 IW1	**SW3** **IW3**	**SW2** **IW2**
PZD area with 1x 32-Bit setpoint and 1x 16-Bit	STW ZSW	SW1 IW1		SW2 IW2

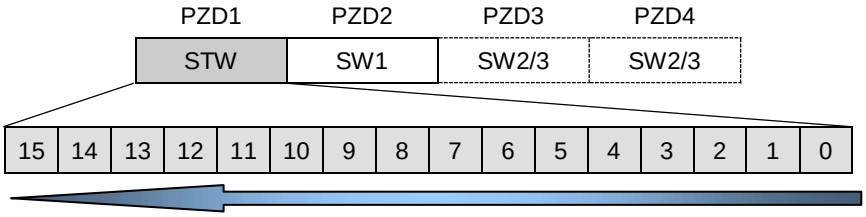
1.5.3.2 Process data for SK 500E (entire series)

	1st word	2nd word	3rd word	4th word
PZD area with 1x16 bit setpoint	STW ZSW	SW1 IW1		
PZD area with up to 3 16 bit setpoints	STW ZSW	SW1 IW1	**SW2** **IW2**	**SW3** **IW3**

Note: 32-Bit setpoints consist of High and Low words (16-Bit each).

1.5.3.3 Control word (STW)

The control word (STW) is the first word transferred to the frequency inverter in the process data area in an order telegram. For example, a control word "Ready for switch-on" corresponds to $047E_{(hex)}$.

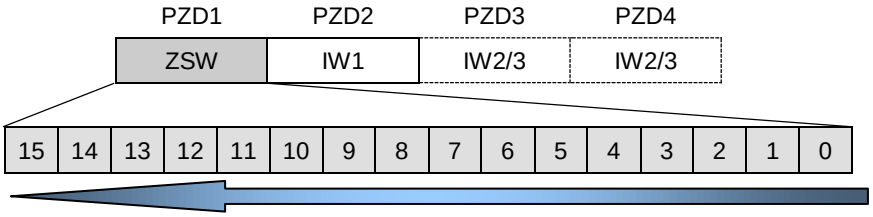


Bit	Value	Meaning	Comments
0	0	OFF 1	Reverse with the brake ramp, with disconnection from supply at f=0Hz
	1	ON	Ready for operation
1	0	OFF 2	Cut off voltage; the inverter output voltage is switched off; the FI enters a state where switching on is disabled.
	1	Operating condition	OFF 2 is cancelled
2	0	OFF 3	Quick stop with programmed quick stop time; with disconnection from supply at f=0Hz; the FI switches to starting disabled condition.
	1	Operating condition	OFF 3 is cancelled
3	0	Disable operation	Cut off voltage; the inverter output voltage is switched off; the FI enters a state where switching on is enabled.
	1	Enable operation	The output voltage is enabled; ramp to the existing setpoint
4	0	Lock ramp generator	Ramp generator is set to zero; no disconnection from supply at f=0Hz; FI remains in the operation enabled state.
	1	Operating condition	Enable ramp generator
5	0	Stop ramp generator	The setpoint currently provided by the ramp generator is "frozen" (frequency is maintained).
	1	Enable ramp generator	Enable setpoint on ramp generator
6	0	Disable setpoint	Selected setpoint value is set to zero on the ramp generator.
	1	Enable setpoint	Selected ramp generator setpoint is activated.
7	0	No acknowledgement	With the switch from 0 to 1, errors which are no longer active are acknowledged.
	1	Acknowledge	Note: When a digital input has been programmed for the "ack.fault" function, this bit must not permanently be set to 1 via the bus (otherwise, edge evaluation would be prevented).
8	0		
	1	Bit 8 active	Bus bit 8 from the control word is set. (Only for SK 200E and SK 500E) For further details of the function please refer to parameter (P480).
9	0		
	1	Bit 9 active	Bus bit 9 from the control word is set. (Only for SK 200E and SK 500E) For further details of the function please refer to parameter (P480).
10	0	PZD invalid	The transmitted process data is invalid.
	1	PZD valid	Valid process data is transferred from the master. **Note:**If setpoints only are transferred via the bus, this bit must be set so that the transferred setpoint is valid.
11	0		
	1	Rotational direction: right	Rotational direction right (priority) ON*
12	0		
	1	Rotational direction: left	Rotational direction left ON*
13	0/1		Reserved
14	0/1	Bit 0 to switch parameter set	00 = Parameter set 1 01 = Parameter set 2
15	0/1	Bit 1 to switch parameter set	10 = Parameter set 3 11 = Parameter set 4

* If Bit 12=0, then "Direction of rotation right ON" applies

1.5.3.4 Status word (ZSW)

In the inverter response telegram, in the area of the process data the status word (ZSW) is transferred as the first word. For example, the status word "Ready for switch-on" corresponds to $0B31_{(hex)}$.



Bit	Value	Meaning	Comments
0	0	Not ready to start	
	1	Ready to start	Initialisation completed, charging relay ON, output voltage disabled
1	0	Not ready for operation	Causes: No command has been activated, fault is signaled, OFF2 or OFF3 activated, starting disabled state activated
	1	Ready for operation	ON command activated, no faults present. The inverter can be started with the command ENABLE OPERATION
2	0	Operation disabled	
	1	Operation enabled	The output voltage is enabled; ramp to the existing setpoint
3	0	No fault	
	1	Fault	Drive fault resulting in stoppage; this state is changed to starting disabled after the fault has been successfully acknowledged
4	0	OFF 2	OFF2 command applied
	1	No OFF 2	
5	0	OFF 3	OFF3 command applied
	1	No OFF 3	
6	0	Starting not disabled	
	1	Starting disabled	Switches first to OFF1, then to ready-to-start status
7	0	No warning	
	1	Warning	Drive operation continues, no acknowledgement necessary
8	0	Actual value not O.K.	Actual value does not match the setpoint (with *POSICON:* failure to reach setpoint position)
	1	Actual value O.K.	Actual value matches required setpoint (setpoint has been reached) (with *POSICON:* setpoint has been reached)
9	0	Local guidance	Guidance on local device has been activated
	1	Guidance requested	The master has been requested to assume guidance.
10	0		
	1	Bit 10 active	Bus bit 10 from the status word is set. For further details of function, please refer to parameter P481.
11	0		
	1	Rotational direction: right	Inverter output voltage is turning right
12	0		
	1	Rotational direction: left	Inverter output voltage is turning left
13	0		
	1	Bit 13 active	Bus bit 13 from the status word is set. For further details of function, please refer to parameter P481.
14	0/1	Currently active parameter set 0	00 = Parameter set 1 01 = Parameter set 2 10 = Parameter set 3 11 = Parameter set 4
15	0/1	Currently active parameter set 1	

Deviations in the status word (ZSW) for SK 300E and SK 700/750E series devices

With the above device types, the meanings of the two bits 10 and 13 in the status word deviate from the status word of the SK 500 E.

Meaning of the two individual bits:

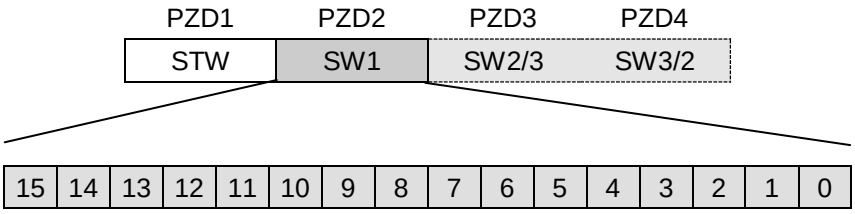
Bit	Value	Meaning	Comments
10	0	MFR 1 reference value undershot	Programmed function of the MFR 1 not met or actual value < programmed reference value
	1	MFR 1 reference value reached	Programmed function of the MFR 1 is fulfilled, or Actual value > programmed reference value
13	0	MFR 4 reference value undershot	Only for SK 700E/750E with POSICON extension: Status MFR 4 = 0
	1	MFR 4 reference value reached	Only for SK 700E/750E with POSICON extension: Status MFR 4 = 1

1.5.3.5 Setpoint 1 (SW1)

The function of the 1st setpoint is set in parameter P546. The following options are available:

Setpoint frequency

The setpoint frequency in setpoint 1 is transferred as a 16 Bit value as standard. Setpoint 1 is transferred to the inverter as the second word in the process data area in the order telegram.



The setpoint is transferred as a whole number with a value range of -32768 to 32767 (8000 hex to 7FFF hex). The value 16384 (4000 hex) is equal to 100%. The value C000 HEX corresponds to -100%. A setpoint of 100% corresponds to the parameter **maximum frequency** (parameter P105) set in the same parameter set.

Setpoint position (16 or 32 Bit)

With the special extension **Posicon (SK XU1-POS) of the SK 700E** the absolute setpoint position can be transferred as a 16 or 32 Bit value in Setpoint 1, whereby the resolution is 1=0.001 rotation. In addition, the control terminals (*setting of POSICON control bits*) can be transferred in binary.

The **SK 53xE / SK54xE version** of the SK 500E series is also able to transfer positions, however here, the 32 Bit position is divided into two 16 Bit components (Low word and High word). The assignment of the two 16 Bit components is then carried out via appropriate parameterisation on 2 arbitrary setpoints (e.g.: SW1 and SW2).

16-Bit setpoint position setting:

As a **16 Bit** value, a range of +32767 (= 32,767 revolutions) to -32768 (= -32,768 revolutions) is possible. The 16 Bit setpoint position is transferred as the second word in the process data area (as with the setpoint frequency)

32-Bit setpoint position setting:

As a **32 Bit** value, the full position range of +/- 50000,000 revolutions is available. With the SK 700E/750E, the 32 Bit setpoint position is transferred in the area of the process data as the **second and third** word (with the SK 500E in any two of the three words PZD2, PZD3, PZD4).

PZD1	PZD2	PZD3	PZD4	
STW	SW1, 32 Bit		SW2	SK 700E/750E POSICON
	P546=3, 32bit setpoint position			
	SW1, 16 Bit	SW2, 16 Bit	SW3	
	P546=21 (23) Low word	P547=22 (24) High word		SK 53xE
	P546[-01]=21 (23) Low word	P546[-02]=22 (24) High word		SK 54xE

Control Bit settings *POSICON (SK 700E/750E/53xE)*:

A 16 Bit value is transferred in which the control terminals of the POSICON special extension unit are mapped. The setpoint position is based on the position array or position increment as per (P610).

The transferred Bits have the following meaning (see Manual BU 710 / BU 0510):

SK 700E + SK TU1-POS	
Bit	**Function**
Bits 0-5	Position array/position increment
Bit 6	Reference point run
Bit 7	Reference point
Bit 8	Teach-in
Bit 9	Quit teach-in
Bit 10	Reset position

SK 500E	
Bit	**Function**
Bits 0-3	Position array/position increment
Bits 4-7	Vacant
Bits 8-15	no significance

1.5.3.6 Second and third setpoint (SW2/3)

With the SK 500E, the assignment of setpoints 2 and 3 to the process data words PZD3 and PZD4 is carried out in the opposite manner to the SK 300E/700E/750E series.

Second and third setpoint SK 300E/SK 700E/SK 750E(SW2/3)

If the PPO type 2 or 4 is used, in addition to setpoint 1, a 2nd setpoint can be transferred in word PZD4 and a 3rd setpoint in PZD3.

PZD1	PZD2	PZD3	PZD4
STW	SW1	SW3	SW2

A third setpoint value can only be transferred if a 32 Bit setpoint value is not transferred in the first setpoint.

PZD1	PZD2	PZD3	PZD4
STW	SW1		SW2

The second and third setpoints are always 16 Bit. The function of the second and third setpoints can be set in the inverter with parameter P547 ‘’*Setpoint function 2*’ and P548 ‘’*Setpoint function 3*’ respectively.

Both setpoints are transferred as whole numbers in the range (-32768 to 32767). The value 16384 (4000 HEX) corresponds to 100%. The value C000 HEX is equal to –100%, so that setpoints in the range –200% to +200% can be transferred. A setpoint of 100% corresponds to the respective nominal value:

Setting	**100% is equal to**
Off	
Setpoint frequency, actual frequency PID, actual frequency PID limited, actual frequency PID monitored, frequency addition, frequency subtraction, maximum frequency	Maximum frequency (P105)
Torque current limit	Torque current limit (P112)
Current limit	Inverter rated current
Servo mode torque	Nominal torque (P112)
Lead torque	Lead torque (P214)

In addition, POSICON control bits can be transferred here (see setpoint 1)

Second and third setpoint SK 500E (SW2/3)

In addition to setpoint 1, a second setpoint can be transferred in word PZD3 and a third setpoint in PZD4.

PZD1	PZD2	PZD3	PZD4
STW	SW1	SW2	SW3

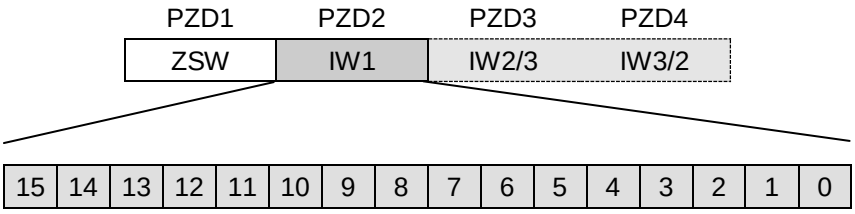
The second and third setpoints are always 16 Bit. The function of the second and third setpoints can be set in the inverter with parameter P547 ‘Setpoint 2 function’ and P548 ‘Setpoint 3 function’ respectively.

Both setpoints are transferred as whole numbers in the range -32768 to 32767. The value 16384 (4000 HEX) corresponds to 100%. The value C000 HEX is equal to –100%, so that setpoints in the range –200% to +200% can be transferred. A setpoint of 100% corresponds to the respective nominal value:

Setting	**100% is equal to**
Off	
Setpoint frequency, actual frequency PID, actual frequency PID limited, actual frequency PID monitored, frequency addition, frequency subtraction, maximum frequency	Maximum frequency (P105)
Torque current limit	Torque current limit (P112)
Current limit	Inverter rated current
Servo mode torque	Nominal torque (P112)
Lead torque	Lead torque (P214)

1.5.3.7 Actual value 1 (IW1)

The actual value 1, i.e. the actual output frequency of the inverter, is transferred as a 16 Bit value as standard in the actual value 1. The actual value 1 is transferred to the master in the inverter response telegram as the second word in the process data area.



The actual value 1 is transferred as a whole number in the range (-32768 to 32767). In addition to the actual frequency, other actual inverter values can be transferred. The setting is made in P543 *'Actual value 1 function*'.

The settings ‘Actual frequency’, ‘Actual speed’, ‘Current’ and ‘Torque current’ are transferred as percentages of the respective nominal values. The value 16384 (4000 HEX) corresponds to 100%. The value C000 HEX corresponds to -100%. Actual values in the range –200% to +200% can be transferred.

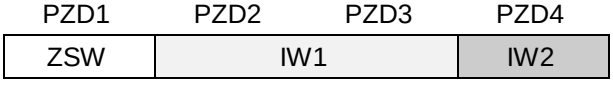
With the setting ‘Digital I/O status’, the states of the control terminals and the relay (MFR) /digital outputs can be transferred:

SK 700E/750E	
Bit	**Status**
Bits 0-5	Digital input 1-6
Bits 6-11 for *POSICON* special extension unit	Digital input 7-12
Bit 6 for encoder special extension unit	Digital input 7
Bits 12-15	Multifunctional relay 1-4

SK 500E	
Bit	**Status**
Bits 0-4	Digital input 1-5
Bits 5-6 (above SK 520E)	Digital input 6-7
Bits 12-15	Relay and digital outputs 1 - 4

With the setting 'Actual position' and 'Setpoint position' the actual absolute position is transferred. The resolution is 1 = 0.001 revolutions.

If **with SK 700E/750E** the value 'Setpoint position 32 Bit' is set in parameter P546 (*Setpoint function 1*), then the actual value (setpoint or actual position) is also transferred as a 32 Bit value in PZD2 and PZD3:



1.5.3.8 Actual value 2 and actual value 3 (IW2/3)

It is possible to forward two more actual values to the controller if PPO type 2 or 4 is used for transfer.

The assignment of the actual values 2 and 3 to the process data words PZD3 and PZD4 is carried out in the same way as the assignment of setpoints 2 and 3. These also differ in sequence between the SK 500E and other inverter series.

Second and third actual value SK 300E/SK 700E/SK 750E(SW2/3)

The actual value 2 (IW2) is transmitted in PZD4. The value to be transferred can be selected in P544 (actual bus value 2). Actual value 3 (IW3) can be transmitted in PDZ3 if actual value 1 is **not** a 32 Bit value. The value to be transferred can be selected in P545 (actual bus value 3).

Second and third setpoint SK 500E (SW2/3)

The actual value 2 (IW2) is transmitted in PZD3. The value to be transferred can be selected in P544 (actual bus value 2). The actual value 3 (IW3) is transmitted in PZD4. The value to be transferred can be selected in P545 (actual bus value 3).

1.5.3.9 The status machine

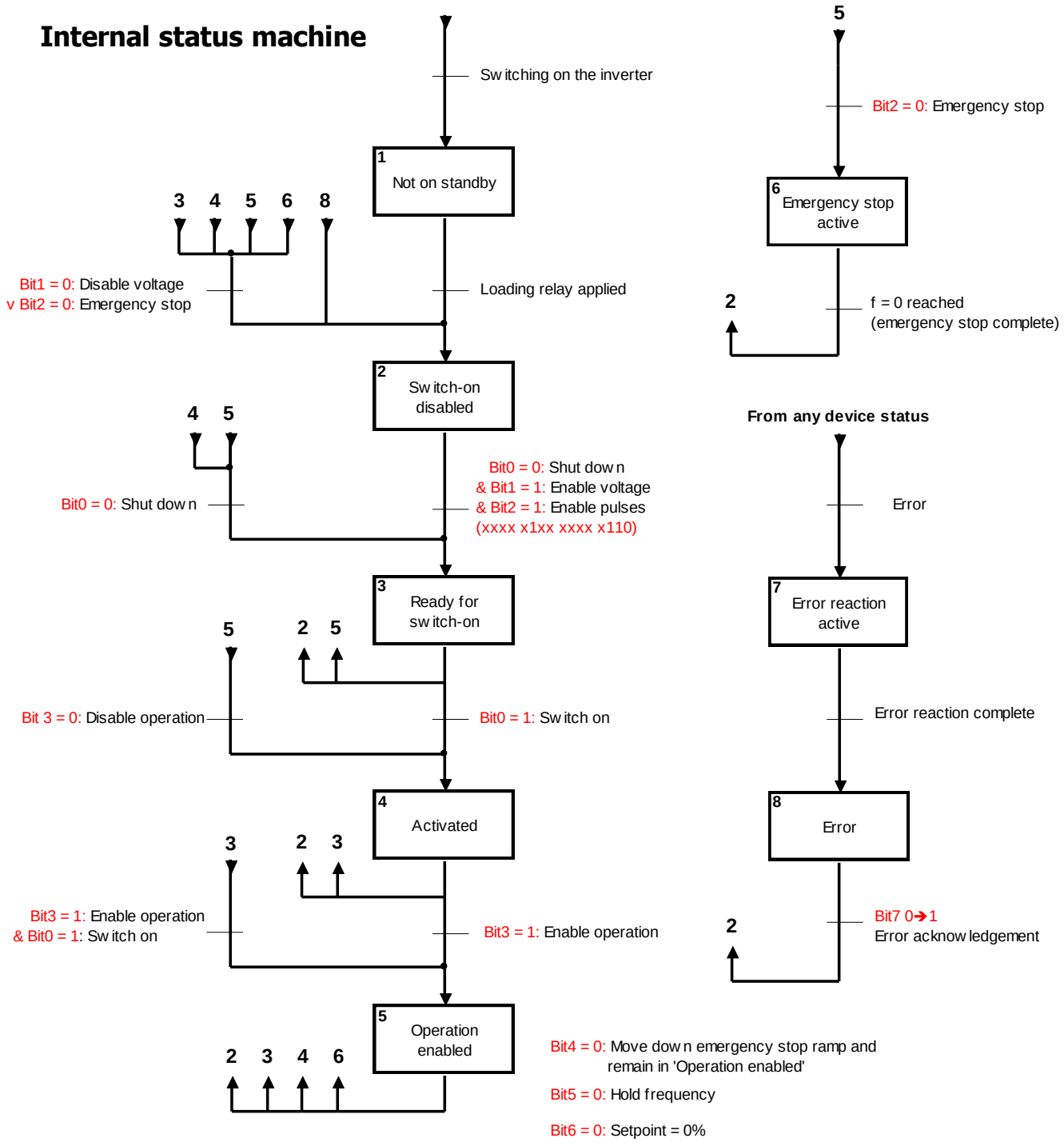
The frequency inverter passes through a status machine. The changes between various states are triggered by the respective control commands in the process data control word. The actual status is returned in the process data status word.

After switching on, the inverter is in **switch-on disabled** status. This status can only be ended by transmitting the “Shut down (Off 1)” command.

The answer to a Master telegram normally does not yet contain a reaction to the control command. The controller must check the answers from the slaves as to whether the control command has been carried out.

The following Bits indicate the status of the frequency inverter:

Status	Bit 6 Switch-on disable	Bit 5 Emergency stop	Bit 4 Disable voltage	Bit 3 Fault	Bit 2 Operation enabled	Bit 1 Standby	Bit 0 Ready for switch-on
Not ready to start	0	X	X	0	0	0	0
Starting disabled	1	X	X	0	0	0	0
Ready to start	0	1	1	0	0	0	1
Activated	0	1	1	0	0	1	1
Operation enabled	0	1	1	0	1	1	1
Fault	0	X	X	1	0	0	0
Error active	0	X	X	1	1	1	1
Emergency stop active	0	0	1	0	1	1	1



Control bits
0. Standby / Shut down
1. Disable / enable voltage
2. Enable pulses / emergency stop
3. Disable / enable operation
4. Betriebsbedingung / HLG sperren
5. Enable / stop RUE
6. Enable / disable setpoint
7. Error acknowledgement (0➔1)
10. Control data valid / invalid
11. Direction of rotation clockwise
12. Direction of rotation anticlockwise
14. Parameter set Bit 0
15. Parameter set Bit 1

Priority of control commands:
1. Disable / enable voltage
2. Emergency stop
3. Shut down
4. Enable operation
5. Switch on
6. Disable operation
7. Reset error

Coding of status:
1: Bit 0 = 0
2: Bit 6 = 1
3: Bit 0 = 1
4: Bit 1 = 1
5: Bit 2 = 1
6: Bit 5 = 0
7: Bit 2 & Bit 3 = 1
8: Bit 3 = 1

1.5.4 Parameter range (PKW)

Using the PKW mechanism, parameter processing can be carried out in the cyclical data traffic. For this the master formulates an order and the inverter formulates the response to this. The parameter area is only used for transfer with PPO type 1 and PPO type 2.

In principle, the parameter range consists of a **parameter identification**, in which the type of order (Write, Read etc.) and the relevant parameters are specified. Individual parameter sets or array elements can be addressed with the aid of the **Index**. The **parameter value** contains the value to be written or read.

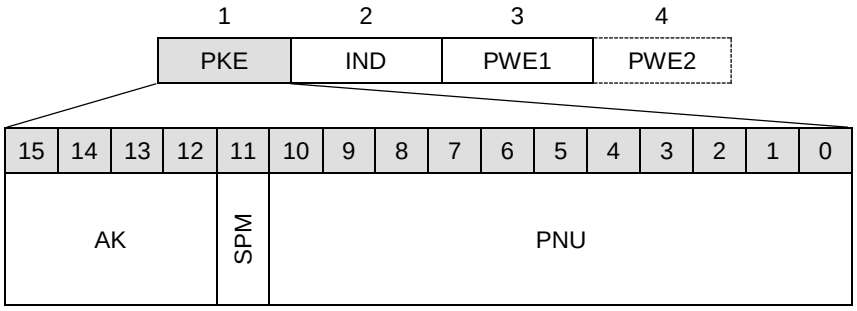
Note: A parameter order must be repeated until the inverter responds with the corresponding response telegram.

NOTE

If parameter changes are made i.e. parameter identifier values (PKW), care must be taken that the maximum number of permissible writing cycles to the frequency inverter EEPROM (100,000 cycles) is not exceeded. I.e. continuous cyclical writing must be prevented. For certain applications it is sufficient if the values are only saved in the RAM memory of the frequency inverter. For further details se Saving in the EEPROM under Parameter P560 in the frequency inverter manual.

1.5.4.1 Parameter label (PKE)

The order or response and the associated parameters are encrypted in the parameter label (**PKE**).



The parameter label (**PKE**) is always a 16 bit value.

PNU: The bits 0 to 10 contain the number of the required parameter (**PNU**),or the number of the current parameter in the response parameter from the inverter.

Note: For the inverter parameter numbers (**PNU**) of the particular inverter series please refer to the relevant operating instructions for the inverter.

SPM: Bit 11 is the toggle-bit for spontaneous messages. This function is **not** supported!

AK: Bits 12 to 15 contain the order or response label.

The following table lists all the orders which can be transferred from the master to the inverter. The right-hand column contains the response, which is normally sent (response label positive). Only certain response labels are possible, depending on the order label. In case of error (response label negative) the inverter will always supply the value 7 in the response label (AK) to the master.

AK	Function	Response label positive
0	No order	0
1	Order parameter value	1 / 2
2	Change parameter value (word)	1
3	Change parameter value (double word)	2
4	Reserved	-
5	Reserved	-
6	Order parameter value (array)	4 / 5
7	Change parameter value (array word)	4
8	Change parameter value (array double word)	5
9	Order the number of array elements	6
10	Reserved	-
11	Change parameter value (array double word) without writing into EEPROM	5
12	Change parameter value (array word) without writing into EEPROM	4
13	Change parameter value (double word) without writing into EEPROM	2
14	Change parameter value (word) without writing into EEPROM	1

Meaning of the values sent in the response label:

AK	Function
0	No response
1	Transfer parameter value (word)
2	Transfer parameter value (double word)*
4	Transfer parameter value (array word)
5	Transfer parameter value (array double word)*
7	Order cannot be executed (with error number in PWE2)

* Only for PPO type 2 and PPO type 4

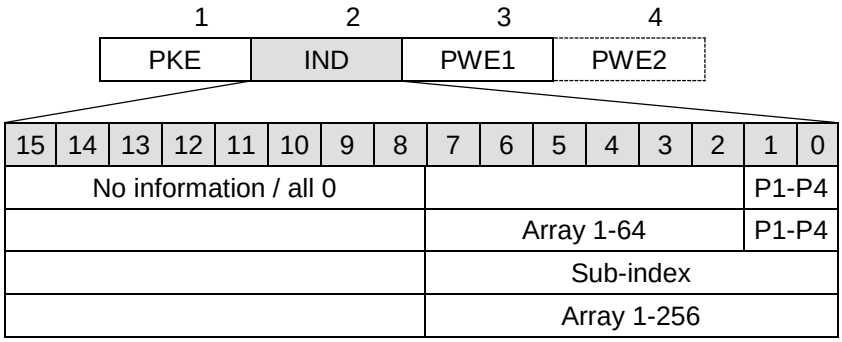
As long as an order has not yet been executed, the inverter provides the response to the last order. Therefore the master must always check whether the received response matches the order sent.
For the plausibility check, the value in the response label (AK), the received parameter number (PNU) with the corresponding Index (IND) as well as the current parameter value (PWE) can be used for the description of parameters.

Error messages if the order cannot be executed

If the response label is "Order cannot be executed" (AK = 7), then an error message is added to the parameter value (**PWE2**) of the inverter response. For the meanings of the transferred values , please refer to the following table.

No.	Meaning
0	Invalid parameter number
1	Parameter value cannot be changed
2	Lower or upper value limit exceeded
3	Incorrect sub-index
4	No array
5	Invalid data type
6	Only resettable (only 0 may be written)
7	Description element cannot be changed
9	Description data not present
201	Invalid order element in the last order received
202	Internal response label cannot be depicted

1.5.4.2 Sub-index (IND)



The structure and function of the parameter index (IND) depends on the type of parameter to be transferred.

For values which depend on the parameter set, the parameter set can be selected via Bits 0 and 1 of the Index (IND) (0 = parameter set 1, 1 = parameter set 2,...).

If the parameter to be processed is also an array parameter (e.g. position array for the POSICON option), then the sub-index of the required parameter can additionally be accessed via Bit 2 to Bit 7 of the sub-index (0 = array element 1, 1 = array element 2,…):

Array element	Parameter set	Index
5 (000101_{BIN})	2 (01_{BIN})	15_{HEX} = 0001 0101 $_{BIN}$
21 (010101_{BIN})	4 (11_{BIN})	57_{HEX} = 0101 0111 $_{BIN}$

If a parameter is not dependent on the parameter set, then Bits 0 -7 are used for the sub-index.

Please refer to the operating instructions for details of the structure of the individual parameters and which values may be called up.

1.5.4.3 Parameter value (PWE)

According to the type of the PPO or parameter, transfer of the parameter value (PWE) is always as a word (16 Bit) or double word (32 Bit) Only one parameter value can be transferred in a telegram.

A 32 bit parameter value comprises PWE1 (high value word) and PWE2 (low value word, 4th word).

A 16 Bit parameter value for PPO1 and PPO2 is transferred in PWE2. For negative values the High word must be set to FFFF hex.

Note: 32-Bit parameter values are only used with the *POSICON* option. All the relevant parameters are described in the *POSICON* supplementary manual.

The parameter value is transferred as an integer value. For parameters with resolutions 0.1 or 0.01 the parameter value must be multiplied by the inverse of the resolution.

Example: A start-up time of 99.99 seconds is to be set:

99.99s $\rightarrow$ 99,99 * 1/0.01 = 99.99 * 100 = 9999. Therefore the value $9999_{dec} = 270F_{hex}$ must be transferred.

1.5.4.4 Master Function Output

With a setting in parameter P503, the inverter control signals (digital and/or analog) which are to be output as a bradcast telegram (type PPO3/PPO4) in USS protocol format via the RS 485 interface can be selected. The control source is still selected in P509. The transfer intervals depend on the USS baud rate which is set:

Baud rate	Interval
4800 Baud	100 ms
9600 Baud	50 ms
19200 Baud	25 ms
38400 Baud	15 ms

1.6 Telegram examples

Various example telegrams are shown below to clarify the control and parameterisation of the frequency inverter with the USS protocol.

Note: When transferring parameter orders, it must be taken into account that the slave does not immediately respond to orders in the parameter channel of the master telegram, but a positive response can be delayed by one or more communication cycles. The master must therefore repeat the required order until the corresponding slave response is received.

The macro generator of the NORD CON control and parameterisation software is used as a programming aid. The macro generator is started directly from the NORD CON program via the menu bar.

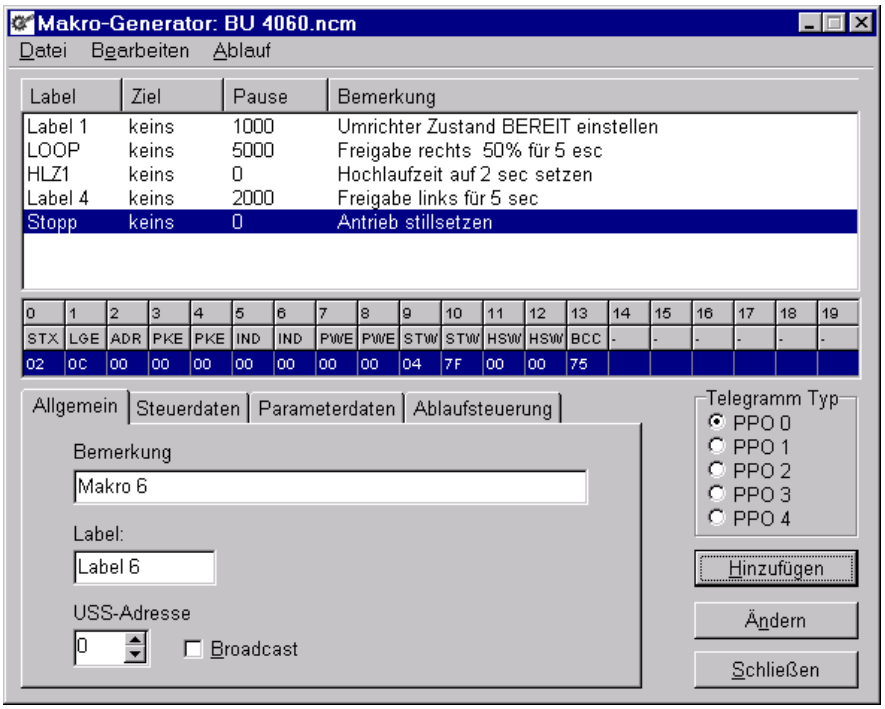
1.6.1 The Macro Generator

Simple process sequences can be simulated with the aid of the macro generator. This can used for instance, for testing during commissioning. Parameterisation of the devices is also possible. The individual telegrams of a macro are shown in hexadecimal format. This information can be used to create control programs based on the USS protocol.

A macro can consist of several steps. The telegram wich is transferred to the inverter can be observed in the Hex view in the overview. A sub-menu provides help for creating the individual steps.

- USS address
- Control word
- Setpoint
- Parameter number
- Parameter index
- Parameter value
- Order

Together, all of these steps comprise a step in the macro The telegram structure in the Hex view of each individual step is shown in the Macro window.



1.6.2 Switch-on block → Standby

A frequency inverter with the USS address 0 is to be switched from the status "Switch-on disabled" (STW Bit 0 – 0), which is active when the device is switched on, to the "Standby" status (STW Bit 0 = 1). Parameter set 1 is valid and no parameter data is transfered.

Procedure:

- Check last status word (ZSW 0A 70)
- Set address (Address 00)
- Generate control word (STW 04 7E)
- Send telegram
- Check response telegram (ZSW 0B 31)

Details:

The status word of frequency inverter → is in *switch-on block* status

Byte No.	0	1	2	3	4	5	6	7	8	**9**	**10**	11	12	13
Meaning	STX	LGE	ADR	PKE	PKE	IND	IND	PWE	PWE	**ZSW**	**ZSW**	IW1	IW1	BCC
Hexadecimal	02	0C	00	00	00	00	00	00	00	**0B**	**70**	00	00	75

Bit	Value	Value $_{HEX}$	Meaning
15	0	0	Parameter set Bit 1 off
14	0		Parameter set Bit 0 off
13	0		Reserved
12	0		Rotation left is off
11	1	B	Rotation right is on
10	0		Reference value undershot
9	1		Bus controller
8	1		Setpoint = actual value
7	0	7	No warning
6	1		Starting disabled
5	1		No emergency stop
4	1		Disable voltage
3	0	0	No fault
2	0		Operation disabled
1	0		Not ready for operation
0	0		Not on standby

Abbreviations used:

PKW	Parameter identifier Value
PZD	Process data
PKE	Parameter identifier
IND	Index
PWE	Parameter Value
STW	Control word 1
ZSW	Status word 1
SW1..3	Setpoint
IW1..3	Actual value

To switch the frequency inverter to the *standby* status, the following telegram must be sent:

0	1	2	3	4	5	6	7	8	**9**	**10**	11	12	13
STX	LGE	ADR	PKE	PKE	IND	IND	PWE	PWE	**STW**	**STW**	SW1	SW1	BCC
02	0C	00	00	00	00	00	00	00	**04**	**7E**	00	00	74

When the frequency inverter switches to *standby* status, it sends the following response telegram:

0	1	2	3	4	5	6	7	8	**9**	**10**	11	12	13
STX	LGE	ADR	PKE	PKE	IND	IND	PWE	PWE	**ZSW**	**ZSW**	IW1	IW1	BCC
02	0C	00	00	00	00	00	00	00	**0B**	**31**	00	00	34

Bit	**Value**	**Value $_{HEX}$**	**Meaning**
15	0	0	Parameter set Bit 1 off
14	0		Parameter set Bit 0 off
13	0		Reserved
12	0		Rotation left is off
11	1	B	Rotation right is on
10	0		Reference value undershot
9	1		Bus controller
8	1		Setpoint = actual value
7	0	3	No warning
6	0		Starting not disabled
5	1		No emergency stop
4	1		Enable voltage
3	0	1	No fault
2	0		Operation disabled
1	0		Not ready for operation
0	1		Ready to start

Note: The control telegram must be sent cyclically as the frequency inverter may not switch to the required status within the response time of a telegram.

1.6.3 Enable with 50% setpoint

A frequency inverter with the USS address 10, which is in "Standby" status (Section 1.6.2) is to be enabled for clockwise rotation with 50% setpoint. The last response telegram was received as follows in the controller.

Procedure:

- Check last status word (ZSW 0A 31)
- Set address (Address 0A)
- Generate control word (STW 04 7F)
- Generate setpoint (2000 hex)
- Send telegram
- Check response telegram (ZSW 0F 37)

Details:

Starting requirement (status word of frequency inverter)

0	1	**2**	3	4	5	6	7	8	**9**	**10**	11	12	13
STX	LGE	**ADR**	PKE	PKE	IND	IND	PWE	PWE	**ZSW**	**ZSW**	IW1	IW1	BCC
02	0C	**0A**	00	00	00	00	00	00	**0B**	**31**	00	00	37

The following telegram must be sent to the inverter

0	1	**2**	3	4	5	6	7	8	**9**	**10**	**11**	**12**	13
STX	LGE	**ADR**	PKE	PKE	IND	IND	PWE	PWE	**STW**	**STW**	**SW1**	**SW1**	BCC
02	0C	**0A**	00	00	00	00	00	00	**04**	**7F**	**20**	**00**	5F

The frequency inverter accelerates the motor in the ramp. When the inverter has reached the 50% setpoint, it responds with the following telegram.

0	1	**2**	3	4	5	6	7	8	**9**	**10**	11	12	13
STX	LGE	**ADR**	PKE	PKE	IND	IND	PWE	PWE	**ZSW**	**ZSW**	IW1	IW1	BCC
02	0C	**0A**	00	00	00	00	00	00	**0F**	**37**	20	00	1C

Note: The status of MFR 1 is indicated in Bit 10 of the response telegram. Depending on the programmed function and status, the status word may differ.

1.6.4 Writing a parameter

When transferring parameter orders, it must be taken into account that the slave does not immediately respond to orders in the parameter channel of the master telegram, but a positive response can be delayed by one or more communication cycles. The master must therefore repeat the required order until the corresponding slave response is received.

The acceleration time parameter (USS No. = 102_{dec} / 66_{hex}) of a frequency inverter with the USS address 3, is to be set to the value 10sec in parameter set 2. No process data is transferred.

As the acceleration time has an internal inverter resolution of 0.01sec, a parameter value of 10 / 0.01 = 1000 ($3E8_{hex}$) must be transferred. PPO1 was selected as the PPO type.

Procedure:

- Set address (Address 03)
- Select parameter (P 102_{dec} / P 66_{hex})
- Select order label (2 = change parameter value (word))
- Select parameter set 2 (IND = 01)
- Set parameter word (1000_{dec} / $3E8_{HEX}$)
- Send telegram
- Check response telegram

The telegram is composed as follows in hexadecimal notation:

0	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	11	12	13	14	15
STX	LGE	**ADR**	**PKE**	**PKE**	**IND**	**IND**	**PWE**	**PWE**	**PWE**	**PWE**	STW	STW	SW1	SW1	BCC
02	0E	**03**	**20**	**66**	**00**	**01**	**00**	**00**	**03**	**E8**	00	00	00	00	80

When the order has been fully implemented by the inverter, it responds with

0	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	11	12	13	14	15
STX	LGE	**ADR**	**PKE**	**PKE**	**IND**	**IND**	**PWE**	**PWE**	**PWE**	**PWE**	ZSW	ZSW	IW1	IW1	BCC
02	0E	**03**	**10**	**66**	**00**	**01**	**00**	**00**	**03**	**E8**	09	31	00	00	88

1.6.5 Reading the acceleration time parameter

The acceleration time parameter (USS No. = 102_{dec} / 66_{hex}) in parameter set 2 of a frequency inverter with the USS address 3, is to be read out. No process data is transferred.

Procedure:

- Set address (Address 03)
- Generate parameter label (PKE 10 66)
- Select parameter set 2 (IND = 01)
- Send telegram
- Check response telegram (PWE = 3E8)

Details:

0	1	**2**	**3**	**4**	**5**	**6**	7	8	9	10	11	12	13
STX	LGE	**ADR**	**PKE**	**PKE**	**IND**	**IND**	PWE	PWE	STW	STW	SW1	SW1	BCC
02	0C	**03**	**10**	**66**	**00**	**01**	00	00	00	00	00	00	7A

The response telegram of the slave contains the required parameter value in internal standardisation and could be as follows:

0	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	9	10	11	12	13
STX	LGE	**ADR**	**PKE**	**PKE**	**IND**	**IND**	**PWE**	**PWE**	ZSW	ZSW	IW1	IW1	BCC
02	0C	**03**	**10**	**66**	**00**	**01**	**03**	**E8**	0B	31	20	00	A8

The value sent in PWE2 is $C8_{HEX}$ corresponding to 1000_{DEC}, with a resolution of 0.01 seconds, this corresponds to an acceleration time of 1000 * 0.01 = 10 seconds

→ 10 / 0.01 = 1000 ($3E8_{hex}$)

1.7 Master Telegram Times

The telegram times to be monitored depend on the currently valid baud rate and the telegram length.

For the data format: 8E1, the following running times apply:

Baud rate	PPO type	Telegram Bytes	Start pause time [msec]	Minimum total run time [msec]	Maximum run time [msec]	Response delay time [msec]
4800	PPO0	14	4,583	32,083	48,1	4,583
4800	PPO1	16	4,583	36,667	55	4,583
4800	PPO2	20	4,583	45,833	68,8	4,583
4800	PPO3	8	4,583	18,333	27,5	4,583
4800	PPO4	12	4,583	27,5	41,3	4,583
9600	PPO0	14	2,292	16,042	24,1	2,292
9600	PPO1	16	2,292	18,333	27,5	2,292
9600	PPO2	20	2,292	22,917	34,4	2,292
9600	PPO3	8	2,292	9,167	13,8	2,292
9600	PPO4	12	2,292	13,75	20,6	2,292
19200	PPO0	14	1,146	8,021	12	1,146
19200	PPO1	16	1,146	9,167	13,8	1,146
19200	PPO2	20	1,146	11,458	17,2	1,146
19200	PPO3	8	1,146	4,583	6,9	1,146
19200	PPO4	12	1,146	6,875	10,3	1,146
38400	PPO0	14	0,573	4,01	6	0,573
38400	PPO1	16	0,573	4,583	6,9	0,573
38400	PPO2	20	0,573	5,729	8,6	0,573
38400	PPO3	8	0,573	2,292	3,4	0,573
38400	PPO4	12	0,573	3,438	5,2	0,573

The start pause time and the typical response delay time are determined by the transfer time for two bytes of data. The maximum response time provided by the telegram is 20msec.

The total run time in the table is the consecutive telegram run time, i.e. the stop bit of the last character immediately follows the start character of the next character. However, in practice there are time delays between the bytes of a telegram. Therefore the factor 1.5 is used for the maximum telegram run time.

Maximum total run time = 1-5 * consecutive telegram run time

The interface driver software must check or maintain compliance with the following telegram parameters and trigger an error if they are repeatedly overshot:

- Telegram length details of the received telegram (LGE)
- Telegram format (start character / STX, check-sum / BCC)
- Character format (parity, start and stop bit)
- Total run time of the slave response

Response delay time (typical transfer duration for 2 bytes, max 20 msec)

1.8 Frequency Inverter Settings

1.8.1 Frequency inverter bus parameters

To operate the inverter with the USS protocol, the bus must be connected to the master and some settings must be made on the frequency inverter.

The frequency inverter can always be parameterised. Control of the inverter via USS can be activated by setting parameter **P509** to value 2, 3 or 4 (**for SK 500E to 2**) (see below). In order to access the inverter via the control unit, only the baud rate in **P511** and the inverter address **P512** need to be set.

The telegram down time **P513** can be selected depending on the USS system.

1.8.1.1 Control clamp parameters

Parameter	Setting value / Description / Note	Comments
P480 ..[-01] ... .. [-12]	**Function BusIO In Bits** *(Function of Bus I/O In Bits)*	
0 ... 72 { 0 }	The Bus I/O In Bits are perceived as digital inputs. They can be set to the same functions as the digital inputs (See P420…of the respective FI manual). **[-01]=** Bus I/O In Bit 0 **[-02]=** Bus I/O In Bit 1 **[-03]=** Bus I/O In Bit 2 **[-04]=** Bus I/O In Bit 3 **[-05]=** Bus I/O In Bit 4 **[-06]=** Bus I/O In Bit 5 **[-07]=** Bus I/O In Bit 6 **[-08]=** Bus I/O In Bit 7 **[-09]=** Flag 1 (only SK 500E) **[-10]=** Flag 2 (only SK 500E) **[-11]=** Bit 8 BUS control word (only for SK 500E) **[-12]=** Bit 9 BUS control word (only for SK 500E)	
P481.. [-01] ... .. [-10]	**Function BusIO Out Bits** *(Function of Bus I/O Out Bits)*	
0 ... 39 { 0 }	The bus I/O Out bits are perceived as multi-function relay outputs. They can be set to the same functions as the digital inputs (See P434…of the respective FI manual). **[-01]=** Bus I/O Out Bit 0 **[-02]=** Bus I/O Out Bit 1 **[-03]=** Bus I/O Out Bit 2 **[-04]=** Bus I/O Out Bit 3 **[-05]=** Bus I/O Out Bit 4 **[-06]=** Bus I/O Out Bit 5 **[-07]=** Bus I/O Out Bit 6 / Flag 1 **[-08]=** Bus I/O Out Bit 7 / Flag 2 **[-09]=** Bit 10 BUS status word (only for SK 500E) **[-10]=** Bit 13 BUS status word (only for SK 500E)	
P482.. [-01] ... .. [-10]	**Stand. BusIO Out Bits** *(Standardisation of Bus I/O Out Bits)*	
-400 … 400 % { 100 }	Adjustment of the limit values of the relay functions/Bus Out Bits. For a negative value, the output function will be output negative. When the limit value is reached and the setting values are positive, the relay contact closes, with negative setting values the relay contact opens.	
P483.. [-01] ... .. [-10]	**Hyst. BusIO Out Bits** *(Hysteresis of Bus I/O Out Bits)*	
1 … 100 % { 10 }	Difference between switch-on and switch-off point to prevent oscillation of the output signal.	

1.8.1.2 Extra functions

Parameter	Setting value / Description / Note	Comments
P502 ... [-01] … ... [-05]	**Master function value** *(Master function value)*	**SK 5xxE**
1 ... 24 { 0 }	Selection of master values (up to SK 535E: max. 3 master values, SK 540 and above: max. 5 master values: **[-01] =** Master value 1 **[-02] =** Master value 2 **[-03] =** Master value 3 *SK 540E and above:* **[-04] =** Master value 4 **[-05] =** Master value 5 Selection of possible setting values for master values: **0 =** Off **1 =** Actual frequency **2 =** Actual speed **3 =** Current **4 =** Torque current **5 =** State of digital inputs and outputs **6 =** *Reserved* **7 =** *Reserved* **8 =** Setpoint frequency **9 =** Error message **10 =** *Reserved* **11 =** *Reserved* **12 =** Digital Out Bit 0…7 **13 =** *Reserved* **14 =** *Reserved* **15 =** *Reserved* **16 =** *Reserved* **17 =** Value analog input 1 **18 =** Value analog input 2 **19 =** Setpoint frequency master value **20 =** Setpoint frequency after master value ramp **21 =** Actual frequency without master value slip **22 =** Speed encoder **23 =** Actual freq. with slip (from SW V2.0) **24 =** Master value, act. freq. with slip (from SW V2.0)	
P503	**Master function output** *(Master function output)*	**SK 300E, SK 700E, SK 750E**
1 ... 6 { 0 }	To use the *master function output*, the inverter controller source must be selected in P509. Only the master frequency (setpoint 1 and control word) is transferred with ***Mode 1***, while the actual values selected in P543, P544 and P545 are transferred in ***Mode 2***. In ***Mode 3*** a 32Bit actual position and a 16Bit setpoint speed (after ramp) is output. Mode 3 is required for synchronous control with the POSICON option. **0 = Off** **1 = USS mode 1** **3 = USS mode 2** **5 = USS mode 3** **2 = CAN Mode 1** up to 250kBaud **4 = CAN Mode 2** up to 250kBaud **6 = CAN Mode 3**	
P503	**Master function output** *(Master function output)*	**SK 5xxE**
1 ... 5 { 0 }	To use the Master function output, the inverter controller source must be selected in P509. The master value to be transmitted is determined via the BUS interface in parameter P502. **0 = Off** **1 = USS** **2 = CAN** (up to 250kBaud) **3 = CANopen** **4 = System bus active** **5 = CANopen+Sys.bus act.**	
P507	**PPO Type** *(PPO Type)*	
1 ... 4 { 1 }	Type of PPO used (see Section 1.5.2 6)	

Parameter	Setting value / Description / Note	Comments
P509	**Interface** *(interface)*	**SK 300E, SK 700E, SK 750E**
0 ... 21 { 0 }	Selection of the interface from which the inverter is controlled. **0 = Control terminal or keyboard control** with the **Control Box** (option) ,the **ParameterBox** (option) or **the Potentiometer option** **1 = Control terminals only,** the inverter can only be controlled via the 4 digital inputs and the analog input. **2 = USS setpoint**, the frequency setpoint is transferred via the USS protocol. Control via the digital inputs is still active. **3 = USS control word**, the control signals (enable, direction of rotation, ...) are transferred via USS, the setpoint via the analog input or the fixed frequencies. **4 = USS**, all control data is transferred via the USS protocol. The analog input and the digital inputs have no function (except safety functions, see below) **5 = …**	
P509	**Control word source** *(Control word source)*	**SK 5xxE**
0 ... 10 { 0 }	Selection of the interface via which the FI is controlled. **0 =** **Control terminal or keyboard control** with the Control Box (if P510=0), the ParameterBox (not extension parameter box) or via BUS I/O Bits. **1 =** **Only control terminals** , the FI can only be controlled via the digital and analog inputs or via the bus I/O Bits. **2 =** **USS** control word: the control signals (enable, direction of rotation, ...) are transferred via the RS485 interface. The setpoint is transferred via the analog input or the fixed frequencies. Above SK 540E this setting should also be selected if communication via Modbus RTU is intended. The frequency inverter automatically detects whether this is a USS protocol or a Modbus protocol. **3 =** …	
P510	**Aux. setpoint interface** *(Auxiliary setpoints interface)*	**SK 700E, SK 750E**
0 ... 8 { 0 }	Selection of the interface from which the inverter is controlled. **0 = Auto:** The auxiliary setpoint value is automatically taken from the interface of the main setpoint value P509 >interface< **1 = USS** **2 = CANbus** **3 = Profibus** **4 = InterBus** **5 = CANopen** **6 = DeviceNet** **7 =** Reserved **8 = CAN Broadcast**	
P510 ... [-01] **... [-02]**	**Setpoints source** *(Setpoints source)*	**SK 5xxE**
0 ... 10 { 0 }	Selection of the setpoint source to be parameterised. **[-01] =** Main **setpoint source** **[-02] =** Auxiliary **setpoint source** Selection of the interface via which the FI receives the setpoint. **0 = Auto:** the source of the auxiliary setpoint is automatically derived from the setting in the parameter P509 >Interface< **1 = Control terminals**, digital and analog inputs control the frequency, including fixed frequencies **2 = USS (**or **Modbus RTU** above SK 540E**)** **3 = CAN** **4 = Profibus** **5 = InterBus** **6 = CANopen** **7 = DeviceNet** **8 = EtherCAT** **9 = CAN Broadcast** **10 = CANopen Broadcast**	

Parameter	Setting value / Description / Note	Comments
P511	**USS baud rate** *(USS baud rate)*	
0 ... 7 { 3 }	Setting of the transfer rate (transfer speed) via the RS485 interface. All bus participants must have the same baud rate setting. **0 =** 4800 Baud **1 =** 9600 Baud **2 =** 19200 Baud **3 =** 38400 Baud **4 =** 57600 Baud *(SK 54xE)* **5 =** 115200 Baud *(SK 54xE)* **6 =** 230400 Baud *(SK 54xE)* **7 =** 460800 Baud *(SK 54xE)* **NOTE:** For communication via Modbus (available for SK 540E and above) a transfer rate of maximum 38400 Baud must be set.	
P512	**USS Address** *(USS Address)*	
0 ... 30 { 0 }	Setting of the FI bus address for USS (or SK 540E and above: also Modbus) communication.	
P513	**Telegram downtime** *(Telegram downtime)*	
-0.1 / 0.0 / 0.1 ... 100.0 s { 0.0 }	Monitoring function of the active bus interface. Following receipt of a valid telegram, the next one must arrive within the set period. Otherwise the FI reports an error and switches off with the error message E010 >Bus Time Out<. **0.0 = Off**: Monitoring is switched off. **-0.1 = No error**: Even if communication between BusBox and FI is interrupted (e.g. 24V error, Box removed, etc.), the FI will continue to operate unchanged.	

Parameter	Setting value / Description / Note	Comments
P543 (P)	**Bus – Actual value 1** *(Bus – Actual value 1)*	
0 ... 12 (24) { 1 }	The return value 1 (IW1) can be set for bus control in this parameter. **SK 300E, SK 700E SK 750E** **0 =** Off **1 =** Actual frequency **2 =** Actual speed **3 =** Current **4 =** Torque current **5 =** Status of digital inputs and relay **6 =** Actual position (only *POSICON, SK700/750E*) **7 =** Setpoint position (only *POSICON, SK700/750E*) **8 =** Setpoint frequency **9 =** Error number **10 =** Actual position increment [1] (only *POSICON, SK700/750E*) **11 =** Setpoint position increment [1] (only *POSICON, SK700/750E*) **12 =** BUS I/O Out Bits 0-7 **SK 500E** **0 =** Off **1 =** Actual frequency **2 =** Actual speed **3 =** Current **4 =** Torque current (100% = P112) **5 =** State of digital inputs and outputs[2] **6 =** Actual position Low word **7 =** Setpoint position Low word **8 =** Setpoint frequency **9 =** Error number **10 =** Actual position increment Low word **11 =** Setpoint position increment Low word **12 =** Bus I/O Out Bits 0...7 **13 =** Actual position High word **14 =** Setpoint position High word **15 =** Actual position increment High word **16 =** Setpoint position increment High word **17 =** Value analog input 1 (P400) **18 =** Value analog input 2 (P405) **19 =** Setpoint frequency master value (P503) **20 =** Setpoint frequency after master value ramp **21 =** Actual frequency without master value slip **22 =** Speed from encoder (only possible with SK 52x/53xE and encoder feedback) **23 =** Actual frequency with slip, *"Actual frequency with slip"* **24 =** Master value, actual freq. with slip, *"Master value, actual freq. with slip"*	
	NOTE: For **SK 540 and SK545E** 5 actual values are available. These are all set in parameter P543, which is divided into 5 array elements for this purpose. Parameters P544 and P545 are not required for this inverter version. **[-01] =** Actual bus value 1 **[-02] =** Actual bus value 2 **[-03] =** Actual bus value 3 **[-04] =** Actual bus value 4 **[-05] =** Actual bus value 5	
P544 (P)	**Actual bus value 2** *(Actual bus value 2)*	**except SK 54xE**
0 ... 12 (24) { 0 }	The return value 2 (IW2) can be set for bus control in this parameter. For setting values, see parameter (P543)	
P545 (P)	**Actual bus value 3** *(Actual bus value 3)*	**except SK 54xE**
0 ... 12 (24) { 0 }	In this parameter, the return value 3 (IW3) can be set for bus control. This is only available if P546 ≠ 3 (only applies for SK 700E / SK 750E). For setting values, see parameter (P543)	

[1] An indicated revolution of the motor results from 8192 encoder increments.

[2] The assignment of the digital inputs in P543/ 544/ 545 = 5

Bit 0 = DigIn 1	Bit 1 = DigIn 2	Bit 2 = DigIn 3	Bit 3 = DigIn 4
Bit 4 = DigIn 5	Bit 5 = DigIn 6	Bit 6 = DigIn 7	Bit 7 = Reserved
Bit 8 = Reserved	Bit 9 = Reserved	Bit 10 = Reserved	Bit 11 = Reserved
Bit 12 = Out 1	Bit 13 = Out 2	Bit 14 = Out 3	Bit 15 = Out 4

Parameter	Setting value / Description / Note	Comments
P546 (P)	**Function Bus setpoint 1** *(Function of bus setpoint 1)*	
0 ... 7 (47) { 1 }	In this parameter, a function is assigned to the delivered setpoint 1 (SW1) for bus control. **NOTE:** Further details can be found in the respective FI manual or in the description of P400.	

SK 300E, SK 700E SK 750E

0 = Off
1 = Setpoint frequency (16 bit)
2 = 16 Bit setpoint position (only *POSICON SK700/750E*)
3 = 32 Bit setpoint position (only *POSICON, SK700/750E* and if PPO- type 2 or 4 are selected)
4 = Control terminals *POSICON (*only *POSICON, SK700/750E*, 16Bit)
5 = Setpoint position (16 Bit) increment [1] (only*POSICON, SK700/750E*)
6 = Setpoint position (32 Bit) increment [1] (only*POSICON, SK700/750E*)
7 = Bus IO In Bits 0-7

SK 500E

0 = Off
1 = Setpoint frequency (16 bit)
2 = Torque current limit (P112)
3 = Actual frequency PID
4 = Frequency addition
5 = Frequency subtraction
6 = Current limit (P536)
7 = Maximum frequency (P105)
8 = Actual PID frequency limited
9 = Actual PID frequency monitored
10 = Torque servo mode (P300)
11 = Lead torque (P214)
12 = Reserved
13 = Multiplication
14 = PI process controller actual value
15 = PI process controller setpoint
16 = PI process controller lead
17 = Digital In bits 0...7
18 = Reserved
19 = Set relay (P434/441/450/455=38)
20 = Set analog output (P418=31)
21 = Setpoint position Low word (SK 530E and above)
22 = Setpoint position High word (SK 530E and above)
23 = Setpoint position increment Low word (SK 530E and above)
24 = Setpoint position increment High word (SK 530E and above)
25 = ... 45 reserved
46 = Setpoint torque process controller
47 = Gearing transfer factor

NOTE: For **SK 540 and SK545E** 5 setpoints are available. These are all set in parameter P546, which is divided into 5 array elements for this purpose. Parameters P547 and P548 are not required for this inverter version.

[-01] = Bus setpoint 1 **[-02] =** Bus setpoint 2 **[-03] =** Bus setpoint 3

[-04] = Bus setpoint 4 **[-05] =** Bus setpoint 5

P547 (P)	**Function Bus setpoint 2** *(Function of bus setpoint 2)*	**except SK 54xE**
0 ... 46 (47) { 0 }	In this parameter, a function is assigned to the delivered setpoint 2 (SW2) for bus control.	

0 = Off
1 = Setpoint frequency
2 = Torque current limit (P112)
3 = Actual frequency PID
4 = Frequency addition
5 = Frequency subtraction
6 = Current limit (not SK 300E)
7 = Maximum frequency (not SK 300E)
8 = Actual PID frequency limited
9 = Actual PID frequency monitored
10 = Torque (not SK 300E)
11 = Torque lead (not SK 300E)
12 = Control terminals *POSICON* (not SK 300E)
13 = Multiplication (not SK 300E)
14 = PI process controller actual value
15 = PI process controller setpoint
16 = PI process controller lead
17 = Digital In bits 0...7
18 = Curve travel calculator (not SK 300E)
19 = Set relay
20 = Set analog output
21 = Setpoint position Low word (SK 530E and above)
22 = Setpoint position High word (SK 530E and above)
23 = Setpoint position increment Low word (SK 530E and above)
24 = Setpoint position increment High word (SK 530E and above)
25 = ... 45 reserved
46 = Setpoint, torque process controller (not SK 300E)
47 = Gearing transfer factor (only SK 500E)

Parameter	Setting value / Description / Note	Comments
P548 (P)	**Function Bus setpoint 3** *(Function of bus setpoint 3)*	**except SK 54xE**
0 ... 46 (47) { 0 }	In this parameter, a function is assigned to the delivered setpoint 3 (SW3) for bus control. This is only available if P546 ≠ 3 (only applies for SK 700E / SK 750E). For setting values, see parameter (P547)	

1.8.1.3 Information parameters

NOTE

As of firmware version V1.9 R0 for the SK 500E series, not only current error messages but also warnings and information messages can be displayed via the parameter. In this context, the parameter **(P700)** has been converted into an array parameter. I.e. error messages are displayed in (P700 [-01]), warnings in (P700[-02]), and information in (P700 [-03]).

For all other series (SK 300E, SK 700E, SK 750E), parameter (P700) still only indicates error messages.

Parameter	Setting value / Description / Note	Comments
P740 ... [-01] ... ... [-06]	**Process data Bus In** *(Process data Bus In)*	**SK 300E, SK 700E, SK 750E**
0000 ... FFFF (hex)	Displays the actual control word and the setpoints.	**[-01]** = Control word **[-02]** = Setpoint 1 (P546) **[-03]** = Setpoint 1 High byte **[-04]** = Setpoint 2 (P547) **[-05]** = Setpoint 3 (P548) **[-06]** = Bus I/O In Bits (P480)

Parameter	Setting value / Description / Note		Comments
P740 ... [-01] ... ... [-13]	**Process data Bus In** *(Process data Bus In)*		**SK 500E to SK 535E**
0000 ... FFFF (hex)	This parameter informs about the actual control word and the setpoints that are transferred via the bus systems.	**[-01] =** Control word	Control word, source from P509.
		[-02] = Setpoint 1 **[-03] =** Setpoint 2 **[-04] =** Setpoint 3	Setpoint data from main setpoint P510 - 01.
		[-05] = Bus I/O In Bits (P480)	The displayed value depicts all Bus In bit sources linked with *OR*.
		[-06] = Parameter data In 1 **[-07] =** Parameter data In 2 **[-08] =** Parameter data In 3 **[-09] =** Parameter data In 4 **[-10] =** Parameter data In 5	Data during parameter transfer.
		[-11] = Setpoint 1 **[-12] =** Setpoint 2 **[-13] =** Setpoint 3	Setpoint data from auxiliary setpoint P510 - 02.

Parameter	Setting value / Description / Note		Comments
P740 ... [-01] ... ... [-23]	**Process data Bus In** *(Process data Bus In)*		**SK 540E / SK 545E**
0000 ... FFFF (hex)	This parameter informs about the actual control word and the setpoints that are transferred via the bus systems. For display, a BUS system must be selected in P509	**[-01]** = Control word	Control word, source from P509.
		[-02] = Setpoint 1 **[-03]** = Setpoint 2 **[-04]** = Setpoint 3 **[-05]** = Setpoint 4 **[-06]** = Setpoint 5	Setpoint data from main setpoint (P510 [-01]).
		[-07] = Bus I/O In Bits (P480)	The displayed value depicts all Bus In bit sources linked with *OR*.
		[-08] = Parameter data In 1 **[-09]** = Parameter data In 2 **[-10]** = Parameter data In 3 **[-11]** = Parameter data In 4 **[-12]** = Parameter data In 5	Data during parameter transfer: Order label (AK), Parameter number (PNU), Index (IND), Parameter value (PWE 1/2)
		[-13] = Setpoint 1 **[-14]** = Setpoint 2 **[-15]** = Setpoint 3 **[-16]** = Setpoint 4 **[-17]** = Setpoint 5	Setpoint data from the master function value (Broadcast), if P509 = 9/10 (P510 [-02])
		[-18] = Control word PLC	Control word, source PLC
		[-19] = Setpoint 1 **[-20]** = Setpoint 2 **[-21]** = Setpoint 3 **[-22]** = Setpoint 4 **[-23]** = Setpoint 5	Setpoint data from the PLC.
P741 ... [-01] ... ... [-06]	**Process data Bus Out** *(Process data Bus Out)*		**SK 300E, SK 700E, SK 750E**
0000 ... FFFF (hex)	Displays the actual status word and actual values.		**[-01]** = Status word **[-02]** = Actual value 1 (P543) **[-03]** = Actual value 1 High byte **[-04]** = Actual value 2 (P544) **[-05]** = Actual value 3 (P545) **[-06]** = Bus I/O Out Bits (P481)

Parameter	Setting value / Description / Note		Comments
P741 ... [-01] … ... [-13]	**Process data Bus Out** *(Process data Bus Out)*		**SK 500E to SK 535E**
0000 ... FFFF (hex)	This parameter provides information about the actual status word and the actual values that are transferred via the bus systems.	**[-01] =** Status word	Status word, source from P509.
		[-02] = Actual value 1 (P543) **[-03] =** Actual value 2 (P544) **[-04] =** Actual value 3 (P545)	
		[-05] = Bus I/O Out Bit (P481)	The displayed value depicts all Bus In bit sources linked with *OR*.
		[-06] = Parameter data Out 1 **[-07] =** Parameter data Out 2 **[-08] =** Parameter data Out 3 **[-09] =** Parameter data Out 4 **[-10] =** Parameter data Out 5	Data during parameter transfer.
		[-11] = Actual value 1 master function **[-12] =** Actual value 2 master function **[-13] =** Actual value 3 master function	Actual value of master function 502/P503.

Parameter	Setting value / Description / Note		Comments
P741 ... [-01] … ... [-23]	**Process data Bus Out** *(Process data Bus Out)*		**SK 540E / SK 545E**
0000 ... FFFF (hex)	This parameter provides information about the actual status word and the actual values that are transferred via the bus systems.	**[-01] =** Status word	Status word, source from P509.
		[-02] = Actual value 1 (P543 [-01]) **[-03] =** Actual value 2 (P543 [-02]) **[-04] =** Actual value 3 (P543 [-03]) **[-05] =** Actual value 4 (P543 [-04]) **[-06] =** Actual value 5 (P543 [-05])	
		[-07] = Bus I/O Out Bit (P481)	The displayed value depicts all Bus In bit sources linked with *OR*.
		[-08] = Parameter data Out 1 **[-09] =** Parameter data Out 2 **[-10] =** Parameter data Out 3 **[-11] =** Parameter data Out 4 **[-12] =** Parameter data Out 5	Data during parameter transfer.
		[-13] = Actual value 1 master function **[-14] =** Actual value 2 master function **[-15] =** Actual value 3 master function **[-16] =** Actual value 4 master function **[-17] =** Actual value 5 master function	Actual value of master function 502/P503.
		[-18] = Status word PLC	Status word via PLC
		[-19] = Actual value 1 PLC **[-20] =** Actual value 2 PLC **[-21] =** Actual value 3 PLC **[-22] =** Actual value 4 PLC **[-23] =** Actual value 5 PLC	Actual value data via PLC

Parameter	Setting value / Description / Note	Comments
P742	**Database version** *(Database version)*	
0 ... 9999	Displays the internal database version of the FI.	

P744	**Configuration level** *(Configuration level)*	**SK 300E, SK 700E, SK 750E**
0 ... 9999	This parameter displays the option modules detected by the FI. The display with the ParameterBox is in plain text. The possible combinations are displayed in code in the ControlBox. Both right digits indicate the customer unit used and the two left digits indicate the special extension unit. The options vary depending on the FI type.	

Customer Unit **SK CU1-…**		Special extension unit **SK XU1-...**	
No IO	**XX00**	Encoder	**01XX**
Basic IO	**XX01**	POSICON	**02XX**
Standard IO	**XX02**		
Multi IO	**XX03**		
USS IO	**XX04**		
CAN IO	**XX05**		
Profibus IO	**XX06**		

P744	**Configuration level** *(Configuration level)*	**SK 5xxE**
0000 ... FFFF (hex)	This parameter displays the design status integrated in the FI. Display is in hexadecimal code (SimpleBox, ControlBox, Bus system). The display is in plain text when the ParameterBox is used.	

SK 500E … 515E	**= 0000**	**SK 530E … 535E**	**= 0201**
SK 520E	**= 0101**	**SK 540E … 545E**	**= 0301**

P745	**Module version** *(Module version)*	**SK 300E, SK 5xxE**
0.0 ... 3276.7	Design status (software version) of the technology unit (SK TU2/3-xxx), but only when a separate processor is present, therefore not for SK TU2/3-CTR. Have this data available if you have a technical query.	

P745 ...[-01] **…** **... [-03]**	**Module version** *(Module version)*	**SK 700E, SK 750E**
0.0 ... 3276.7	Software version of the installed module [-01] Technology unit [-02] Customer Unit [-03] Special Extension Unit	

Parameter	Setting value / Description / Note	Comments
P746	**Module status** *(Module status)*	**SK 300E, SK 5xxE**
0000 ... FFFF (hex)	Indicates the actual status (readiness, error, communication) of the technology unit (SK TU2/3-xxx), but only when own processor is present, therefore not for the SK TU2/3-CTR. Code details can be found in the respective BUS module manual. Different contents are shown depending on the modules.	
P746 ... [-01] **…** **... [-03]**	**Module status** *(Module status)*	**SK 700E, SK 750E**
0000 ... FFFF (hex)	Status of integrated modules [-01] Technology unit [-02] Customer Unit [-03] Special Extension Unit	

NOTE

When activated, the functions **block current**, **quick stop**, **remote control** and **cancel error** are available at the (local) control terminals. To operate the drive, a high signal must be present on the digital inputs being used before the drive can be enabled.

2 Modbus RTU

(SK 540E and above)

2.1 The bus system

Modbus is an open communication protocol, which is based on a Master/Slave architecture. The bus system must be set up in a linear configuration, whose ends are terminated with terminating resistors. In principle, up to 256 participants are possible within a bus system. These communicate with each other via RS485.

2.2 Features

As standard, frequency inverters of version SK 540E and above provide the Modbus in version **Modbus RTU <8, E, 1>**. Installation is by means of a two-core cable with an additional GND connection.

- Electrically isolated bus interface
- Modbus RTU <8, E, 1>
- up to 32 participants can be connected to a segment (communication via RS485)
- Point to point communication (between 2 participants) is possible via RS232
- Connection via terminal bar X7:73/74 (SK 520E and above) or
- connection via RJ12 socket (X11)
  Caution: with more than 2 participants, communication via RS232 is not possible, and for their protection, the RS232 contacts TXD and RXD must not be connected.
- Termination resistors can be connected via DIP switch on the FI (DIP 1).
- Address range 0,1,3 … 30
  Address 2 must not be used!
  Address 0 is reserved for the master (Broadcast Mode)
- The baud rate is adjustable (4800Baud … 38400Baud)

With communication between only 2 participants, an RS232 connection can be set up. In this case, care must be taken that the communication speed may be lower, especially with long cable lengths.

For a network with more than 2 participants, the RS485 interface must always be used.

Switchover between the Modbus and the USS protocol is automatic. The condition for this is that address 2 is not set in parameter (P512).

The frequency inverter can process 2 versions of the Modbus protocol.

1. **Communication via Bus IOs:** If the frequency inverter is to be accessed via Bus IO Bits, the functions must be assigned in parameters (P480) and (P481). The source for the control word and the setpoints (P509/P510) must be set to "Control terminals". (For details: see "Coil list")
2. **Process data communication:** If process data is to be exchanged or parameters changed, the source for the control word and the setpoints (P509/P510) must be set to "USS". The definition of the parameters is made in the parameters (P543) to (P548). (For details: see "Process data")

2.3 Telegram Structure

The address field consists of eight Bits, which represent the address of the recipient. In its response, the Slave returns this address to the Master, so that the master can identify the response. The function field consists of 8 Bits. These encode how the content of the data field is to be interpreted. If the Slave has received the query from the Master correctly, it responds with the same function code. The structure of the data field is explained in detail in the section "Function Codes". Finally, a 16Bit CRC checksum is transmitted.

Address	Function Codes	Data	CRC
8 bit	8 bit	Variable = N x 8 bits	16 bit

2.4 RTU Frames

In RTU mode the start of transmission is not marked by control codes, but rather via a break in transmission at least 3.5 characters long. The length of the transmission break therefore depends from the transfer speed. The end of the message is also marked by a break in transmission which is at least 3.5 characters long.

2.5 Function Codes

Function codes specify the required action associated with the transmission of the telegram. The following codes are supported:

Function Code	Function name	Description
01h	Read Coil	Reading access to all IN & OUT bits on the the bus
05h	Write Single Coils	Writing access to individual bus IN bits
0Fh	Write Multiple Coils	Simultaneous writing access to all bus IN bits
03h	Read Holding Register	Reading access to parameters
06h	Write Single Register	Writing access to an individual parameter (max 16Bit)
10h	Write Multiple Register	Writing access to 32Bit parameters or several PZD data

2.5.1 01h Read Coil

This function enables the readout of inverter bits. The addresses of the bits are listed in the "Coil List".

Master → Slave			Slave → Master		
Function Code	1 Byte	0x01	Function Code	1 Byte	0x01
Start address	2 Byte	0x0000 to 0x000F	Number of bytes	1 Byte	1 to 2
Number of bits	2 Byte	1 to 16	Status of bits	n Byte	

Example:

4 bits are queries from the address 0x0008 (Bus OUT bits 1 to 4). The bus OUT bits 1 and 2 are High and the other two bits are Low.

Query (Master → Slave)		Response (Slave → Master)	
Address	0x08	Address	0x08
Function Code	0x01	Function Code	0x01
Start address High	0x00	Number of bytes	0x01
Start address Low	0x08	Status of Coils	0x03
Number of High Coils	0x00	CRC High	0x12
Number of Low Coils	0x04	CRC Low	0x15
CRC High	0xBC		
CRC Low	0x92		

2.5.2 05h Write Single Coils

Writes a single 1Bit value The addresses of the bits are listed in the Coil List.

The value 0x0000 is written if a bit is to be deleted. 0xFF00 is written if the bit is to be set.

Master → Slave			Slave → Master		
Function Code	1 Byte	0x05	Function Code	1 Byte	0x05
Address	2 Byte	0x0000 to 0x0007	Address	2 Byte	0x0000 to 0x0007
Coil value	2 Byte	0x0000 or 0xFF00	Coil value	2 Byte	0x0000 or 0xFF00

Example:

Bus IN Bit 2 is set to the address 0x0001.

Query (Master → Slave)		Response (Slave → Master)	
Address	0x08	Address	0x08
Function Code	0x05	Function Code	0x05
Address High	0x00	Address High	0x00
Address Low	0x01	Address Low	0x01
Coil value High	0xFF	Coil value High	0xFF
Coil value Low	0x00	Coil value Low	0x00
CRC High	0xDD	CRC High	0xDD
CRC Low	0x63	CRC Low	0x63

2.5.3 0Fh Write Multiple Coils

Via this access, all of the 8 writable coils can be switched simultaneously.

Master → Slave			**Slave → Master**		
Function Code	1 Byte	0x0F	Function Code	1 Byte	0x0F
Start address	2 Byte	0x0000 to 0x0007	Start address	2 Byte	0x0000 to 0x0007
Number of Coils	2 Byte	0x0001 to 0x0008	Number of Coils	2 Byte	0x0001 to 0x0008
Number of bytes	1 Byte	1			

Example:

Bus IN Bits 2, 4 and 5 are set from start address 0x0001.

Query (Master → Slave)		**Response (Slave → Master)**	
Address	0x08	Address	0x08
Function Code	0x0F	Function Code	0x0F
Start address High	0x00	Start address High	0x00
Start address Low	0x01	Start address Low	0x01
Number of High Coils	0x00	Number of High Coils	0x00
Number of Low Coils	0x04	Number of Low Coils	0x04
Number of bytes	0x01	CRC High	0x05
Coil value	0x0D	CRC Low	0x51
CRC High	0x02		
CRC Low	0xF9		

2.5.4 03h Read Holding Register

This enables the readout of one or more parameters. However, usually only a single 16Bit format parameter can be read out. The function code 0x10 must be used for 32Bit parameters.

The only exception to this are the process parameters P050 and P051. Here, all the elements of the array assigned to the parameter can be read out simultaneously.

NOTE

The parameter (P050) "Process data IN" and (P051) "Process data OUT" are executed in the background and are not visible to the user. From a structural point of view, these are array parameters ([-01 … -04]). Assignment of the setpoints in parameter (P050) is carried out via the parameters (P546 (… P548)). The return of the actual values in parameter (P051) is assigned in parameters (P543 (… P545)).

Master → Slave			**Slave → Master**		
Function Code	1 Byte	0x03	Function Code	1 Byte	0x03
Start address	2 Byte	0x0000 to 0xFFFF	Number of bytes	2 Byte	0x01 to 0x08
Number of parameters	2 Byte	0x0001 to 0x0004	Parameter value	N*2Byte	

Example 1:

Parameter P102, parameter set 1 is read out (Content = 200 / 0x00C8).

Query (Master → Slave)		**Response (Slave → Master)**	
Address	0x08	Address	0x08
Function Code	0x03	Function Code	0x03
Start address High	0x19	Number of bytes	0x02
Start address Low	0x80	Parameter value High	0x00
Number of parameters High	0x00	Parameter value Low	0xC8
Number of parameters Low	0x01	CRC High	0x65
CRC High	0x82	CRC Low	0xD3
CRC Low	0x27		

Example 2:

The following 4 process data are read out: status word and actual values 1 to 3 (P051[-00] to P051[-03]) status word = 0x2B37 // IW1 = 0x09C4 // IW2 = 0x0203 // IW3 = 0x09C4.

Query (Master → Slave)		**Response (Slave → Master)**	
Address	0x08	Address	0x08
Function Code	0x03	Function Code	0x03
Start address High	0x0C	Number of bytes	0x08
Start address Low	0xC0	Parameter value 1 High	0x2B
Number of parameters High	0x00	Parameter value 1 Low	0x37
Number of parameters Low	0x04	Parameter value 2 High	0x09
CRC High	0x47	Parameter value 2 Low	0xC4
CRC Low	0xFC	Parameter value 3 High	0x02
		Parameter value 3 Low	0x03
		Parameter value 4 High	0x09
		Parameter value 4 Low	0xC4
		CRC High	0x65
		CRC Low	0xD3

2.5.5 06h Write Single Register

Enables writing of a single 16Bit parameter.

Master → Slave			Slave → Master		
Function Code	1 Byte	0x06	Function Code	1 Byte	0x06
Address	2 Byte	0x0000 to 0xFFFF	Address	2 Byte	0x0000 to 0xFFFF
Parameter Value	2 Byte	0x0000 to 0xFFFF	Parameter Value	2 Byte	0x0000 to 0xFFFF

Example:

Parameter P102, parameter set 2 is written with the value 0x0123 (see also the item "Parameter access" in Section 2.8 Description of parameters).

Query (Master → Slave)		Response (Slave → Master)	
Address	0x08	Address	0x08
Function Code	0x06	Function Code	0x06
Address High	0x19	Address High	0x19
Address Low	0x81	Address Low	0x81
Parameter value High	0x01	Parameter value High	0x01
Parameter value Low	0x23	Parameter value Low	0x23
CRC High	0x9E	CRC High	0x9E
CRC Low	0x6E	CRC Low	0x6E

2.5.6 10h Write Multiple Register

This command enables several parameters to be written consecutively, and for parameters with a data length of 32Bit.

In the process data area, all process data of the P050 parameter array can be written simultaneously.

If parameters are written with this access, only a single parameter can be written with a telegram. This access is used to write 32Bit parameters.

NOTE

The parameter (P050) "Process data IN" and (P051) "Process data OUT" are executed in the background and are not visible to the user. From a structural point of view, these are array parameters ([-01 … -04]). Assignment of the setpoints in parameter (P050) is carried out via the parameters (P546 (… P548)). The return of the actual values in parameter (P051) is assigned in parameters (P543 (… P545)).

Master → Slave			Slave → Master		
Function Code	1 Byte	0x10	Function Code	1 Byte	0x10
Start address	2 Byte	0x0000 to 0xFFFF	Start address	2 Byte	0x0000 to 0xFFFF
Number of parameters	2 Byte	0x0001 to 0x0004	Number of parameters	2 Byte	0x0001 to 0x0004
Number of bytes	1 Byte	0x01 to 0x08			
Parameter Value	N*2 Byte				

Example 1:

Parameter P613 [0] is written with the value 0x00123456.

Query (Master → Slave)		Response (Slave → Master)	
Address	0x08	Address	0x08
Function Code	0x10	Function Code	0x10
Start address High	0x99	Start address High	0x99
Start address Low	0x40	Start address Low	0x40
Number of parameters High	0x00	Number of parameters High	0x00
Number of parameters Low	0x02	Number of parameters Low	0x02
Number of bytes	0x04	CRC High	0x6E
Parameter value 1 High	0x00	CRC Low	0x19
Parameter value 1 Low	0x12		
Parameter value 2 High	0x34		
Parameter value 2 Low	0x56		
CRC High	0x29		
CRC Low	0xAE		

Example 2:

Parameters P050[1] to P050[3], i.e. setpoint values 1 to 3 are written.

Control word1 = 1000 // SW2 = 2000 // SW3 = 3000.

Query (Master → Slave)		Response (Slave → Master)	
Address	0x08	Address	0x08
Function Code	0x10	Function Code	0x10
Start address High	0x0C	Start address High	0x0C
Start address Low	0x81	Start address Low	0x81
Number of parameters High	0x00	Number of parameters High	0x00
Number of parameters Low	0x03	Number of parameters Low	0x03
Number of bytes	0x06	CRC High	0xD3
Parameter value 1 High	0x03	CRC Low	0xE9
Parameter value 1 Low	0xE8		
Parameter value 2 High	0x07		
Parameter value 2 Low	0xD0		
Parameter value 3 High	0x0B		
Parameter value 3 Low	0xB8		
CRC High	0xF5		
CRC Low	0xDF		

2.6 Exception Responses

If a query by the Modbus Master cannot be answered correctly, an error message is sent instead of the normal response. The error message is structured as follows:

Slave → Master		
Function Code	1 Byte	0x80 + Function code of the Master query
Exception Code	1 Byte	0x01 to 0x06

Exception Code	**Description**
01h	• A function code has been sent, which is not supported by the FI.
02h	• The telegram which has been sent is too long. • For read queries, the data range to be read out is too large. • The queried parameter is not known. • The parameter sub-index is not known.
03h	• An incorrect data content has been transmitted in the function "Write Single Coil". • The number of parameters is above the limit set by Modbus.
04h	• Error in access to the parameter database of the FI. • The number of coils to be written in the function "Write Single Coil" has been exceeded
06h	• The Slave is still occupied with current query and cannot receive a new order.

Example:

Parameter P102, parameter set 2 is written with the value 0x0123.

Query (Master → Slave)		**Response (Slave → Master)**	
Address	0x08	Address	0x08
Function Code	0x06	Function Code	0x06
Address High	0x19	Address High	0x19
Address Low	0x81	Address Low	0x81
Parameter value High	0x01	Parameter value High	0x01
Parameter value Low	0x23	Parameter value Low	0x23
CRC High	0x9E	CRC High	0x9E
CRC Low	0x6E	CRC Low	0x6E

2.7 Watchdog

Modbus communication can be monitored via the parameter P513. Monitoring is started with the first valid telegram. If the FI does not receive a new telegram within the time set in P513, error 10.0 is triggered in the FI.

2.8 Description of parameters

Coil List

Via the Coil List it is possible to obtain direct access to the Bus IN/OUT bits. In order for these bits to function, they must be parameterised in parameter P480 and P481 and the control word and setpoint must be parameterised to the setting "Control terminals" via P509/P510.

Bus IO In Bits			**Bus IO Out Bits**		
Coil number	Name	R/W	Coil number	Name	R/W
0000h	Bus IO In 1	R/W	0008h	Bus IO OUT 1	R
0001h	Bus IO In 2	R/W	0009h	Bus IO OUT 2	R
0002h	Bus IO In 3	R/W	000Ah	Bus IO OUT 3	R
0003h	Bus IO In 4	R/W	000Bh	Bus IO OUT 4	R
0004h	Bus IO In 5	R/W	000Ch	Bus IO OUT 5	R
0005h	Bus IO In 6	R/W	000Dh	Bus IO OUT 6	R
0006h	Bus IO In 7	R/W	000Eh	Bus IO OUT 7	R
0007h	Bus IO In 8	R/W	000Fh	Bus IO OUT 8	R

Process data

The process data is sent to the FI by means of parameter access. In order for this process data to function, the setpoint source P509/P510 must be set to "USS".

NOTE

The parameter (P050) "Process data IN" and (P051) "Process data OUT" are executed in the background and are not visible to the user. From a structural point of view, these are array parameters ([-01 … -04]). Assignment of the setpoints in parameter (P050) is carried out via the parameters (P546 (… P548)). The return of the actual values in parameter (P051) is assigned in parameters (P543 (… P545)).

Parameter {factory setting}		Setting value / Description / Note		
P050	**[-01] … [-04]**	**Process data IN** *(Process data In)*		
0000 ... FFFF (hex) { all 0 }		This parameter is an internal parameter, which can neither be edited nor displayed.. The assignment of the setpoints is carried out via parameters (P546) … (P548) (SK540E and above: (P546[-01]) … (P546[-03])).	**[-01] =** Control word	Control word, source from P509.
			[-02] = Setpoint 1 **[-03] =** Setpoint 2 **[-04] =** Setpoint 3	(P546) or (P546[-01]) (P547) or (P546[-02]) (P548) or (P546[-03]) Setpoint data from main setpoint (P510 [-01]).
P051	**[-01] … [-04]**	**Process data OUT** *(Process data OUT)*		
0000 ... FFFF (hex) { all 0 }		This parameter is an internal parameter, which can neither be edited nor displayed.. The assignment of the actual values is carried out via parameters (P543) … (P545) (SK540E and above: (P543[-01]) … (P543[-03])).	**[-01] =** Status word	Status word, source from P509.
			[-02] = Actual value 1 **[-03] =** Actual value 2 **[-04] =** Actual value 3	(P543) or (P543[-01]) (P544) or (P543[-02]) (P545) or (P543[-03])

Parameter access

The FI parameters cannot be directly accessed via the functions 03h, 06h or 10h, as many FI parameters have array elements. Therefore, the addresses for NORD parameters are according to the following model:

Start address	
Bit 15 – Bit 6	Bit 5 – Bit 0
Parameter number	Array Index

The lower 5 bits are available for the array elements, so that the maximum array size is 63. The parameter values are shifted by 6 places.

Examples

- P102 Parameter set 1 = 0x1980
- P102 Parameter set 2 = 0x1981
- P510 Array element 2 = 0x7F81

NOTE

The description of the inverter parameters can be found in the main manual for the frequency inverter (BU0500). However, parameters related to bus communication can also be found in Section 1.8 .

3 Faults

3.1 Troubleshooting

The majority of frequency inverter functions and operating data are continuously monitored and simultaneously compared with limiting values. If a deviation is detected, the inverter reacts with a warning or an error message.

Basic information on this topic is contained in the manual for the basic equipment.

Errors cause the frequency inverters to switch off, in order to prevent a device fault.

The following options are available to reset a fault (acknowledge):

1. Switching the mains off and on again,
2. By an appropriately programmed digital input (P420 ... P425 = Function 12),
3. By switching of the “Enable” on the frequency inverter (if no digital input is programmed for acknowledgement),
4. By Bus acknowledgement or
5. By P506, the automatic error acknowledgement.

Device LEDs:	As delivered, with SK 300E series devices (except ATEX versions) and SK 500E (without technology unit), 2 LEDs (green/red) are externally visible. These indicate the actual device status. The **green LED** indicates that the mains voltage is present and operational, while a flashing code that increases in speed shows the degree of overload at the frequency inverter output. The**red LED** signals actual error by flashing with a frequency which corresponds to the number code of the fault.

The following table shows all the faults which are attributable to bus operation. In the operating display of the optional "ControlBox" only error E010 is displayed. A finer categorisation of errors can be obtained from the information parameters P700 "Actual Faults" or P701 "Last Fault 1...5".

NOTE

As of firmware version V1.9 R0 for the SK 500E series, not only current error messages but also warnings and information messages can be displayed via the parameter. In this context, the parameter **(P700)** has been converted into an array parameter. I.e. error messages are displayed in (P700 [-01]), warnings in (P700[-02]), and information in (P700 [-03]).

For all other series (SK 300E, SK 700E, SK 750E), parameter (P700) still only indicates error messages.

3.1.1 Error display

ControlBox / SimpleBox: The 4-digit, 7 segment display of these boxes indicates a fault with its number and the prefix "E". If the cause of the error is no longer present, the error display flashes and the error can be acknowledged with the OK key.

ParameterBox: The error messages are shown in plain text.

3.1.2 Error memory

The current error is saved in parameter P700 and the last five error messages are saved in parameter P701 [-01]…[-05]. Further information on inverter status at the time the error occurred are stored in parameters P702 to P706 / P799. More detailed information can be found in the main manual for the frequency inverter.

3.2 Error messages

Table of possible bus-specific error messages

Display in the ControlBox		Fault	Cause
Group	**Details in P700 / P701**	**Text in the ParameterBox**	• **Remedy**
E010	**10.0**	**(Bus Timeout)**	Telegram timeout, data transfer is faulty. Check P513. • Check external Bus connection. • Check bus protocol program process. • Check Bus Master.
	10.2	**Bus Timeout Option**	Telegram timeout for external bus module, telegram communication is faulty. • Check external connection. • Check bus protocol program process. • Check Bus Master.
	10.4	**Init error Option**	External bus module initialisation failure • Check P746. • Bus module not correctly plugged in. • Check Bus module current supply.
	10.1	**System error option**	External Bus module system failure
	10.3		
	10.5		
	10.6		
	10.7		
	10.8	**Error option**	Communication error in external module connection error/fault in external module

4 Additional information

4.1 Maintenance and servicing information

In normal use, NORD frequency inverters and their accessories are maintenance-free.

If air intake filters have been built into the control cabinet, then these should also be regularly cleaned or replaced.

If you contact our technical support, please have the precise device type (name plate/display), accessories and/or options, the software version used (P707) and the series number (name plate) at hand.

Repairs

The device must be sent to the following address if it needs repairing:

NORD Electronic DRIVESYSTEMS GmbH
Tjüchkampstr. 37
26605 Aurich, Germany

For queries about repairs, please contact:

Getriebebau NORD GmbH & Co. KG
Tel.: 04532 / 401-515
Fax: 04532 / 401-555

If a frequency inverter or accessories are sent in for repair, no liability can be accepted for any added components, e.g. such as line cables, potentiometer, external displays, etc.!

Please remove all non-original parts from the frequency inverter.

NOTE

If possible, the reason for returning the component/device should be stated. If necessary, at least one contact for queries should be stated.

This is important in order to keep repair times as short and efficient as possible.

On request you can obtain a suitable goods return voucher from Getriebebau NORD GmbH.

Internet information

You can also find the comprehensive manual in German and in English on our Internet site.

www.nord.com

4.2 Abbreviations in this manual

CU ..... Customer Unit (customer interface (internal)
DI, DIN . Digital input
EMC ..... Electromagnetic compatibility
FI ..... Frequency inverter
HW ..... Hardware
IND ..... Index
IW.....Actual value
STW .....Control word
SW .....Software version, setpoint
TU .....Technology Unit (external)
ZSW .....Status word

5 Keyword index

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