Bonfiglioli
Vectron

Active Next Generation

Operating Instruction
Expansion Module EM-AUT-11
ANG210/ANG410/ANG510/ANG610

Bonfiglioli

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1 General Information about the Documentation

The present **supplement** to the operating instructions and the Quick Start Guide is valid for expansion modules EM-AUT of the frequency inverters series ANG.

1.1 Instruction manuals

For better clarity, the documentation is structured according to the customer-specific requirements made on the frequency inverter.

Quick start guide

The Quick Start Guide describes the basic steps required for mechanical and electrical installation of the frequency inverter. The guided commissioning supports you in the selection of necessary parameters and the configuration of the frequency inverter by the software.

Operating instructions

The Operating Instructions describe all functions of the frequency inverter. The parameters required for adapting the frequency inverter to specific applications and several additional functions are described in detail.

Application manual

The application manual supplements the documentation for purposeful installation and commissioning of the frequency inverter. Information on various subjects connected with the use of the frequency inverter is described specific to the application.

If you need a copy of the documentation or additional information, contact your local representative of BONFIGLIOLI.

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The products for ProfiNET® communication comply with the specifications of the user organization "PROFIBUS Nutzerorganisation e. V.".

The present documentation was prepared with great care and was subjected to extensive and repeated reviews. For reasons of clarity, it was not possible to include all details of all types of the product in the documentation. Neither was it possible to consider all conceivable installation, operation or maintenance situations. If you require further information or if you encounter specific problems which are not dealt with in sufficient detail in the documentation, contact your local BONFIGLIOLI agent.

The present document was created in English. Other language versions are translations.

1.2 This document

This document describes the Automation Interface module *EM-AUT ACTIVE NEXT GENERATION (ANG)* series.

The information in this document pertains specifically to the *Automation Interface EM-AUT* of *ACTIVE NEXT GENERATION (ANG)* series. You will find further information in the basic operating instructions document "**VEC1105**".

This document contains important information on the installation and use of the product in its specified application range. Compliance with this document contributes to avoiding risks, minimizing repair cost and downtimes and increasing the reliability and service live of the frequency inverter.

For this reason, make sure you read the document carefully.

IMPORTANT:

Compliance with the documentation is required to ensure safe operation of the frequency inverter. BONFIGLIOLI VECTRON GmbH shall not be held liable for any damage caused by any non-compliance with the documentation.

In case any problems occur which are not covered by the documentation sufficiently, please contact the manufacturer.

This document applies to expansion modules of the following device series:

- EM-AUT-11 (Profinet)
- EM2-AUT-11 (PNC)

In this manual the designation "EM-AUT-11" also applies to EM2-AUT-11 modules.

1.3 Warranty and liability

BONFIGLIOLI VECTRON GmbH (hereinafter referred to as "manufacturer") notes that the contents of this document do not form part of any previous or existing agreement, assurance or legal relationship between the manufacturer and the user of the document (hereinafter referred to as the "User"). Neither are they intended to supplement or replace such agreements, assurances or legal relationships. Any obligations of the manufacturer shall solely be based on the relevant purchase agreement which also includes the complete and solely valid warranty stipulations. These contractual warranty provisions are neither extended nor limited by the specifications contained in this documentation.

The manufacturer reserves the right to correct or amend the specifications, product information and omissions in these operating instructions without prior notice. The manufacturer assumes no responsibility to update the document. The manufacturer shall not be liable for any damage, injuries or costs which may be caused by the aforementioned reasons.

In addition, the manufacturer excludes any warranty and disclaims all liability, including without limitation direct, indirect, special, punitive, incidental, exemplary or consequential damages arising out of or in connection with one or more of the following causes:

- inappropriate use of the frequency inverter,
- non-compliance with the instructions, warnings and prohibitions contained in the documentation,
- unauthorized modifications of the solar inverter,
- insufficient monitoring of parts of the machine/plant which are subject to wear,
- repair work at the machine/plant not carried out properly or in time,
- catastrophes by external impact and Force Majeure.

1.4 Obligation

This document must be read before commissioning. Anybody entrusted with tasks in connection with the

- transport,
- assembly,

- installation of the frequency inverter and
- operation of the frequency inverter

must have read and understood the Operating Instructions and, in particular, the safety instructions in order to prevent personal and material losses.

1.5 Copyright

Any copyrights relating to this document shall remain with

BONFIGLIOLI VECTRON GmbH
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Germany

This document is intended for the operator of the frequency inverter. Any disclosure or copying of this document, exploitation and communication of its contents (as hardcopy or electronically) shall be forbidden, unless permitted expressly.

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1.6 Storage

The documentation forms an integral part of the frequency inverter. It must be stored such that it is accessible to operating staff at all times. In case the frequency inverter is sold to other users, this Operating Instructions document must also be handed over.

2 General safety instructions and information on use

The chapter "General safety instructions and information on use" contains general safety instructions for the Operator and the Operating Staff. At the beginning of certain main chapters, some safety instructions are included which apply to all work described in the relevant chapter. Special work-specific safety instructions are provided before each safety-relevant work step.

2.1 Terminology

According to the documentation, different activities must be performed by certain persons with certain qualifications.

The groups of persons with the required qualification are defined as follows:

Operator

This is the entrepreneur/company who/which operates the frequency inverter and uses it as per the specifications or has it operated by qualified and instructed staff.

Operating staff

The term Operating Staff covers persons instructed by the Operator of the frequency inverter and assigned the task of operating the frequency inverter.

Skilled Personnel

The term Skilled Personnel covers staff that are assigned special tasks by the Operator of the frequency inverter, e.g. installation, maintenance and service/repair and troubleshooting. Based on their qualification and/or know-how, Skilled Personnel must be capable of identifying defects and assessing functions.

Qualified electrician

The term Qualified Electrician covers qualified and trained staff who has special technical know-how and experience with electrical installations. In addition, Qualified Electricians must be familiar with the applicable standards and regulations, they must be able to assess the assigned tasks properly and identify and eliminate potential hazards.

Instructed person

The term Instructed Person covers staff who was instructed and trained about/in the assigned tasks and the potential hazards that might result from inappropriate behavior. In addition, instructed persons must have been instructed in the required protection provisions, protective measures, the applicable directives, accident prevention regulations as well as the operating conditions and verified their qualification.

Expert

The term Expert covers qualified and trained staff who has special technical know-how and experience relating to frequency inverter. Experts must be familiar with the applicable government work safety directives, accident prevention regulations, guidelines and generally accepted rules of technology in order to assess the operationally safe condition of the frequency inverter.

Process data area (PZD)

Process data area (PZD), includes control words and set points, or status information and actual values.

Parameter area (PKW)

Parameter area (PKW) is for reading/writing parameter values, e.g. reading out faults, or reading out information about the properties of a parameter such as, for example, min/max limits, etc. The PKW (parameter identifier value) telegram section can be used to monitor and/or change any parameter in the inverter.

2.2 Designated use

The frequency inverter is designed according to the state of the art and recognized safety regulations.

The frequency inverters are electrical drive components intended for installation in industrial plants or machines. Commissioning and start of operation is not allowed until it has been verified that the machine meets the requirements of the EC Machinery Directive 2006/42/EC and DIN EN 60204-1.

The frequency inverters meet the requirements of the low voltage directive 2014/35/EU and DIN EN 61800-5-1. CE-labelling is based on these standards. Responsibility for compliance with the EMC Directive 2014/30/EU lies with the operator. Frequency inverters are only available at specialized dealers and are exclusively intended for commercial use as per EN 61000-3-2.

No capacitive loads may be connected to the frequency inverter.

The technical data, connection specifications and information on ambient conditions are indicated on the rating plate and in the documentation and must be complied with in any case.

2.3 Misuse

Any use other than that described in "Designated use" shall not be permissible and shall be considered as misuse.

For example, the machine/plant must not be operated

- by uninstructed staff,
- while it is not in perfect condition,
- without protection enclosure (e.g. covers),
- without safety equipment or with safety equipment deactivated.

The manufacturer shall not be held liable for any damage resulting from such misuse. The sole risk shall be borne by the operator.

Explosion protection

The frequency inverter is an IP 20 protection class device. For this reason, use of the device in explosive atmospheres is not permitted.

2.4 Residual risks

Residual risks are special hazards involved in handling of the frequency inverter which cannot be eliminated despite the safety-compliant design of the device. Remaining hazards are not obvious and can be a source of possible injury or health damage.

Typical residual risks include:

Electrical hazard

Danger of contact with energized components due to a defect, opened covers or enclosures or improper working on electrical equipment.

Danger of contact with energized components in frequency inverter if no external disconnection device was installed by the operator.

Electrostatic charging

Touching electronic components bears the risk of electrostatic discharges.

Thermal hazards

Risk of accidents by hot machine/plant surfaces, e.g. heat sink, transformer, fuse or sine filter.

Charged capacitors in DC link

The DC link may have dangerous voltage levels even up to three minutes after shutdown.

Danger of equipment falling down/over, e.g. during transport
Center of gravity is not the middle of the electric cabinet modules.

2.5 Safety and warning signs on the frequency inverter

- Comply with all safety instructions and danger information provided on the frequency inverter.
- Safety information and warnings on the frequency inverter must not be removed.

2.6 Warning information and symbols used in the Operating Instructions

2.6.1 Hazard classes

The following hazard identifications and symbols are used in the Operating Instructions to mark particularly important information:

DANGER

Identification of immediate threat holding a **high** risk of death or serious injury if not avoided.

WARNING

Identification of immediate threat holding a **medium** risk of death or serious injury if not avoided.

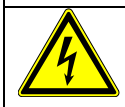
CAUTION

Identification of immediate threat holding a **low** risk of minor or moderate physical injury if not avoided.

NOTICE

Identification of a threat holding a risk of material damage if not avoided.

2.6.2 Hazard symbols

Symbol	Meaning	Symbol	Meaning
	General hazard		Suspended load
	Electrical voltage		Hot surfaces
	Danger of crushing		

2.6.3 Prohibition signs

Symbol	Meaning
	No switching; it is forbidden to switch the machine/plant, assembly on

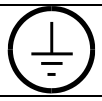
2.6.4 Personal safety equipment

Symbol	Meaning
	Wear body protection
	Wear ear protectors

2.6.5 Recycling

Symbol	Meaning
	Recycling, to avoid waste, collect all materials for reuse

2.6.6 Grounding symbol

Symbol	Meaning
	Ground connection

2.6.7 ESD symbol

Symbol	Meaning
	ESD: Electrostatic Sensitive Devices, i.e. components and assemblies sensitive to electrostatic energy

2.6.8 Information signs

Symbol	Meaning
	Tips and information making using the frequency inverter easier.

2.6.9 Font style in documentation

Example	Font style	Use
1234	bold	Representation of parameter numbers
Parameter	inclined, font: Times New Roman	Representation of parameter names
1234	font: Courier New	Representation of parameter and other values
P.1234	bold	Representation of parameter numbers without name, e.g. in formulas
Q.1234	bold	Representation of source numbers

2.7 Directives and guidelines to be adhered to by the operator

The operator must follow the following directives and regulations:

- Ensure that the applicable workplace-related accident prevention regulations as well as other applicable national regulation are accessible to the staff.
- An authorized person must ensure, before using the frequency inverter, that the device is used in compliance with its designated use and that all safety requirements are met.
- Additionally, comply with the applicable laws, regulations and directives of the country in which the frequency inverter is used.
- Any additional guidelines and directives that may be required additionally shall be defined by the operator of the machine/plant considering the operating environment.

2.8 Operator's general plant documentation

- In addition to the Operating Instructions, the operator should issue separate internal user manuals for the frequency inverter. The Operating Instructions of the frequency inverter must be included in the Operating Instructions of the whole plant.

2.9 Operator's/operating staff's responsibilities

2.9.1 Selection and qualification of staff

- Any work on the frequency inverter may only be carried out by Skilled Personnel. The staff must not be under the influence of any drugs. Note the minimum age required by law. Define the staff's responsibility pertaining to all work on the frequency inverter clearly.
- Work on the electrical components may only be performed by a qualified electrician according to the applicable rules of electrical engineering.
- The operating staff must be trained for the relevant work to be performed.

2.9.2 General work safety

- In addition to the Operating Instructions of the machine/plant, any applicable legal or other regulations relating to accident prevention and environmental protection must be complied with. The staff must be instructed accordingly.
  Such regulations and/or requirements may include, for example, handling of hazardous media and materials or provision/use of personal protective equipment.
- In addition to these Operating Instructions, issue any additional directives that may be required to meet specific operating requirements, including supervision and reporting requirements, e.g. directives relating to work organization, workflow and employed staff.
- Unless approved of expressly by the manufacturer, do not modify the frequency inverter in any way, including addition of attachments or retrofits.
- Only use the frequency inverter if the rated connection and setup values specified by the manufacturer are met.
- Provide appropriate tools as may be required for performing all work on the frequency inverter properly.

2.9.3 Ear protectors

- The frequency inverter produces noise. For this reason it should be installed in areas where people normally don't stay.
- Noise emission in operation is < 85 dB(A) in the case of sizes 1 through 7.
- Noise emission in operation is approx. 86 dB(A) in the case of size 8. Ear protectors must be used when staying near the frequency inverter

2.10 Organizational measures

2.10.1 General

- Train your staff in the handling and use of the frequency inverter and the machine/plant as well as the risks involved.
- Use of any individual parts or components of the frequency inverter in other parts of the operator's machine/plant is prohibited.
- Optional components for the frequency inverter must be used in accordance with their designated use and in compliance with the relevant documentation.

2.10.2 Use in combination with third-party products

- Please note that BONFIGLIOLI VECTRON MDS GmbH will not accept any responsibility for compatibility with third-party products (e.g. motors, cables or filters).
- In order to enable optimum system compatibility BONFIGLIOLI VECTRON MDS GmbH offers components facilitating commissioning and providing optimum synchronization of the machine/plant parts in operation.
- If you use the frequency inverter in combination with third-party products, you do so at your own risk.

2.10.3 Handling and installation

- Do not commission any damaged or destroyed components.
- Prevent any mechanical overloading of the frequency inverter. Do not bend any components and never change the isolation distances.
- Do not touch any electronic construction elements and contacts. The frequency inverter is equipped with components which are sensitive to electrostatic energy and can be damaged if handled improperly. Any use of damaged or destroyed components will endanger the machine/plant safety and shall be considered as non-compliance with the applicable standards.
- Only install the frequency inverter in a suitable operating environment. The frequency inverter is exclusively designed for installation in industrial environments.
- If seals are removed from the case, this can result in the warranty becoming null and void.

2.10.4 Electrical connections

- The five safety rules must be complied with.
- Never touch live terminals. In sizes 1 through 7, the DC-link may have dangerous voltage levels up to 3 minutes after shutdown. In size 8, the DC-link may have dangerous voltage levels up to 10 minutes after shutdown.
- When performing any work on/with the frequency inverter, always comply with the applicable national and international regulations/laws on work on electrical equipment/plants of the country in which the frequency inverter is used.
- The cables connected to the frequency inverters may not be subjected to high-voltage insulation tests unless appropriate circuitry measures are taken before.
- Only connect the frequency inverter to suitable supply mains. The frequency inverter may be operated in TN, TT and IT grid types. Precautions must be taken for operation in IT grids. Operation in a corner-grounded TN grid shall not be permissible.

2.10.4.1 The five safety rules

When working on/in electrical plants, always follow the five safety rules:

1 Disconnect
2 Secure to prevent restarting
3 check for absence of voltage,
4 carry out earthing and short-circuiting
5 cover or shield neighboring live parts

2.10.5 Safe operation

- During operation of the frequency inverter, always comply with the applicable national and international regulations/laws on work on electrical equipment/plants.
- Before commissioning and the start of the operation, make sure to fix all covers and check the terminals. Check the additional monitoring and protective devices according to the applicable national and international safety directives.
- During operation, all covers must be installed correctly, and all electrical cabinet doors must be closed. During operation, never open the machine/plant.
- No connection work shall be carried out while power supply is on.
- The machine/plant holds high voltage levels during operation, is equipped with rotating parts (fan) and has hot surfaces. Any unauthorized removal of covers, improper use, wrong installation or operation may result in serious injuries or material damage.
- Some components, e.g. the heat sink or braking resistor, may be hot even some time after the machine/plant was shut down. Don't touch any surfaces directly after shutdown. Wear safety gloves where necessary.
- The frequency inverter may hold dangerous voltage levels until the capacitor in the DC link is discharged. After shutdown, wait for at least 3 minutes (sizes 1 through 7) and at least 10 minutes (size 8) before starting any electrical or mechanical work on the frequency inverter. Even after this waiting time, make sure that the equipment is de-energized in accordance with the safety rules before starting the work.
- In order to avoid accidents or damage, only qualified staff and electricians may carry out the work such as installation, commissioning or setup.
- In the case of a defect of terminals and/or cables, immediately disconnect the frequency inverter from mains supply.
- Persons not familiar with the operation of the frequency inverter and children must not have access to the device.
- Do not bypass nor decommission any protective devices.
- The frequency inverter may be connected to power supply every 60 s. This must be considered when operating a mains contactor in jog operation mode. For commissioning or after an emergency stop, a non-recurrent, direct restart is permissible.
- After a failure and restoration of the power supply, the motor may start unexpectedly if the AutoStart function is activated.
  If staff are endangered, a restart of the motor must be prevented by means of external circuitry.
- Before commissioning and the start of the operation, make sure to fix all covers and check the terminals. Check the additional monitoring and protective devices according to EN 60204 and applicable the safety directives (e.g. Working Machines Act or Accident Prevention Directives).

2.10.6 Maintenance and service/troubleshooting

- Visually inspect the frequency inverter when carrying out the required maintenance work and inspections at the machine/plant.

- Perform the maintenance work and inspections prescribed for the machine carefully, including the specifications on parts/equipment replacement.
- Work on the electrical components may only be performed by a qualified electrician according to the applicable rules of electrical engineering. Only use original spare parts.
- Unauthorized opening and improper interventions in the machine/plant can lead to personal injury or material damage. Any repair work may only be carried out by the manufacturer or persons approved/licensed by the manufacturer. Any repair work must be carried out by qualified electricians. Check protective equipment regularly.
- Before performing any maintenance work, the machine/plant must be disconnected from mains supply and secured against restarting. The five safety rules must be complied with.

2.10.7 Final decommissioning

Unless separate return or disposal agreements were made, recycle the disassembled frequency inverter components:

- Scrap metal materials
- Recycle plastic elements
- Sort and dispose of other component materials

Electric scrap, electronic components, lubricants and other utility materials must be treated as special waste and may only be disposed of by specialized companies.

In any case, comply with any applicable national disposal regulations as regards environmentally compatible disposal of the frequency inverter. For more details, contact the competent local authorities.

After the end of product service life, the user/operator must take the device out of operation.

For more information about the decommissioning of the device refer to the applicable operating instructions document.

Disposal requirements under European Union WEEE regulations

The product is marked with the WEEE symbol shown below.

This product cannot be disposed as general household waste. Users responsible for the final disposal must make sure that it is carried out in accordance with the European Directive 2012/19/EU, where required, as well as the relative national transposition rules. Fulfil disposal also in according with any other legislation in force in the country.

3 Technical data

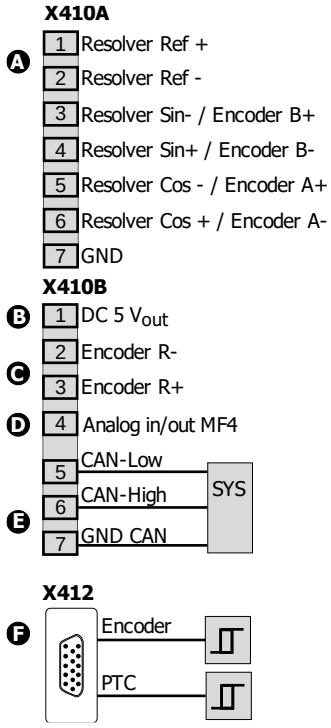
When using the EM-AUT expansion modules, the technical data **of the frequency inverter** must be considered.

Control terminal X410A		
	Main function	Other function
X410A.1	Resolver Ref +	-
X410A.2	Resolver Ref -	-
X410A.3	Resolver Sin -	Encoder B +
X410A.4	Resolver Sin +	Encoder B -
X410A.5	Resolver Cos -	Encoder A +
X410A.6	Resolver Cos+	Encoder A -
X410A.7	Ground GND	

Control terminal X410B		
	Main function	Other function
X410B.1	-	Output $5V_{DC}$ [2)]
X410B.2	-	Encoder R -
X410B.3	-	Encoder R +
X410B.4	Analog in/out MF4 [1)3)]	
X410B.5	System bus, CAN low	
X410B.6	System bus, CAN high	
X410B.7	Ground GND_{CAN}	

1) The control electronics parameters can be configured as required.
2) The maximum power available is reduced by the other control outputs of the frequency inverter and expansion module.
3) Analog input or Analog output or Temperature monitoring

Block diagram



Ⓐ Ⓒ Resolver / Speed sensor input

The encoder interface is suitable for typical market resolvers or TTL encoders.
Please check chapter 3 "Technical data".

Ⓑ Voltage output for encoder supply

DC 5 V, P_{max} = 1 W, observe the maximum power supply

Ⓓ Analog input /Analog output MF4

You can use the terminal optionally as analog input, analog output, PTC, KTY, PT1000 or digital input.
Please check chapter 3 "Technical data".

Ⓔ Communication interface system bus

Galvanic decoupled CAN-connection according to ISO-DIS 11898 (CAN High Speed), bus termination can be activated via internal switch.
The Protocol CANopen or Systembus is set up via *CAN Interface (CAN-Systembus / CANopen)* **276**.

F Inputs for Absolute encoder and PTC/KTY/PT1000 (15 pole female connector HD-Sub-D)

The additional encoder interface on **EM-AUT** is designed for connection of standard commercial TTL encoder (optionally with reference track, without commutation tracks), SinCos (with reference track, without commutation tracks), EnDat 2.1 (SinCoS track required), Hiperface and SSI encoders (optionally with TTL [RS-422] or SinCos track). The encoder supply voltage at contacts X412.6 (V_{Enc}) and X412.15 (0VL) can be adjusted through parameter *Supply voltage* **1187** in between DC 5.0 … 12 V. See chapter 6.5.4 "Supply voltage". Maximum load: 1 W.

Motor temperature input:

- PTC Trigger resistance = 3.99 kΩ, Hysteresis = 2.3 kΩ
- KTY input
- PT1000 input
- Bimetal temperature sensor (NC)

• Use PTC resistors with safe isolation from motor winding according to EN 61800-5-1.

Technical data of control terminals X410

Resolver input (X410A.1) ... (X410A.6):

Reference voltage $U_{REF\ eff}$ = 2.5 V, I_{max} = 40 mA (Ref)
Input voltage $U_{min\ eff}$ = 2 V, voltage-proof until 6 V_{rms} (Sin and Cos)
Ratio U_{IN}/U_{REF} = 0.5
Excitation frequency = 8 kHz
Input impedance: >95 Ω at 8 kHz, Maximum pole pairs = 7,
30000 rpm at nº of pole pares = 1.

Speed sensor input (Alternative function) (X410A.3) ... (X410B.2):

- A/B tracks (TTL encoder)
- R track (Reference track, only evaluable with TTL encoders)
A/B tracks: constant part V =DC 2.5 V ±0.5 V, RS485 Standard
R track: constant part V =DC 2.5 V ±0.5 V, RS485 Standard
Frequency signal, f_{max} = 300 kHz, voltage-proof until 6 V,
TTL (push-pull) according to specification RS-422A / RS-485: U_{max} = 5 V

Voltage output DC 5 V for encoder supply (X410B.1):

P_{max} = 1 W. Depending on the load on the digital outputs of the frequency inverter and expansion module, this value may be lower.

EM-AUT: Analog input / output MF4 (X410B.4):

Analog signal: Input voltage: DC -10 V to 10 V (R_i = 69.5 kΩ), DC 0 V to 10 V (R_i = 69.5 kΩ), DC 0 ... 20mA (R_i = 249 Ω), PTC, KTY, PT1000.
Resolution 13 Bit
Output voltage: DC 0 V to 10 V
Resolution 12 Bit
Digital input: Low signal: DC 0 ... 4 V, High signal: DC 6 ... 30 V.

NOTICE

Module damage

The MF4OA output used as analog output (terminal X410B.4) cannot permanently withstand short circuits and external voltages. External voltages can damage the module.

• Avoid short circuits and external voltages.

Conductor cross-section:

The control terminals are suitable for the following cable sizes:

with ferrule:	0.25 … 1.0 mm²
without ferrule:	0.14 … 1.5 mm²

Encoder and PTC input X412 (HD-Sub-D)	
Encoder input:	**Motor temperature evaluation**
Internal resistance <120 Ω	**PTC-Input** Trigger resistance = 3.99 kΩ Hysteresis = 2.3 kΩ
A/B track: sine-shaped differential signal 0.6…1.2 Vpp	**KTY-Input** **PT1000 Input**
R-track: Differential signal 0.2…1.7 Vpp	
Clock and data Signal: V =DC 2.5 V ±0.5 V (RS485 Standard)	**PTC or bimetal temperature sensor (NC)**
Power supply encoder: V_{ENC} track: Supply DC 5 … 12 V (max. 1 W) $V_{ENC,Sense}$ track: encoder sensor cable	

CAUTION

Device damage

Exceeding the permitted power value for the DC 24V-Supply may damage the device.

The maximum total power load of the ANG DC 24V-Supply must not exceed 4 W. The Encoder supply voltages are supplied by the ANG DC 24V-Supply and must therefore be taken into account as well as the digital outputs of the ANG Controller.

- The manufacturer recommends connecting an external DC 24 V power supply to the inputs of the control terminal and to supply the input voltages of the digital inputs of the ANG-Controller directly from this external voltage.
- Note the encoder manufacturer's input power specifications.

NOTICE

Device damage

The inputs for motor temperature evaluation are not insulated by default. Inappropriately insulated components may lead to device damage.

- Only motor temperature evaluations which feature a safe insulation from the motor winding as per EN61800-5-1 may be connected.

BONFIGLIOLI servo motors of types BMD, BCR and BTD are provided with safe insulation from the motor winding.

4 Functional description

WARNING

Unintended movements! Device damage!

With the EM-AUT module, it is possible from a controller to access **ALL** frequency inverter parameters. There is **no access control** via the control level as with the KP500 manual control unit or the VPlus PC software.

Changing parameters, the functions of which are not known to the user, can result in unintended movements and material and/or personal losses as well as inoperativeness of the frequency inverter.

- Proceed with due caution and contact the manufacturer when in doubt.

The expansion modules EM-AUT can only be used with frequency inverter of the ANG series. The EM-AUT expansion module is mounted on the frequency inverter **as an integrated component**. Do not remove this component.

This document exclusively describes the EM-AUT expansion modules. It is not to be understood as fundamental information for the operation of the frequency inverters of the ANG series.

The expansion modules EM-AUT can only be used with frequency inverter of the ANG series.

This document is not to be understood as providing general/basic information on PROFINET. It requires basic knowledge of the methods and effects of PROFINET on the user's side.

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In some chapters, setting and display options via the PC software VPlus are described as an alternative to the KP500 control unit. If you wish to use the VPlus PC software, you will need an optional serial interface adapter KP232 or direct Ethernet connection with the PROFINET system.

With older firmware versions, the EM2-AUT modules may show up as "EM-AUT" in VPlus in Parameter 1. Check the labels on your component/device to verify the status of your module.

The EM-AUT expansion modules are hardware components to complete the functionality of the frequency inverter. They allow the data exchange within a network and between directly connected components such as control and regulation elements.

Specification: PROFINET IO device, real-time class 1, conformance class A.

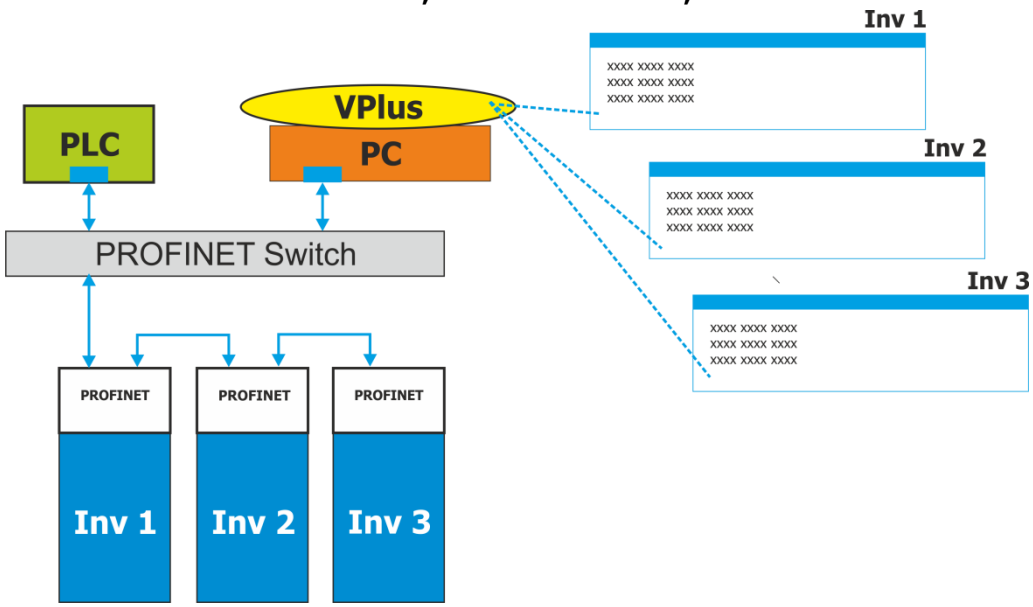


Figure 4-1: PROFINET function graph

The PROFINET component has the manufacturer ID **0x020B** (hexadecimal). The latest device description can be downloaded from the Bonfiglioli.com website. The file name is similar to **GSDML-V2.33-Bonfiglioli-020B-ANG-20170809.xml**, where the version number and the date might differ.

The manufacturer ID is assigned by PROFIBUS Nutzerorganisation e. V. in Karlsruhe.

With older firmware versions, the EM2-AUT modules may show up as "EM-AUT" in VPlus in Parameter 1. Check the labels on your component/device to verify the status of your module.

EM2-AUT modules feature R-track evaluation for absolute encoder AND for SinCos-encoder. Check the labels on your component/device to verify the status of your module.

For further details on the telegram structure under the PROFINET standard, see chapter "Available objects".

The expansion modules EM-AUT extend the functionality of the frequency inverters of the ANG series by the following functions:

- Resolver / TTL interface. See chapter 6.2.
- CAN interface (galvanic decoupled) for CANopen or System bus
  (CAN interface ISO-DIS 11898, CAN High Speed, max. 1 MBaud).
  See chapter 5.4 "Systembus interface".
- PROFINET® communications.
  See chapter 9 "Setting process data".
- Analog input (DC -10…+10 V, DC 0…+10 V) / output (DC 0…+10 V) or as PTC, KTY, PT1000 input. See chapter 13.
- Encoder interface X412 including PTC evaluation via HD-Sub-D female connector.
  Supported encoder types:

- TTL (optionally with Reference track, without commutation tracks)
- SinCos (with Reference tracks, without commutation tracks)
- EnDat 2.1 (encoder type with SinCos track required)
- Hiperface
- SSI encoder (optionally with TTL [RS-422]- or SinCos track)

4.1 Supported configurations

ANG inverters support different types of control and reference values:

- Standard (without Positioning functions)
- Positioning via contacts (or remote contacts)
- Positioning via Motion Control Interface (MCI) via field bus

Motion control configurations are set when parameter *Configuration* **30** = `x40` (in this example `240`). To use the full functionality of the Motion Control Interface Parameter *Local/Remote* **412** = `1-Control via State machine` must be set.

The inverter's behavior with respect to *control word | status word* and *modes of operation /modes of operation display* varies in the two different types of configuration.

Standard:

Necessary settings:

- C*onfiguration* **30** ≠ x40.
- *Local/Remote* **412** = `2 - Control via Remote-Contacts`

The control (Start, Stop, Frequency change over, etc.) is typically carried out via:

- Digital contacts
- Remote contacts via Field bus

Reference values result from the selected configuration. Typical configurations:

Reference speed / Reference frequency:

- Analogue input
- Fixed values from parameters
- Target velocity

Percentage reference value for technology controller or Torque control:

- Analogue input
- Fixed values from parameters

Please refer to chapter "Configurations without Motion Control" for the control without Positioning functionality.

Positioning via contacts (or remote contacts):

Necessary settings:

- C*onfiguration* **30** = x40.
- *Local/Remote* **412** = `0 - Control via Contacts` or `2 - Control via Remote-Contacts`

The control (Start, Stop, Target position change over, etc.) is carried out typically via:

- Digital contacts
- Remote contacts via Field bus

Reference values result from the selected configuration. Typical configurations:

- Reference speed / Reference frequency

– Reference target position

Please refer also to the application manual "Positioning".

MCI (Motion Control Interface – Positioning via Field bus):

Necessary settings:

– *Configuration* **30** = x40.
– *Local/Remote* **412** = `1 - Control via Statemachine`

The control (Start, Stop, mode change over, etc.) is carried out via the process data channel (PZD) *PZD1Control word*.

Reference values result from the selected Modes of Operation.

Typical Modes of Operation are:

– Reference speed via target velocity
– Target position

The usage of the Motion Control Interface is described in this manual in Chapters "Motion Control Interface (MCI)" and "Motion control configurations".

4.2 Initialization time

When the frequency inverter is turned on, the expansion module must be initialized in addition to the frequency inverter. The initialization can take up to 20 seconds.

Wait until the initialization phase is complete before starting the communication (RUN LED).

5 Installation

5.1 General information

The installation of the expansion module must be carried out by qualified personnel according to the general and regional safety and installation directives. For a safe operation of the frequency inverter it is necessary that the documentation and the device specifications be complied with during installation and commissioning. In the case of special applications, you may also have to comply with further guidelines and instructions.

For further information refer to the operating instructions document "**VEC1105**".

5.2 Mechanical Installation

The EM-AUT module is mounted on the frequency inverter as an integrated component. Do not remove this component.

5.3 Electrical Installation

WARNING

Severe injury by electric current

If the following instructions are not complied with, there is direct danger with the possible consequences of death or severe injury by electric current. Further, failure to comply can lead to destruction of the frequency inverter and/or of the expansion module.

- Make sure that the frequency inverter is discharged.

WARNING

Live system

When the frequency inverter is disconnected from power supply, the mains, DC-link voltage and motor terminals may still be live for some time.

- Wait for at least three minutes until the DC link capacitors have discharged before starting work on the unit.

5.3.1 Control terminals

CAUTION

Communication faults

Without GND_{CAN} connection telegram faults or telegram interruptions can occur.

- For the connections of two or more devices CAN Low, CAN High and GND_{CAN} must be connected.

CAUTION

Device damage

Connecting or disconnecting control lines on a live system may damage the device.

- Switch off power supply before connecting or disconnecting the control inputs and outputs.

CAUTION

Device damage

Exceeding the permitted power value for the DC 24V-Supply may damage the device.

The maximum total power load of the ANG DC 24V-Supply must not exceed 4 W. The Encoder supply voltages are supplied by the ANG DC 24V-Supply and must therefore be taken into account as well as the digital outputs of the ANG Controller.

- The manufacturer recommends connecting an external DC 24 V power supply to the inputs of the control terminal and to supply the input voltages of the digital inputs of the ANG-Controller directly from this external voltage.
- Note the encoder manufacturer's input power specifications.

NOTICE

Unexpected operating behavior

The power output on terminal **X410B.1** may be loaded with a maximum power of 1 Watt. Depending on the total load on the DC 24 V supply voltage, the available power output may decrease. Higher power loads can cause unexpected operating behavior.

- Avoid higher power loads.

NOTICE

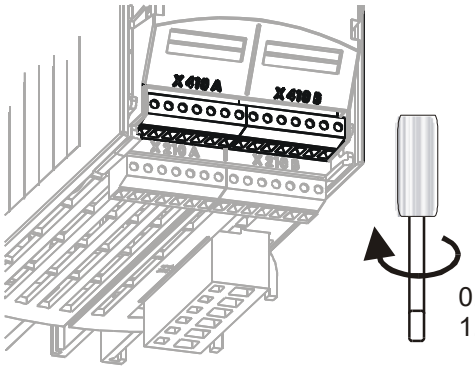
Electromagnetic Interference

Inappropriate shielding of lines may result in electromagnetic interferences.

- In order to minimize electromagnetic interference and to obtain a good signal quality, connect the shield of the cable to a ground plane (PE) at both ends.

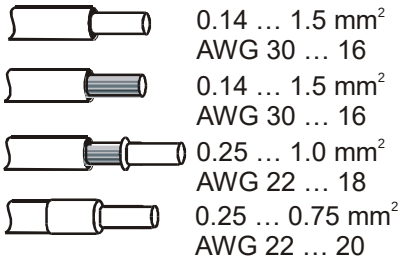
Please see chapter"Technical data" for technical details.

Expansion module EM-AUT



0.2 … 0.3 Nm
1.8 … 2.7 lb-in

Wieland DST85 / RM3,5



0.14 … 1.5 mm²
AWG 30 … 16

0.14 … 1.5 mm²
AWG 30 … 16

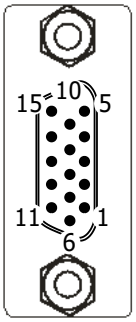
0.25 … 1.0 mm²
AWG 22 … 18

0.25 … 0.75 mm²
AWG 22 … 20

Encoder and PTC input X412 (female connector HD-Sub-D)

Contact	Function					
	SinCos	TTL	Hiperface	EnDat 2.1	SSI	
Housing	PE		PE	PE	PE	
1				Clock-	Clock-	
2				Clock+	Clock+	
3	Cos-	B-	Cos-	Cos-	(optionally B- / Cos-)	

4	Cos+	B+	Cos+	Cos+	(optionally B+ / Cos+)
5	TM_{PTC-}		TM_{PTC-}	TM_{PTC-}	TM_{PTC-}
6	V_{Enc}		V_{Enc}	V_{Enc}	V_{Enc}
7	R-	-			
8	-	R-	Data-	Data-	Data-
9	Sin-	A-	Sin-	Sin-	(optionally A- / Sin-)
10	TM_{PTC+}		TM_{PTC+}	TM_{PTC+}	TM_{PTC+}
11	$V_{Enc,Sense}$			$V_{Enc,Sense}$	$V_{Enc,Sense}$
12	R+	-			
13	-	R+	Data+	Data+	Data+
14	Sin+	A+	Sin+	Sin+	(optionally A+ / Sin+)

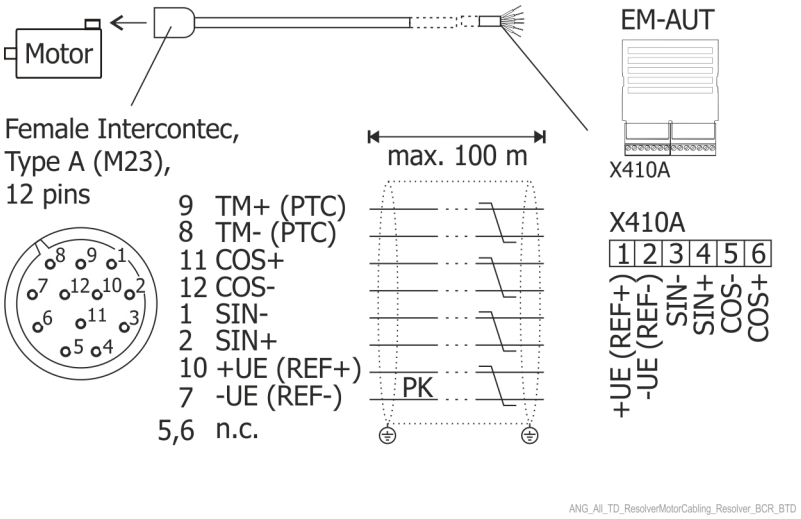


Function and signal	
Function	**Signal**
Housing	Shield connected with PE
A+/A- Sin+/Sin- B+/B- Cos+/Cos-	0.6 V … 1.2 Vpp incremental signal In the case of SSI encoders, the A+/A- and B+/B- tracks can be used, as an option, for TTL [RS-422] or SinCos signals.
R+/R-	Reference track (RS485 Standard)
Clock+/Clock-	Clock signal (RS485 Standard)
Data+/Data-	Data signal (RS485 Standard)
TM_{PTC} + TM_{PTC} –	Motor Temperature evaluation
V_{Enc} GND	Encoder supply (DC 5 …12 V)**,** max. load capacity 1 W
V_{EncS}	Measuring line for monitoring of V_{Enc} [2)]

[2)] Voltage control via the measuring line can be activated, as an option, through parameter *Power Supply* **1186**.

5.3.2 Cable assembly Resolver

Contact assignment BONFIGLIOLI VECTRON assembled cable for connection of Resolvers

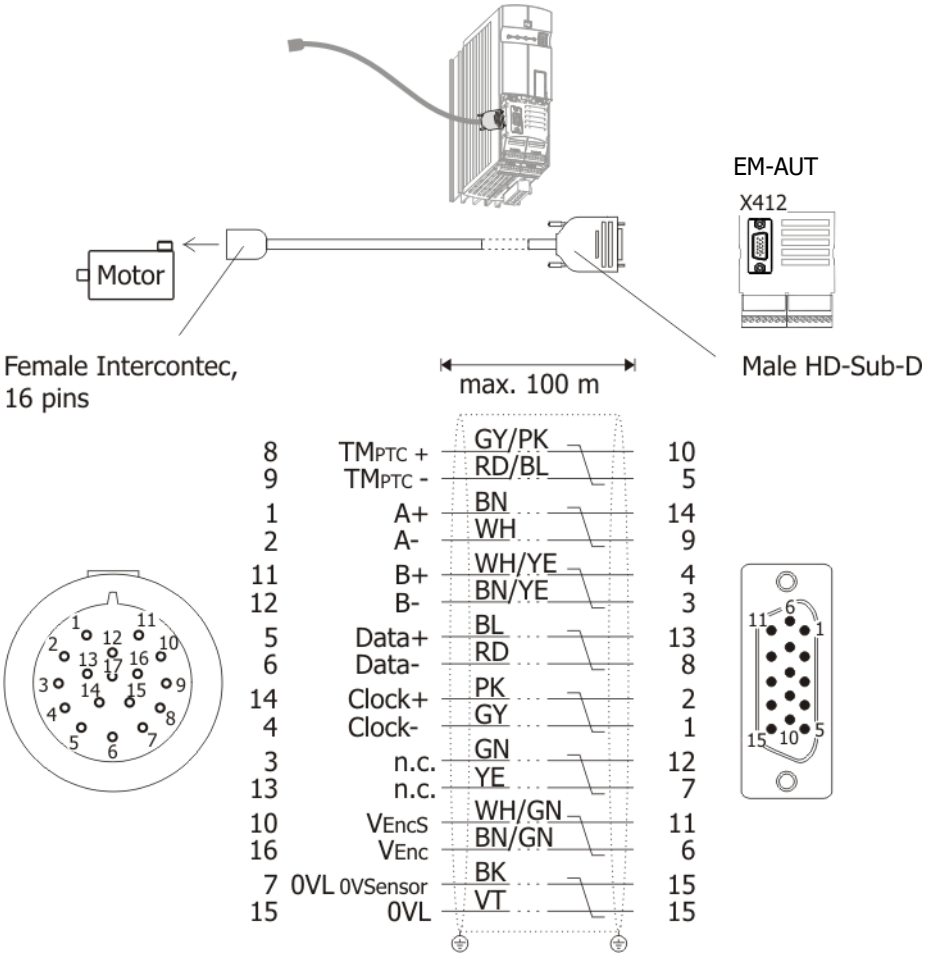


BONFIGLIOLI VECTRON MDS assembled cable	
Cable	Resolver Flexible Wire
Cable size	4x0.25 mm² + 2x0.5 mm²
Length	3 m, 5 m or 10 m

The cable has open leads with wire ferrules at the inverter side. The wires for the encoder evaluation have to be connected to the expansion module terminal X410A. The wires for the motor temperature evaluation (PTC) have to be connected to the basic device terminal X210B.

5.3.3 Cable assembly EnDat 2.1 for BCR/BTD

Contact assignment BONFIGLIOLI VECTRON assembled cable for BCR/BTD



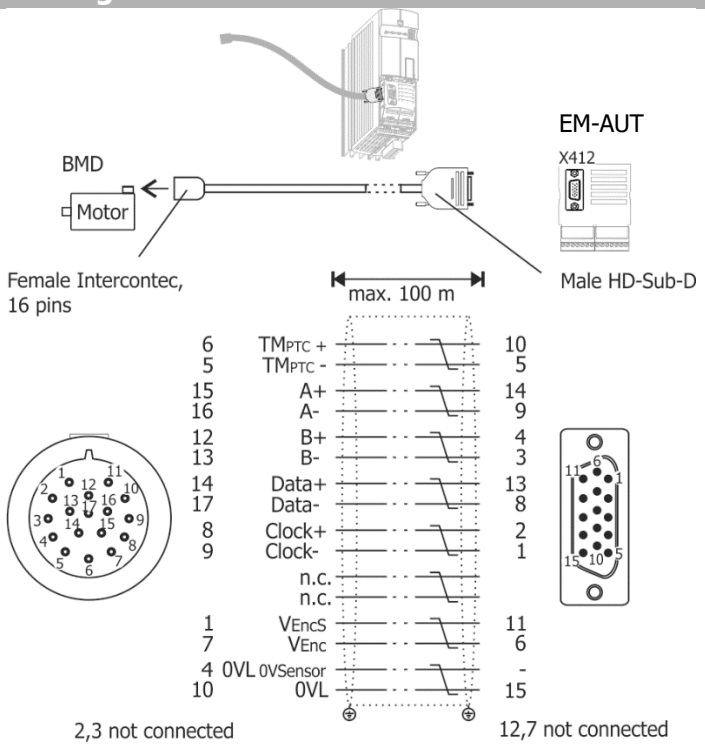
BONFIGLIOLI VECTRON assembled cable	
Encoder cable	8 double-circuit twisted lines
Cable size	0.14 mm²
Length	3 m, 5 m or 10 m

- Use PTC/KTY/PT1000 evaluations with safe insulation from motor winding according to EN 61800-5-1.
- Use shielded and twisted cables.
- Install encoder cable separately from motor cable.
- Connect the shield of the encoder line properly on both sides.

BONFIGLIOLI recommends using the pre-assembled cables for synchronous motor types BCR and BTD.

5.3.4 Cable assembly EnDat 2.1 for BMD

Contact assignment BONFIGLIOLI VECTRON cable for BMD



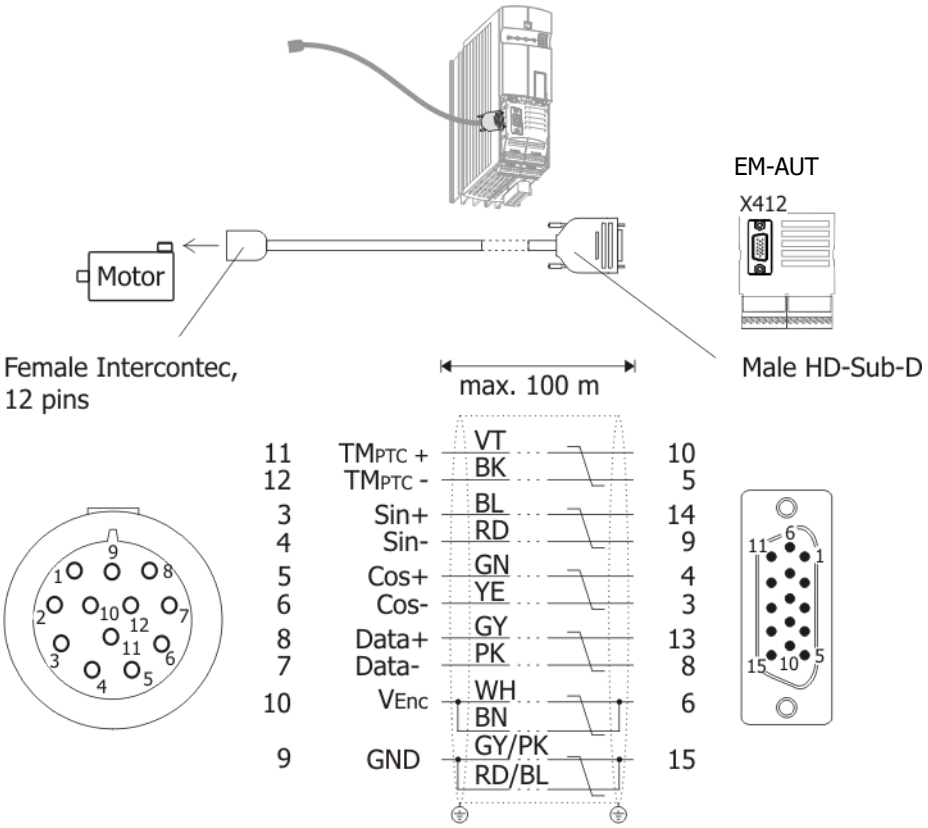
BONFIGLIOLI VECTRON assembled cable	
Encoder cable	8 twisted two-wire lines
Cable size	0.14 mm^2
Length	3 m, 5 m or 10 m

- Use PTC/KTY/PT1000 evaluations with safe insulation from motor winding according to EN 61800-5-1.
- Use shielded and twisted cables.
- Install encoder cable separately from motor cable.
- Connect the shield of the encoder line properly on both sides.

BONFIGLIOLI VECTRON recommends using the pre-assembled cables for synchronous motors types BMD.

5.3.5 Cable assembly Hiperface for BCR/BTD

Contact assignment BONFIGLIOLI VECTRON assembled cable for BCR/BTD



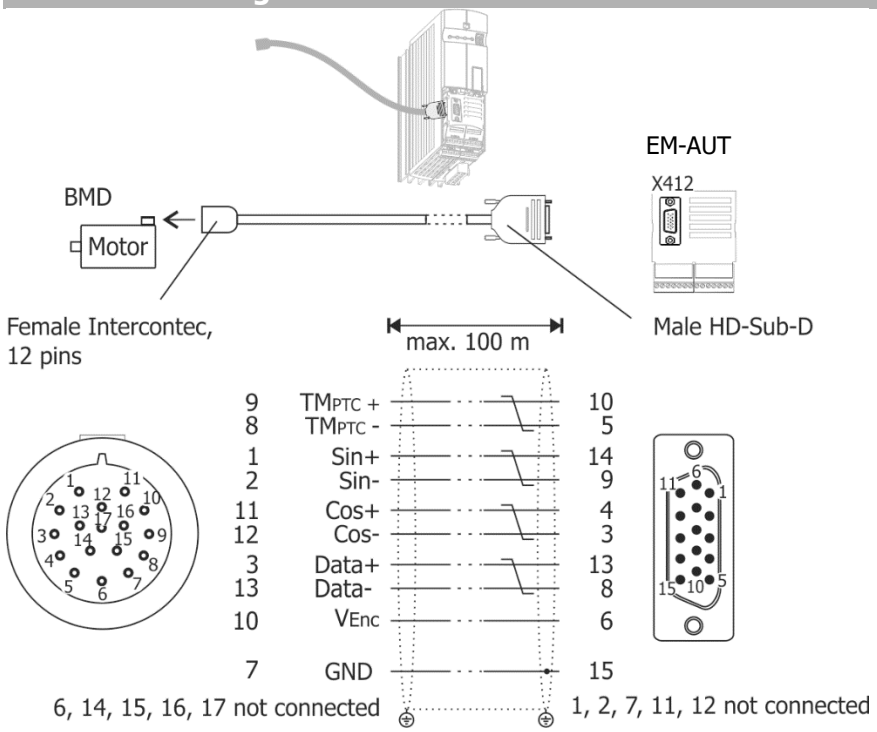
BONFIGLIOLI VECTRON assembled cable	
Encoder cable	8 double-circuit twisted lines
Cable size	0.14 mm²
Length	3 m, 5 m or 10 m

- Use PTC/KTY/PT1000 evaluations with safe insulation from motor winding according to EN 61800-5-1.
- Use shielded and twisted cables.
- Install encoder cable separately from motor cable.
- Connect the shield of the encoder line properly on both sides.

BONFIGLIOLI recommends using the pre-assembled cables for synchronous motors types BCR and BTD.

5.3.6 Cable assembly Hiperface for BMD

Contact assignment BONFIGLIOLI VECTRON cable for connection of BMD



BONFIGLIOLI VECTRON assembled cable	
Encoder cable	8 double-circuit twisted lines
Cable size	0.14 mm²
Length	3 m, 5 m or 10 m

- Use PTC/KTY/PT1000 evaluations with safe insulation from motor winding according to EN 61800-5-1.
- Use shielded and twisted cables.
- Install encoder cable separately from motor cable.
- Connect the shield of the encoder line properly on both sides.

BONFIGLIOLI VECTRON recommends using the pre-assembled cables for synchronous motors types BMD.

5.3.7 Encoder Power supply

Encoder power can be supplied in several ways. Depending on the consumers connected, there are different encoder power supply requirements. The encoders connected at the X410 terminal are supplied via X410B.1 and X410A.7. The encoders connected at the X412 terminal are supplied via the X412.6 and X412.15 terminals.

NOTICE

Incorrect data!

If the encoder is not supplied with power before the inverter starts or after the inverter shuts down, it may produce faulty readings.

- Ensure that the encoder is supplied with sufficient power before the inverter starts evaluating and after the inverter shuts down to ensure the faulty readings are prevented.

Generally, there are three different application types:

- Supply via terminal X410B.1 (DC 5 V) and X410A.7 (GND)
  - Low power demand (< 1 W) and voltage supply = 5 V:

  ➔ Internal power supply.
  - High power demand (> 1 W) or voltage supply > 5 V:

  ➔ Internal power supply.
- Supply via HD Sub connector X412.6 (DC 5 V) and X412.15 (GND)
  - Low power demand (< 1 W) and voltage supply = 5 … 12 V:

  ➔ Internal power supply.
  - High power demand (> 1 W) or voltage supply > 12 V:

  ➔ Connect encoder directly to external power supply.

Encoders with high power demand (> 1 W) or voltage higher than DC 5 V or DC 12 V must be connected to an external power supply directly.

5.3.7.1 Internal power supply

Encoders with low power consumption (< 1 W) can be supplied, in most cases, by the internal power supply unit.

For voltage supply via X412 activate the *Power supply* **1186** with either setting "`1 - internal`" or "`5- internal, sense`".

See chapter 6.5.3 "Power supply".

The voltage value for the supply voltage via X412 can be set up via parameter *Supply voltage* **1187**. See chapter 6.5.4 "Supply voltage".

The voltage supply via X410B.1/X410A.7 is set up fixed with DC 5 V.

If power supply of the encoders is done via the internal power supply, a total power of 4 W is available for all consumers connected to digital, analog interfaces and encoder interfaces. This includes all interfaces.

For each individual encoder a maximum of 1 W is available.

5.3.7.2 Direct connection of external power supply to the encoder

Encoders with high power demand (> 1 W) or voltage higher than DC 12 V (X412) or DC 5 V (X410) must be connected to an external power supply directly.

When using encoder input 3 (X412):

Set parameter *Power supply* **1186** to "`1-internal`". See chapter 6.5.3 "Power supply".

This setting must be used for proper function of the evaluation. However, the power supply terminals do not have to be connected but should remain open.

The voltage level set in *Supply voltage* **1187** is irrelevant when the terminal is open. See chapter 6.5.4 "Supply voltage".

CAUTION

Faults and system shutdown

Setting *Power supply* **1186** to modes with a "sense" line while leaving the power supply terminals unconnected will result in faults and subsequently in system shutdown.

- Do not set *Power supply* **1186** to modes with a "sense" line in this configuration.

5.4 Systembus interface

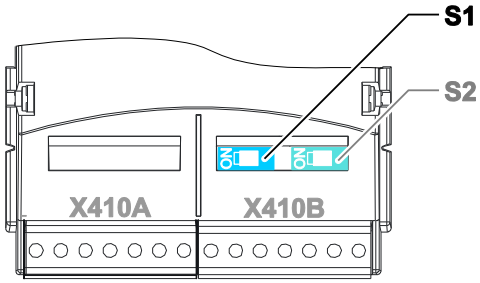
The CAN connection is physically designed according to **ISO-DIS 11898** (CAN High Speed). The bus topology is the line structure.

The frequency inverter series ANG supports via the available CAN interface the protocol "Systembus".

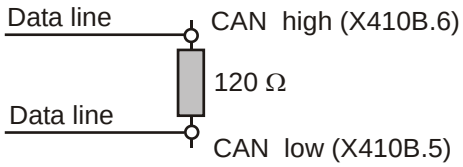
5.4.1 Bus termination

The bus necessary on the phase in the physically first and last subscriber can be activated via the DIP switch S2 on the EM-AUT expansion module.

- Set S2 to **ON** (Left position) for passive termination.



By default, the bus termination is set to OFF (switch in right position).



passive

5.4.2 Cables

For the bus line, use twisted cable with harness shield (**no foil shield**).

NOTICE

Control and communication cables must be kept physically separate from the power cables. The braided shield of the communication cable is to be connected to ground (PE) on both sides on a large area and with good conductivity.

5.4.3 Control terminal X410B

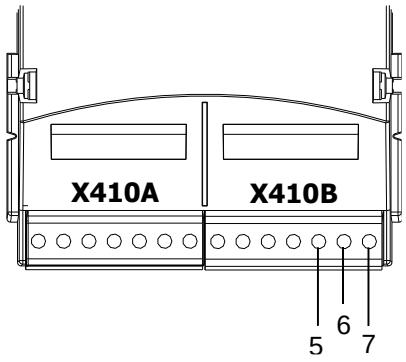
CAUTION

Communication faults

Without GND_{CAN} connection telegram faults or telegram interruptions can occur.

- For the connections of two or more devices CAN Low, CAN High and GND_{CAN} must be connected.

The system bus is connected via three sockets of the plug **X410B** on the EM-AUT expansion module.



Control terminal X410B

Terminal	Input/output	Description
X410B.5	CAN-Low	CAN-Low
X410B.6	CAN-High	CAN-High
X410B.7	GND_{CAN}	CAN-GND

6 Commissioning the encoder

This chapter describes how the different encoder types are commissioned.

6.1 General Information

Following feedback systems are supported:

Feedback System	Speed Sensor 1 (X210)	Speed Sensor 2 (X410)	Speed Sensor 3 (X412)
HTL	Possible	Not possible	Not possible
Resolver	Not possible	Possible	Not possible
TTL (Tracks A, B, R)	Not possible	Possible	Possible
TTL (Tracks A, B)	Not possible	Possible	Possible
SinCos (Tracks Sin, Cos)	Not possible	Not possible	Possible
Hiperface	Not possible	Not possible	Possible
EnDat 2.1 (+SinCos tracks)	Not possible	Not possible	Possible
SSI (with or without SinCos or TTL tracks)	Not possible	Not possible	Possible
Output TTL Encoder emulation (A, B)	Not possible	Possible	Not possible

Each Speed Sensor Interface can be configured independently of the other Speed Sensor Interfaces. Each Speed Sensor Interface can be configured with one Feedback system from the following table:

Speed Sensor 1 (X210)	Speed Sensor 2 (X410)	Speed Sensor 3 (X412)
HTL or no Usage	Resolver or TTL or Output TTL Encoder emulation or no Usage	SinCos or TTL or Hiperface or EnDat 2.1 or SSI or no Usage

Speed Sensor 1 is part of the Basic device and therefore described in the ANG Operating instructions. See the Operating Instructions document **VEC1105**.

The Speed Sensor 3 interface supports, with systems Hiperface, EnDat 2.1 and SSI, both Singleturn and Multiturn encoders. Multiturn encoders must be configured as such in order to avoid unwanted effects.

The internal resolution of encoder information is 32 bits, 16 bits for the position in one turn and 16 bits for the number of turns. Encoders with other properties will be converted to this format internally.

In the case of motor encoders with a Multiturn portion of more than 16 bits, clear identification of the position in the frequency inverter is not guaranteed.

In the case of motor encoders with a multiturn portion of less than 16 bits, the free bits are filled up to 16 bits and managed in a fail-safe manner, whereby the MSB represents the sign.

Example: An encoder has a multiturn portion of 13 bits. 3 bits are managed additionally in the inverter, thus 8 (=2^3) overflows of the multiturn portion are recognized.

This information may be lost in some situations, if the DC link is discharged very quickly due to external conditions.

In the case of usage in positioning applications (configuration x40), the incremental encoder or resolver can be used for the reference system directly in user units [u]. Using gear factors, a gear transmission between the encoder and the travel distance can be considered.

The input data of the encoder is evaluated via the reference systems. The evaluated parameters (e.g. motor frequency, drive speed in rev/s, position in rev.) are available for diagnosis via actual value parameters, see chapter 15.

- Check the power demand of the encoder to be connected. The internal power supply unit can only supply a maximum total of 4 W for all consumers connected. See chapter "Speed Sensor Power supply".
- Install encoder cables separate from motor cables to minimize interference.
- Upon first commissioning and during operation, make sure that the encoder and other electrical components can acclimatize in order to prevent condensation and resulting malfunction.

Information on use

After mains on, an initialization may be required depending on the encoder type. This may take up to 5 seconds, depending on the encoder type. This delay can be eliminated by powering the basic device and the encoder using an external DC 24 V supply.

When the encoder or motor (including motor encoder) are replaced, re-calibration will typically be required to obtain the absolute position. This applies to the encoder-internal value (depending on the encoder type used, this value cannot be changed), position angle *Offset* **1188** and, in positioning applications (configuration x40), referencing *Home-Offset* **1131**. After encoder replacement, always check the position angle *Offset* **1188** and carry out a referencing operation in the case of positioning applications (configuration x40).

NOTICE

When an absolute value encoder is used, referencing is not required after encoder or motor replacement to ensure **correct function of the ANG device**. Adjustments of *Home-Offset* **1131** are applied directly.

After encoder or motor replacement, **correct function of the system** is achieved by performing a referencing operation or offset adjustment.

The signals provided by the encoder are used in the expansion module for various plausibility checks. This makes the system more fail-safe and less prone to unwanted interference.

During operation, the encoders and communication with the encoder are monitored. Critical conditions are reported via device errors. Most error evaluations will only be performed when the power output stage is activated.

WARNING

Danger of system failure!

Changing the value while the system is in operation or standstill can result in significant failures of the system (independent of the motor system).

Some absolute value encoder types allow to "nullify" or re-calibrate the position transmitted by the encoder.

- Do not use this function in synchronous motors, as this will change the commutation angle for the synchronous motors via *Offset* **1188** and correct speed control is not guaranteed.

CAUTION

Inconsistent encoder values

Via parameter *Change Sense of Rotation* **1199**, you can change the direction of rotation of the motor system. In the case of absolute value encoders, a modification of **P.1199** will result in a modification of actual value.

- While modifying the value of **P.1199**, slave drives in an electronic gear must be switched off.

6.2 Speed sensor input 2 Resolver / TTL Encoder

The six speed sensor inputs can be set via the parameter *Operation mode* **493** and selection of the corresponding operation mode for the evaluation of a two-channel speed sensor (TTL incremental speed sensor) with reference impulse or via a resolver.

Operation mode		Function
0 -	Off	Speed measurement not active
4 -	Quadruple evaluation[1)]	Two-channel speed sensor with recognition of direction of rotation via track signals A and B; four signal edges are evaluated per division mark.
104 -	Quadruple evaluation inverted	Like operation mode 4; the actual speed value is inverted (alternatively to exchanging the track signals).
1004 -	Quadruple evaluation with reference impulse	Two-channel speed sensor with recognition of direction of rotation via track signals A and B; four signal edges are evaluated per division mark. The reference impulse is used for speed sensor monitoring.
1104 -	Quadruple evaluation inverted with reference impulse	Like operation mode 1004; the actual speed value is inverted (alternatively to the exchange of the track signals).
10000 -	Resolver	Two signal Resolver via signals SIN and COS; four signal sinusoidal are evaluated.
10100 -	Resolver Inverted	Like operation mode 10000; the actual speed value is inverted.

[1)] The speed sensor inputs are suitable according to specification RS-422A / RS-485 for a 5 V push-pull signal.

6.2.1 TTL incremental encoder – Division marks speed sensor 2

The number of increments of the connected speed sensor can be parameterized via the parameter *EC2 Division marks* **494**. Select the number of division marks of the speed sensor according to the speed range of the application.

The maximum number of division marks S_{max} is defined by the limit frequency of f_{max} = 300 kHz of the speed sensor inputs track A and track B.

$$S_{max} = 300000\,Hz \cdot \frac{60\,s/min}{n_{max}}$$

n_{max} = Max. speed of the motor in RPM

To ensure a good true running of the drive mechanism, a sensor signal must be evaluated at least every 2 ms (signal frequency f = 500 Hz). The minimum number of division marks S_{min} of the incremental speed sensor for a required minimum speed n_{min} can be calculated from this requirement. The evaluation of four signal edges per mark is firmly defined in the function of speed sensor 2.

$$S_{min} = 500\,Hz \cdot \frac{60\,s/min}{A \cdot n_{min}}$$

n_{min} = Min. speed of the motor in RPM
A = 4 (quadruple evaluation)

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Fact. Sett.**
494	Division marks speed sensor 2	1	8192	1024

6.2.2 Resolver evaluation

The resolver input is used for evaluating the position information of a resolver.

If the nº. of resolver pole pairs > 1, the measured electric angle runs through the range of 0º ..360º several times during one mechanical revolution.

For the detection of the position angle of the rotor at synchronous motor, the ratio of the nº. of motor pole pairs must be an integer.

The nº. of pole pairs of the resolver can be adjusted via parameter *RES Nº. of Pole Pairs* **381**.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Fact. Sett.**
381	RES Nº. of Pole Pairs	1	7	1

Offset of the Resolver

In order to enable the start of a synchronous machine, the absolute position of the rotor must be known. This information is required in order to actuate the stator windings in the right order depending on the position of the rotor. The position of the rotary field in the synchronous machine must be controlled in order to obtain a continuous movement of the rotor. During first commissioning, the position of the rotor winding of the resolver is adjusted to the rotor displacement angle of the synchronous motor by adjusting the offset. For operating a synchronous machine with resolver, the offset must be adjusted in order to obtain perfectly true running and a maximum torque.

The correct *RES Offset* **382** is adjusted when the *flux-forming voltage* **235** reaches the value 0 (approximately) while the motor is turning.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Fact. Sett.**
382	RES Offset	-360.0°	360.0°	0

BONFIGLIOLI servo motors of types BMD, BCR and BTD are set up with an offset of 0.0° ex works. For these motors an offset adjustment is usually not necessary.

Automatic setup

WARNING

In certain circumstances, the motor speed may reach high values. Decouple the motor from the load to avoid possible hazards (personal injury and damage to the machine). Lock or barrier the motor shaft and make sure that no loose parts can be moved in an uncontrolled manner through a sudden acceleration of the motor shaft.

NOTICE

Ensure that the motor commissioning is finished before the automatic offset setup is executed. Set up additionally the *RES Nº. of Pole Pairs* **381** of the resolver.

NOTICE

If a wrong direction is caused by an incorrect wiring, this is typically detected during the Automatic Offset setup. Always ensure before starting the setup, that the wiring is correct.

The offset can be determined and adjusted as follows:

- Set up parameter *SETUP Selection* **796** to "550 – Para-Ident. Offset, DS0" if the auto setup should be done for all data sets.

For single data sets use the following settings:

After the start via *SETUP Selection* **796** the Auto-Tuning of the Resolver is started. The status of the Auto-Tuning is displayed by *SETUP Status* **797**.

- For the Auto-Tuning a controller release via STO must be done. Switch the STO inputs when *SETUP Status* **797** shows "STO".

If a correct Resolver Offset was detected, this value is set up automatically in *Offset* **382**. Additionally the device executes a Reset. The Resolver is now tuned to the motor.

If U, V and W are connected correctly, the "clockwise" sense of rotation is defined as seen on the front of the motor shaft in accordance with DIN EN 60034-8.

Possible errors and corrections:

If during the auto-tuning error "F1420" shows, this is an indication of an incorrect direction of rotation of the resolver in comparison to the motor.

Execute one of the following actions to adjust the direction of rotation of the encoder to the motor:

- a) Switch two motor phases, e.g. U and V. Note the motor direction of rotation.
- b) Invert the direction of rotation of the resolver via parameter *Operation mode* **493**.
- c) Invert the direction of rotation of the resolver by exchanging Sin+ and Sin-.

Manual setup

The offset can be determined and adjusted as follows:

- During first commissioning "SEtUP" will be displayed in the control unit. Press ESC to stop this operation. The guided commissioning ("SETUP") is performed after adjusting the offset.
- Open the parameter menu "PARA" and enter the machine data indicated on the type plate or the data sheet of the motor.
- Adjust parameter *RES Nº. of Pole Pairs* **381** to the number of pole pairs of the resolver.

Before adjusting the offset, take the following **safety precautions**:

- Disable the frequency inverter via STO (controller release).
- If possible, uncouple the motor from the load so that the motor shaft turns freely. If installed, release the mechanical brake.

If uncoupling is not possible, make sure that the motor is loaded as little as possible.

WARNING

In certain circumstances, the motor speed may reach high values. If the motor is not uncoupled from the load, personal and material damage may result. To avoid such damage, make the following settings in any case.

- Set the max. permissible output frequency of the frequency inverter to a low frequency value via parameter *Switch-Off Limit* **417**. Select the frequency value such that uncontrolled acceleration of the motor ("overspeeding") is detected at an early stage. This limitation is necessary in order to avoid injury and material damage.

- Set parameter *Current Limit* **728** of the speed controller to a low current value (e.g. 10% of the rated motor current). In this way it is made sure that there are no excessive currents of the offset is set incorrectly.

WARNING

Unintended Starting!

If the Drive is supplied with voltage, it can suddenly start. This may lead to personal and material damage.

- Prior to starting the manual adjustments, disconnect the drive from voltage supply.
- Comply with the five safety rules.
- If possible, wear protective clothing.

- Turn motor shaft manually. Check the sense of rotation of the resolver via the actual value of parameter *Frequency Speed Sensor 2* **219**. In the case of a clock-wise rotation of the motor shaft, positive values are displayed for the actual frequency value. If the displayed sense of rotation does not correspond to the actual sense of rotation, change the connections SIN+ and SIN- at socket X410A of the frequency inverter.

The *Offset* **382** must be between 0° and 360°, divided by the number of motor pole pairs. If the number of resolver pole pairs is higher than 1, the possible range is between 0° and the max. offset.

$$\text{Max. Offset} = \frac{360\ °}{\text{number of motor pole pairs / number of resolver pole pairs}}$$

If the adjusted value is changed by the max. offset, this does not affect the *flux-forming voltage* **235**.

- Adjust a low reference speed value (approx. 10% lower than the *Switch-off Limit Frequency* **417**), and enable the frequency inverter via digital input S1IND (controller release) and S2IND (start clock-wise operation) in order to accelerate the motor.
- If an overcurrent is detected or a fault message is issued due to an overload, the guided commissioning (setup) will start first. Confirm the machine and resolver data. After completion of the guided commissioning, adjust the parameter *Limit Current* **728** to a low value again because this value was overwritten during the guided commissioning.

Depending on the behavior of the motor after start, carry out the following steps:

– Motor does not turn, or the motor shaft only turns to a new position and stops again:

- Check if the parameters *No. of Pole Pairs* **373** for the motor and *No. of Pole Pairs* **381** for the resolver are set correctly.

If these values are adjusted correctly, take the following measures complying with the safety instructions.

WARNING

The mains, direct voltage and motor sockets can be live with dangerous voltage after disconnection of the frequency inverter. Work only on the device after a waiting period of some minutes until the DC link capacitors have discharged.

- Before electrical installation work, de-energize the frequency inverter and take appropriate precautions to make sure it is not re-energized unintentionally. Make sure that the frequency inverter is de-energized.
- Exchange two motor phases (e.g. U and V) at the frequency inverter sockets because the senses of rotation of the motor and the resolver do not correspond to each other.
- Switch on the power supply again.
- As described above, adjust a low speed reference value and start the motor.

If the motor does not start despite the phase exchange:

- Increase the parameter value for *Offset* **382** by 90°, divided by the no. of motor pole pairs.

If the motor still does not turn, exchange the two motor phases (e.g. U and V) again.

The motor turns and accelerates until it reaches the *Frequency Switch-Off Limit* 417:

- Check the resolver lines and check the resolver connection contacts.
- In the case of fault message "Overfrequency" F1100: increase the parameter value for *Offset* **382** by 180°, divided by the no. of motor pole pairs.

If the motor turns at the adjusted speed and in the right direction, carry out the fine adjustment of the offset:

- Adjust the parameter value for *Offset* **382** in small steps (e.g. 2.5°) until the *flux-forming voltage* **235** is approximately 0.
  - In case the flux-forming voltage deviates from 0 significantly, adjust the offset in bigger steps.
  - In the case of a positive flux-forming voltage: increase the offset.
  - In the case of a negative flux-forming voltage: reduce the offset.
- Adjust parameters *Frequency Switch-Off Limit* **417** and *Current Limit* **728** to the required values.
- Repeat the **fine adjustment** of the offset at 50% of the rated frequency.

  This completes the offset adjustment.
- Start the guided commissioning. This is required for optimum current control.

6.2.3 Filter time constant speed sensor 2/Resolver

Via parameter *Encoder 2/Resolver: Filter time constant* **11**94, you can filter the speed of the encoder 2. This filter can be applied in cases where the encoder fluctuates (in example for mechanical reasons). Change the value in small steps and check each result and do not to change the value in too big steps.

Parameters		Settings		
No.	Description	Min.	Max.	Factory setting
1194	Encoder 2/Resolver: Filter time constant	0 us	32000 us	0 us

6.2.4 Resolver Inverted Evaluation mode

If a synchronous motor which is not from BONFIGLIOLI should be connected to the resolver input it can be necessary to change the sign of the sinus track. This can be set via parameter *Evaluation Mode* **492**.

Evaluation Mode 492	Function
Bonfiglioli	Factory setting. For Bonfiglioli synchronous motors.
inverted	The sign of the sinus track is changed.

6.2.5 Gear factor speed sensor 2

If the speed sensor is coupled to the motor via one or more gears, the transmission ratio between the motor and the encoder must be configured via *EC2 Gear Factor Numerator* **513** and *EC2 Gear Factor Denominator* **514**.

Parameters		Settings		
No.	Description	Min.	Max.	Factory setting
513	EC2 Gear Factor Numerator	-300.00	300.00	1.00
514	EC2 Gear Factor Denominator	0.01	300.00	1.00

$$\frac{\text{Revolutions of the Motor shaft}}{\text{Revolutions of the EC2 encoder shaft}} = \frac{EC\ 2\ Gear\ Factor\ Numerator\ \mathbf{513}}{EC\ 2\ Gear\ Factor\ Denominator\ \mathbf{514}}$$

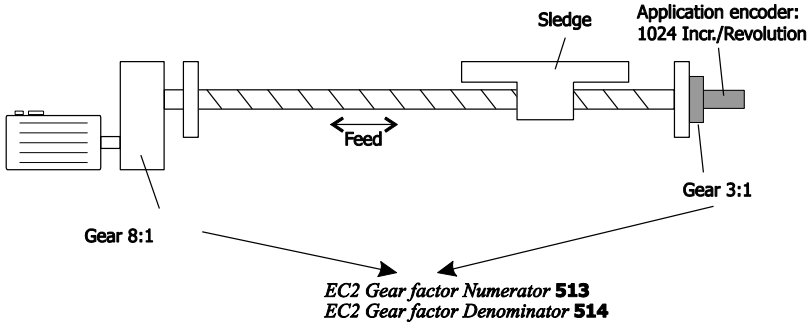
NOTICE

Gear factors *EC2 Gear Factor Numerator* **513** and *EC2 Gear Factor Denominator* **514** must always be referred to the motor.

Gear factors *EC2 Gear Factor Numerator* **513** and *EC2 Gear Factor Denominator* **514** must be set to 1/1 when used as motor encoder.

Example

On a linear axis, the motor is flange-connected via a gear (transmission ratio 8:1) and the application connector is flange-connected via a second gear (transmission ratio 3:1).



1 motor revolution = 1/8 turn on output side

= 1/8x3 encoder turn

$$\frac{EC\,2\,Gear\,Factor\,Numerator\,\mathbf{513}}{EC\,2\,Gear\,Factor\,Denominator\,\mathbf{514}} = \frac{\text{Revolutions of the Motor shaft}}{\text{Revolutions of the EC2 encoder shaft}} = \frac{8}{3}$$

6.3 Speed sensor 2 output (X410): TTL Encoder emulation

This chapter describes the commissioning of speed sensor 3 at X410 interface.

The emulation output is transmitted via the X410.A and X410.B terminals. `Speed sensor 1` or `speed sensor 3` can be selected as input signal for the encoder emulation.

The Encoder Emulation settings are located in the `Machine data --> TTL encoder emulation` branch of the VPlus software.

Using the parameter *Operation mode* **656** you can choose to perform the TTL encoder emulation via the `speed sensor 1` or `speed sensor 3`.

Using the parameter *Division marks* **657** you can select the emulation's output number of the division marks. The number of division marks always corresponds to one mechanical revolution of the motor shaft. The value range lies between 30 to 8192 marks.

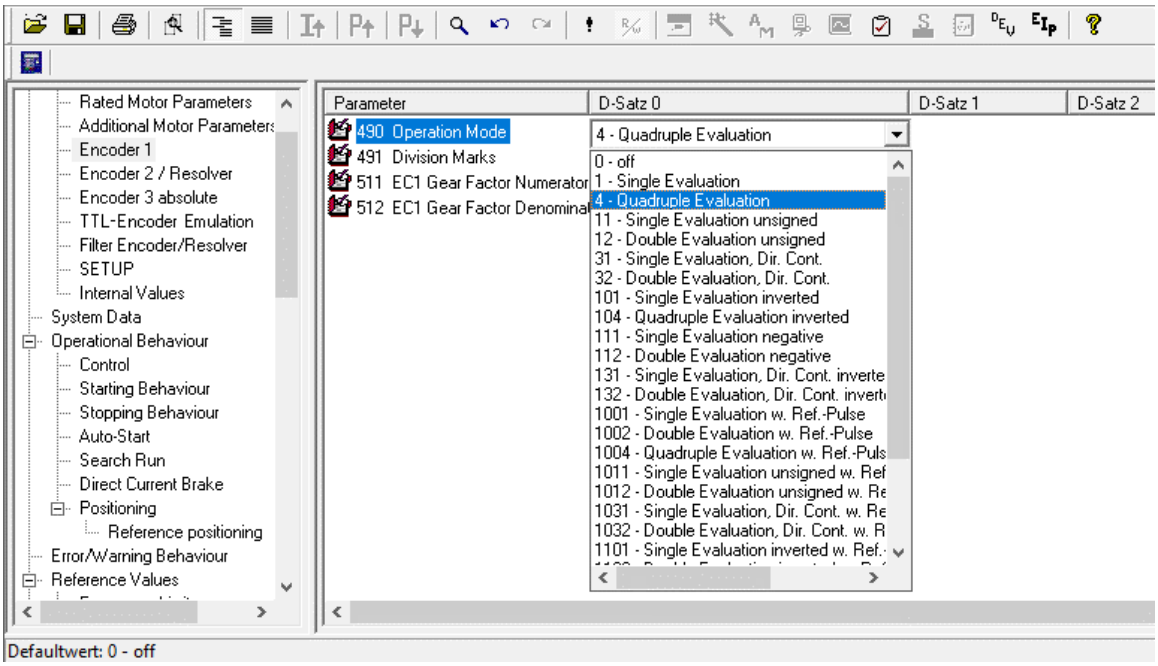
Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Default**
656	Operation mode	0 – Off		0 – Off
		1 – TTL-Encoder Emulation DG 1		
		2 – TTL-Encoder Emulation DG 3		
657	Division marks	30	8192	1024

Selecting Encoder

For the next step, select the encoder to utilize as input source of the emulation. Encoder DG1 and DG3 are available for selection here.

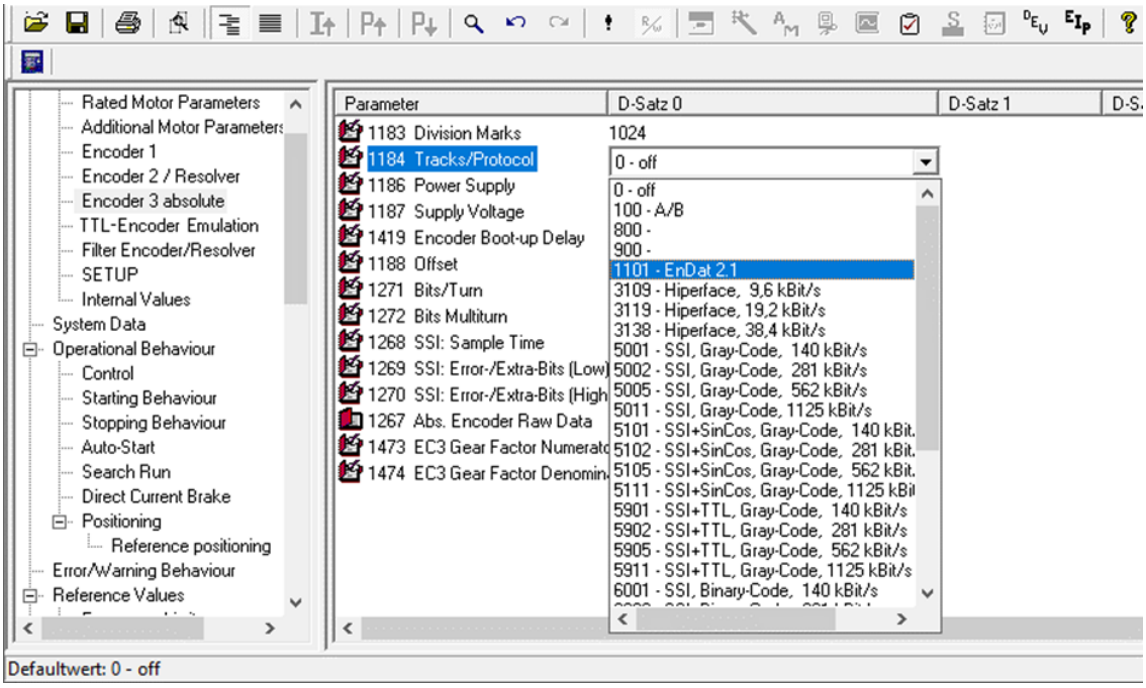
Encoder DG1

DG1 is selected, when for Parameter *Operation Mode* **490** any selection other than zero is made.



Encoder DG3

DG3 is selected, when for Parameter *Operation Mode* **1184** any selection other than zero is made.



6.4 Speed sensor 3 (X412): Commissioning Description

This chapter describes the commissioning of speed sensor 3.

6.4.1 SinCos encoders

This chapter describes how SinCos encoders are commissioned.

Step 1:

Turn the frequency inverter on for parameter configuration (mains voltage or DC 24 V).

Step 2:
Configure the frequency inverter according to the following parameters.

- Adjust the *Division marks* **1183** according to the encoder data sheet (see Chapter 6.5.1), in the case of SinCos encoders, the value is typically 1024 pulses/turn.
- Set *Tracks/Protocol* **1184** to value 100 (please see chapter 6.5.2).
- Adjust the *Supply voltage* **1187** according to the encoder data sheet (see Chapter 6.5.4), in the case of SinCos encoders, the value is typically 5.0V.
- Adjust *Power supply* **1186** according to the connections (see chapter 6.5.3). Bonfiglioli Vectron recommends evaluating the sense line (settings: "5-intern, Sense" or "6-Via X410A, Sense"), if available and connected.
- **Attention**: Always set the *Supply voltage* **1187** first and then set *Power supply* **1186**.
- If the encoder is used as a motor encoder for a synchronous servomotor, set *Offset* **1188** according to chapter 5.3. This step is not required in the case of asynchronous motors or if the encoder is used as an application encoder.

Step 3:
Turn the frequency inverter off.

Step 4:
Connect the SinCos encoder to the EM-AUT. See chapter 5.3.

Step 5:
Turn the frequency inverter on.

Step 6:
Check the encoder for proper function.

SinCos encoders are no absolute value encoders. In configurations "Positioning" x40 you will have to carry out a referencing operation with SinCos encoders after mains on.

6.4.2 Hiperface encoders

This chapter describes how Hiperface encoders are commissioned.

Step 1:
Turn the frequency inverter on for parameter configuration (mains voltage or DC 24 V).

Step 2:
Configure the frequency inverter according to the following parameters.

- Adjust the *Division marks* **1183** according to the encoder data sheet (see Chapter 6.5.1), in the case of Hiperface encoders, the value is typically 1024 amplitudes/turn (in example SRS50/SRM50).

- Set *Tracks/Protocol* **1184** according to the encoder data sheet to value 3109, 3119, 3138 or 700 (please see chapter 6.5.2).
- Typical values:
- Sick SEK37/SEL37 & SEK52/SEL52: 9.6 kBaud → value 3109
- Sick SKS36/SKM36: 9.6 kBaud → = value 3109
- Sick SRS50/SRM50: 9.6 kBaud → = value 3109
- Adjust the *Supply voltage* **1187** according to the encoder data sheet (see Chapter 6.5.4), in the case of Hiperface encoders, the value is typically 8.0 V.

- Adjust *Power supply* **1186** according to the connections to "1-internal" or "2-Via X410A" (see chapter 6.5.3).
- In the case of Hiperface encoders, the sense line (settings "5-intern, Sense") is typically not used, as it is not defined in the Hiperface standard Specification. Thus, using the sense line is not required in the case of Hiperface encoders.
- **Attention**: Always set the *Supply voltage* **1187** first and then set *Power supply* **1186**.
-
- Set the number of *Bits/Turn* **1271** according to the encoder data sheet (see chapter 6.5.7).
- Typical values:
- Sick SEK37/SEL37 & SEK52/SEL52: 9 bits/t
- Sick SKS36/SKM36: 12 bits/t
- Sick SRS50/SRM50: 15 bits/t
- Set the *Bits Multiturn* **1272** according to the encoder data sheet (see chapter 6.5.8),
- Typical values:
- Sick SEL37, SEL52, SKM36, SRM50: 12 bits/t

In the case of singleturn encoders (e.g. Sick SEK37, SKS36, SRS50), you will have to set *Bits Multiturn* **1272** = 0.

- If the encoder is used as a motor encoder for a synchronous servomotor, set *Offset* **1188** according to chapter 6.5.6. This step is not required in the case of asynchronous motors or if the encoder is used as an application encoder.

Step 3:
Turn the frequency inverter off.

Step 4:
Connect the Hiperface encoder to the EM-AUT. Bonfiglioli Vectron recommends the use of pre-assembled cables (see chapter 5.3.5).

Step 5:
Turn the frequency inverter on.

Step 6:
Check the encoder for proper function.

Step 7:
In configurations "Positioning" x40: Carry out referencing operation once.

If the data track cannot be evaluated, error "F1719 Dig. encoder: Protocol error" will be triggered. In this case, check *Tracks/Protocol* **1184** setting.

When the frequency inverter is turned on, the absolute position is read via the data tracks. Via the incremental tracks, the position is counted up internally and compared to the updated absolute position at regular intervals. This guarantees a very high positioning and speed accuracy at all supported transmission rates.

6.4.3 EnDat 2.1 encoders

This chapter describes how EnDat 2.1 encoders are commissioned.

EM-AUT-11 supports EnDat 2.1 encoders with SinCos tracks. EnDat 2.1 encoders without SinCos tracks cannot be evaluated.

The PROFINET module supports, in the case of EnDat 2.1 encoders, a baud rate of 100 kBit/s. Other baud rates will not be supported.

Step 1:

Turn on the frequency inverter for parameter configuration (mains voltage or DC 24 V).

Step 2:

Configure the frequency inverter according to the following parameters.

- Adjust the *Division marks* **1183** according to the encoder data sheet (see Chapter 6.5.1), in the case of EnDat 2.1 encoders, the value is typically 512 amplitudes/turn, (e.g. Heidenhain ECN 1113, EQN 1125).
- Set *Tracks/Protocol* **1184** to value 1101 (please see chapter 6.5.2).
- Adjust the *Supply voltage* **1187** according to the encoder data sheet (see Chapter 6.5.4), in the case of EnDat 2.1 encoders, the value is typically 5.0V.
- Adjust *Power supply* **1186** according to the connections (see chapter 6.5.3). Bonfiglioli Vectron recommends evaluating the sense line (settings: "5-intern, Sense").
- **Attention**: Always set the *Supply voltage* **1187** first and then set *Power supply* **1186**.
- If the encoder is used as a motor encoder for a synchronous servomotor, set *Offset* **1188** according to chapter 6.5.6. This step is not required in the case of asynchronous motors or if the encoder is used as an application encoder.

Parameters *Bits/Turn* **1271** and *Bits Multiturn* **1272** have no function in the case of EnDat 2.1 encoders. The required data is exchanged directly between the encoder and inverter.

Step 3:

Turn the frequency inverter off.

Step 4:

Connect the EnDat 2.1 encoder to the EM-AUT. Bonfiglioli Vectron MDS recommends the use of pre-assembled cables (see chapter 5.3.3).

Step 5:

Turn the frequency inverter on.

Step 6:

Check the encoder for proper function.

Step 7:

In configurations "Positioning" x40: Carry out referencing operation once.

If the data track cannot be evaluated, error "F1719 Dig. encoder: Protocol error" will be triggered. In this case, check *Tracks/Protocol* **1184** setting.

When the frequency inverter is turned on, the absolute position is read via the data tracks. Via the incremental tracks, the position is counted up internally and compared to the updated absolute position at regular intervals. This guarantees a very high positioning and speed accuracy at all supported transmission rates.

6.4.4 SSI encoders

This chapter describes how SSI encoders are commissioned. You can connect SSI encoders with binary evaluation and SSI encoders with Gray code evaluation.

For a correct function of the speed control, an SSI encoder with incremental tracks (TTL [RS-422] level or SinCos tracks) must be used.

If the SSI encoder is used for positioning (and not for speed feedback), you can also use a SSI encoder without incremental tracks.

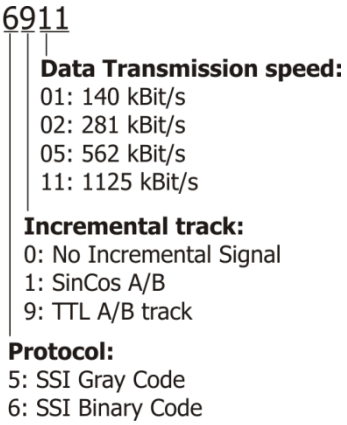
HTL tracks cannot be used as incremental tracks.

Step 1:
Turn the frequency inverter on for parameter configuration (mains voltage or DC 24 V).

Step 2:
Configure the frequency inverter according to the following parameters.

- Set *Tracks/Protocol* **1184** according to the encoder data sheet (please see chapter 6.5.2).

  SSI operation modes key:



If a SSI encoder without incremental track (*Tracks/Protocol* **1184** = 50xx or 60xx) is used for positioning, the speed of the data track must be as high as possible for optimum control quality.

The usable transmission rate depends on the length of the encoder cable.

- Adjust the *Division marks* **1183** according to the encoder data sheet (see Chapter 6.5.1), in the case of SSI encoders, the value is typically 512 amplitudes/turn. If an encoder without incremental tracks is used (setting via *Tracks/Protocol* **1184**), this information is not needed and the setting of this parameter will be ignored.
-
- Adjust the *Supply voltage* **1187** according to the encoder data sheet (see Chapter 6.5.4), in the case of SSI encoders with TTL [RS-422] or SinCos track, the value is typically 5.0V.
- Adjust *Power supply* **1186** according to the connections (see chapter 6.5.3). Bonfiglioli Vectron recommends evaluating the sense line (settings: "5-intern, Sense"), if available and connected.
-
- Set the number of *Bits/Turn* **1271** according to the encoder data sheet (see chapter 6.5.7).
- Set the *Bits Multiturn* **1272** according to the encoder data sheet (see chapter 6.5.8).

- Set *SSI: Error-/Extra-Bits (Low)* **1269** and *SSI: Error-/Extra-Bits (High)* **1270** , if additional information from the encoder is supported (see chapter 6.5.9).
- Adjust *SSI: Sample time***1268** according to the encoder data (see chapter 6.5.10).
- If the encoder is used as a motor encoder for a synchronous servomotor, set *Offset* **1188** according to chapter 6.5.6. This step is not required in the case of asynchronous motors or if the encoder is used as an application encoder.

In the case of singleturn encoders, you will have to set *Bits Multiturn* **1272** = 0.

Step 3:

Turn the frequency inverter off.

Step 4:

Connect the SSI encoder to the EM-AUT. See chapter 5.3.

Step 5:

Turn the frequency inverter on.

Step 6:

Check the encoder for proper function.

Step 7:

In configurations "Positioning" x40: Carry out referencing operation once.

If the data track cannot be evaluated, error "F1719 Dig. encoder: Protocol error" will be triggered. In this case, check *Tracks/Protocol* **1184** setting.

When the frequency inverter is turned on, the absolute position is read via the data tracks. Via the incremental tracks, the position is counted up internally and compared to the updated absolute position at regular intervals. This guarantees a very high positioning and speed accuracy at all supported transmission rates.

Encoders without incremental track can only be used as application encoders (for example for positioning applications).

6.4.5 Commissioning of linear encoders

In addition to the settings described in the previous chapters, the conversion from the rotary to the translatory system must be considered when it comes to commissioning a linear encoder. This conversion is influenced greatly by the diameter of the turning wheel.

The following applies:

Circumference = π * diameter

Linear encoders are normally not suitable for speed control, as the sampling time is too long to enable good speed control. For this reason, the following descriptions are based on the use as a position encoder in configuration x40.

For the calculations described in this chapter, an Excel worksheet was prepared by Bonfiglioli. Please contact your local sales agent. This Excel worksheet will help you to carry out the calculations required for commissioning linear encoders with ANG frequency inverters.

Linear encoders typically have a fixed resolution (e.g. 1 mm). In some linear encoders, the resolution can be configured. First check the resolution of the linear encoder using the data sheet or the parameter configuration.

The resolution of the linear encoder must be assigned in the frequency at the resolution of the selected user units. This is done using the four parameters *Bits/Turn* **1271**, *Bits Multiturn* **1272**, *EC2 Gear Factor Numerator* **513** and *EC2 Gear Factor Denominator* **514**.

The positioning reference system is always referred to the output side, in user units, through parameters *Feed constant* **1115**, *Gear Box: Driving Shaft Revolutions* **1116** and *Gear Box: Motor Shaft Revolutions* **1117**. Thus, these parameters must also be considered when configuring the linear encoder.

Parameters *Bits/Turn* **1271** and *Bits Multiturn* **1272** are virtual quantities in the case of a linear encoder and are determined by the mechanical properties of the system. Different properties of the mechanical system (e.g. gear transmission or turning wheel diameter) will lead to different parameter settings.

Shifting of a bit in parameters *Bits/Turn* **1271** and *Bits Multiturn* **1272** has the same effect as doubling or halving in parameters *EC2 Gear Factor Numerator* **513**/ *EC2 Gear Factor Denominator* **514**.

Reduction of *Bits/Turn* **1271** or increase of *Bits Multiturn* **1272** by 1 Bit

--> has the same effect as doubling of **513** / **514**

Increase of *Bits/Turn* **1271** or reduction of *Bits Multiturn* **1272** by 1 Bit

--> has the same effect as halving of **513** / **514**.

Required data:

The following data is needed for commissioning of the linear encoder:

Gear transmission [] or input speed / output speed [rpm/rpm]

Encoder resolution [bits]

Running wheel diameter [m]

Required accuracy [m] or resolution [increments/m]

Step 1: Identify gear values reference system:

The input speed (motor speed) will determine the setting for parameter *Gear Box: Motor Shaft Revolutions* **1117**, the output speed will determine the setting for parameter *Gear Box: Driving Shaft Revolutions* **1116**.

The value should be entered as exactly as possible. Shifting of decimal places or multiplication with appropriate factors can increase accuracy.

Example:

Input speed: 1401 rpm

Output speed: 77.3 rpm i = 18.12

Encoder resolution: 24 Bit

Diameter: 160 mm = 0.16 m

Required accuracy: 0.01 mm = 0.00001 m

- ➔ *Gear Box: Motor Shaft Revolutions* **1117 =** 14010
- ➔ *Gear Box: Driving Shaft Revolutions* **1116 =** 773

Step 2:

Identify feed constant reference system:

The feed constant is calculated by multiplying the diameter and π by the resolution. The resolution is the reciprocal of the accuracy.

$$\text{Accuracy [m]} = \frac{1}{\text{Resolution}\left[\frac{\text{u}}{\text{m}}\right]}$$

$$\textit{Feed constant}\ \mathbf{1115}\ [\text{u}] = \frac{\pi \cdot \text{Diameter [m]}}{\text{Accuracy}[\frac{\text{m}}{\text{u}}]}$$

$$= \pi \cdot \text{Diameter [m]} \cdot \text{Resolution}\left[\frac{\text{u}}{m}\right]$$

Example:

Diameter: 0.16 m = 160 mm

Required resolution: 0.00001 m = 0.01 mm

➔ *Feed constant* **1115 =** 50265 u

Step 3:

Calculate auxiliary quantity reference system

In the following step, the ratio of the *Feed constant* **1115** to *Gear Box: Driving Shaft Revolutions* **1116** and *Gear Box: Motor Shaft Revolutions* **1117** is used in the calculations frequently. For better clarity, auxiliary quantity "R" (=reference system) is calculated now:

$$\text{R} = \frac{\textit{Feed constant}\ \mathbf{1115}\ \frac{[\text{u}]}{\text{U}} \cdot \textit{GearBox : DrivingShaftRevolutions}\ \mathbf{1116}}{\textit{GearBox : MotorShaftRevolutions}\ \mathbf{1117}}$$

Example:

Feed constant **1115 =** 50265 rev

Gear Box: Driving Shaft Revolutions **1116 =** 773

Gear Box: Motor Shaft Revolutions **1117 =** 14010

➔ R = 2773.365 rev = 50265 x 773 / 14010 rev

Step 4:

Determine the encoder resolution:

First determine the number of user units per encoder increment. If, for example, the encoder features a resolution of 1 mm and 0.01 is to be used as the "user unit", β = 100.

β = Number of user units per encoder increment

Step 5:

Calculate *Bits/Turn* **1271** :

The reference system and the number of user units per encoder increment β determine parameter *Bits/Turn* **1271**.

$$\textit{Bits / Revolution} = \text{Log}_2 \frac{\textit{Feed Constant}\ \mathbf{1115}\ \frac{[\text{u}]}{\text{U}} \cdot \textit{GearBox : DrivingShaftRevolutions}\ \mathbf{1116}}{\beta \cdot \textit{GearBox : MotorShaftRevolutions}\ \mathbf{1117} \cdot}$$ or

$$Bits / Revolution = \mathrm{Log}_2 \frac{R}{\beta}$$

$$= \frac{1}{\mathrm{Ln}\ 2} \cdot \mathrm{Ln} \frac{R}{\beta}$$

Round the value up to the next natural number.

With the values above, *Bits/Turn* **1271**=5.

Conversion of logarithm base 2 and other bases:

$$\mathrm{Log}_2 a = \frac{\mathrm{Log}_{10} a}{\mathrm{Log}_{10} 2} = \frac{\mathrm{Ln}\ a}{\mathrm{Ln}\ 2}$$

Step 6:

Calculate *Bits Multiturn* **1272** :

Bits Multiturn **1272** is calculated from the subtraction of the total number of position bits of the encoder with the *Bits/Turn* **1271** calculated above.

$$Multiturn = GeberBits - Bits/Umdrehung$$

With the values above, *Bits Multiturn* **1272**=19.

Step 7:

Calculation of speed sensor 2 gear factors

For calculation of speed sensor 2 gear factors, the *preliminary numerator* is calculated first as follows:

Preliminary Numerator **= 2 ^** *Bits/Turn* **1271**

Then, the preliminary denominator is calculated as follows:

$$PreliminaryDenominator = \frac{Feed\ Constant\ \mathbf{1115}\ \frac{[\mathrm{u}]}{\mathrm{U}} \cdot GearBox : DrivingShaftRevolutions\ \mathbf{1116}}{\beta \cdot GearBox : MotorShaftRevolutions\ \mathbf{1117} \cdot}$$

or

$$PreliminaryDenominator = \frac{R}{\beta}$$

With the example values, the following results are obtained:

Preliminary Numerator = 32.

Preliminary Denominator = 27.7336.

The values calculated in this way can be used directly for parameters *EC2 Gear Factor Numerator* **513** and *EC2 Gear Factor Denominator* **514**. To increase accuracy, the following intermediate "Optimization" step is recommended. This intermediate step is not necessary if accuracy is already sufficient.

EC2 Gear Factor Numerator **513** = 32.00.

EC2 Gear Factor Denominator **514** = 27.73

Step 8:

Optional: Optimization of gear factors

The steps carried out above will result (provided that calculation was made correctly) in a denominator which is smaller than the numerator. This advantage is used for optimization.

The following is set:

EC2 Gear Factor Numerator **513** = 300.00.

Value 300.00 is always used to achieve maximum accuracy.

$$ConclusiveDenominator = 300.00 \cdot \frac{PreliminaryDenominator}{PreliminaryNumerator}$$

With the example values, the following results are obtained:

EC2 Gear Factor Numerator **513** = 300.00

EC2 Gear Factor Denominator **514** = 260.00

Parameter *EC2 Gear Factor Numerator* **513** is limited to value range -300.00...300.00. To maximize the value range of the factors, the maximum value 300.00 is used for optimization.

Step 9:

Optional: Check of accuracy:

This section describes the calculations required for determining the accuracy. The check is not required for proper function, it is solely for determining the accuracy limits.

Due to rounding operations in the parameters described above, there will be an error across the total travel distance. This error is calculated in the following steps:

$$(1)\ Distance\_ref[u] = \frac{Distance\_ref[m]}{Accuracy\left[\frac{m}{u}\right]}$$

$$(2)\ Distance\_act[internal] = \text{RoundDown}\left(\frac{EC2GearFactorNumerator\,\mathbf{513}}{EC2GearFactorDenominator\,\mathbf{514}} \cdot \frac{Distance\_ref[u]}{ß} \cdot \frac{2^{16}}{2^{Bits/Revolution}\mathbf{1271}}\right)$$

$$(3)\ Distance\_act[u] = \text{RoundDown}\left(Distance\_act[intern] \cdot \frac{R}{2^{16}}\right)$$

$$(4)\ Error[u] = Distance\_act[u] - Distance\_ref[u]$$

$$(5)\ Error[m] = Distance\_act[u] \cdot Accuracy\left[\frac{m}{u}\right] - Distance\_ref[m]$$

The error can be reduced by increasing the accuracy of the gear factors. By using the 2 decimal places of parameters *EC2 Gear Factor Numerator* **513** and *EC2 Gear Factor Denominator* **514** and the optimization described in the previous step (“8 Optimization of gear factors”), accuracy can be increased.

At a maximum travel distance of 10 m, the following is obtained:

Non-optimized gear factors

Distance_nominal [rev] = 1 000 000 rev
Distance_actual [internal] = 23 633 609
Distance_actual [rev] = 1 000 131 rev
Error [rev] = 131 rev
Error [m] = 0.00131 m
Error [mm] = 1.3 mm
Optimized gear factors
Distance_nominal [rev] = 1 000 000 rev
Distance_actual [internal] = 23 630 769
Distance_actual [rev] = 1 000 011 rev
Error [rev] = 11 rev
Error [m] = 0.00011 m
Error [mm] = 0.11 mm

Parameter *EC2 Gear Factor Numerator* **513** is limited in value range -300.00...300.00, *EC2 Gear Factor Denominator* **514** is limited in value range 0.01 to 300.00. In many situations, choosing a modifier is useful which sets the greater of the two parameters to a value slightly below 300.00.

6.4.5.1 Checking the settings

Upon completion of the setup, check the system for proper function.

WARNING

Wrong setup of the linear encoder can result in incorrect movements or direction of movement.

The following requirements must be met when it comes to testing the linear encoder:

- Before the start of the test, make sure the hardware limit switches work properly.
- Before the start of the test, make sure the emergency stop works properly.

Use

- slow speeds
- slow ramps
- Deactivate for the test the position controller by setting **1118** = 0.

To reduce the speeds, you can use the so-called "Speed Override" mode.

Via actual value parameter *Abs. encoder raw data* **1267**, you can monitor the encoder value transmitted. Carry out a travel operation across a distance which can be measured easily (e.g. 10 cm). Check if the actual value parameter *Abs. encoder raw data* **1267** changes and the *Act. Position* **1108** changes across the distance in accordance with your settings.

Via the scope function of VPlus, you can check the commissioning of the linear encoder.

Adjust the following scope sources:

1003 Act. Position * 1000

1007 Ref. Position * 1000

1013 Contouring Error *10 or 1012 Contouring Error *1

442 Hz: Act. Speed

For more information on VPlus, see chapter 14.

As the time base, choose the observation period for some seconds.

When starting a motion block or a travel command via field bus, Ref. Position is set to Act. Position. The two curves of sources 1003 and 1007 must be identical as from the start time of the travel command. If the two curves are not identical, the parameter factors have not been set correctly.

If the ramp Act. Position is steeper than the ramp of Ref. Position, the ratio 513/514 must be reduced.

If the ramp Act. Position is less steep than the ramp of Ref. Position, the ratio 513/514 must be increased.

Via the source of the contouring error, the quality of the settings can be checked additionally. The contouring error must not increase continuously. Due to the mechanical characteristics, a small constant contouring error is typical to the system, continuous (significant) increasing of the contouring error (also in negative direction) indicates that linear encoder parameters have be set up incorrectly.

When the position controlled is deactivated, rounding errors may result in a minor continuous increase in the contouring error. In most cases however, this is small enough to be distinguishable.

As soon as the settings have been checked for correctness, repeat the tests using sources 1002/ 1006 (resolution 10 times higher than sources 1007/1011), then using 1001 / 1005 and then using 1000 and 1004. In this way, the settings are checked again at a higher accuracy. Note that, with a higher accuracy, overflows may be displayed in Scope more frequently. This does not affect the function.

Depending on the reference system chosen (Parameter *Feed constant* **1115**, *Gear Box: Driving Shaft Revolutions* **1116** and *Gear Box: Motor Shaft Revolutions* **1117**), some sources may not have the required significance in Scope. Then, switch to the next smaller couple as shown above. Always start with the highest setting.

Activate the position controller again. Position controller *Limitation* **1118** settings must always match the reference system and the mechanical system.

A contouring error will typically build up during acceleration or deceleration. During constant travel operations, the contouring error should become smaller again. Note that the *Maximum frequency* **419** is exceeded by the output of the position controller. Ensure that the total of *Maximum frequency* **419** and position controller *Limitation* **1118** can be reached by the mechanical equipment. A reduction of the maximum frequency may be a good idea in certain applications in order to limit the total to the mechanically possible maximum.

In most application, limitation of position controller *Limitation* **1118** to approx. 10 % of the maximum frequency makes sense.

With the position controller activated, check the function again.

6.4.5.2 Initialize counting direction

First check if the counting direction of the user units meets the requirements. You can change the counting direction by inverting the parameter *EC2 Gear Factor Numerator* **513** (e.g. by inverting parameter *EC2 Gear Factor Numerator* **513** from 200.00 to -200.00).

WARNING

By changing parameter *EC2 Gear Factor Numerator* **513**, the encoder values will be re-calculated in the internal user unit format. As a result, the value of *Act. Position* **1108** may change. Especially when software limit switches are used or in the case of feedback to a PLC, this can result in warnings or application errors. For this reasons, after changing the parameters of the reference system and the encoder, always check the *Act. Position* **1108**, considering the permissible travel distance (e.g. *Pos. SW Limit Switch* **1145**).

6.4.5.3 Initializing home position

For positioning application, a certain point of the system is typically defined as the home position. After checking the correct reference system of the positioning and linear encoder (see Chapter 6.4.5.1) and setting the counting direction, the home position can be initialized.

Move (e.g. in JOG mode) to the required system home position. At this position, stop the drive. Set parameter *Home Offset* **1131** = 0.

By default, *Home Offset* **1131** is set to zero. Upon first commissioning, you do not have to change the value, but this step is required in the case of commissioning following a change.

Now, read the value in parameter *Act. Position* **1108**. Invert this value. Enter the inverted value in *Home Offset* **1131**.

Example:

Act. Position **1108** = 7654 u → *Home Offset* **1131** = - 7654

Once you have set up the home position offset, check the system for correct function again (see chapter 6.4.5.1).

If required for the application, set up the software limit switches now.

Referencing using an absolute value encoder is not necessary after completion of first commissioning. The referencing setting *Operation mode* **1220** with setting "10 – No referencing required" can be used after initialization.

6.5 Speed sensor input 3 (X412) – Parameter descriptions

The encoder input is used for evaluating the position information from the encoder.

Depending on the encoder system used, certain parameters need to be set up. The following table describes the use of the individual parameters for the encoder systems.

Parameters		Encoder system			
No.	**Description**	**SinCos TTL**	**Hiperface**	**EnDat 2.1**	**SSI**
1183	Division marks	X	X	X	(X)
1184	Encoder signals/log	X	X	X	X
1186	Power supply	X	X	X	X
1187	Supply voltage	X	X	X	X
1188	Offset	1)			
1268	SSI: Sampling interval	---	---	---	X
1269	SSI: Error-/Extra-Bits (Low)	---	---	---	X
1270	SSI: Error-/Extra-Bits (High)	---	---	---	X
1271	Bits/Turn	---	X	---	X
1272	Bits Multiturn	---	X	---	X
1473	EC3 Gear Factor Numerator	X	X	X	X
1474	EC3 Gear Factor Denominator	X	X	X	X

X: Parameter must be configured according to the encoder data sheet.

--- Parameter has no function for this encoder type.

(X): In the case of SSI encoders the evaluation of the division marks depends on the setting of *Tracks/Protocol* **1184**.

1): Setting the offset is required in the case of synchronous motors.

In addition, the following actual value parameters are available:

Parameters		Encoder system			
No.	**Description**	**SinCos**	**Hiperface**	**EnDat 2.1**	**SSI**
1267	Abs. encoder raw data	---	X	X	X
1274	Warning Dig. Encoder	---	---	X	---

If positioning (configurations x40) is used, please note to the instructions in chapter 0.

Gear factors *EC3 Gear Factor Numerator* **1473** and *EC3 Gear Factor Denominator* **1474** must be set to 1/1 when used as motor encoder.

6.5.1 Division marks

In parameter *Division marks* **1183**, you can set the type-specific number of division marks of the encoder. The number of division marks is typically described in amplitudes/revolution in the case of encoders with SinCos tracks. Enter the division marks or amplitudes/revolution in parameter *Division marks* **1183**.

Parameters		Settings		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
1183	Division marks	0	8192	1024

In the case of SSI absolute value encoders, evaluation of *Division marks* **1183** is active only if *Tracks/Protocol* **1184** is described in an operation mode for evaluation of TTL [RS-422] or SinCos tracks (settings 51xx, 59xx, 61xx and 69xx).

6.5.2 Tracks/Protocol

Via parameter *Tracks/Protocol* **1184**, you can specify the type-specific number of analog Tracks/Protocol of the encoder and evaluation of a reference track.

The EM-AUT module supports, in the case of EnDat 2.1 encoders, a baud rate of 100 kBit/s. Other baud rates will not be supported.

Key of Tracks/Protocol:

6910

Data transmission speed:

- 01: 100 kBit/s
- 02: 250 kBit/s
- 05: 500 kBit/s
- 10: 1000 kBit/s

EnDat 2.1 SSI

- 09: 9,6 kBit/s
- 19: 19,2 kBit/s
- 38: 38,4 kBit/s

Hiperface

Incremental track:

0: No Incremental Signal
1: SinCos A/B
8: TTL A/B
9: TTL A/B + R track

Protocol:

0: SinCos without Absolute value
1: EnDat 2.1
3: Hiperface
5: SSI Gray Code
6: SSI Binär Code

The identifiers of track A/B and Sin/Cos are typically ambivalent and can be set to A = Sin and B = Cos.

	Tracks/Protocol **1184**		**Function**
	0 -	off	Evaluation is turned off. **Factory setting**.
SinCos	100 -	A/B	Evaluation of analog Tracks/Protocol A and B.
TTL	800 -	A/B	Evaluation of analog Tracks/Protocol A and B.
	900 -	A/B, R	Evaluation of analog Tracks/Protocol A and B as well as reference track R.
EnDat 2.1	1101	EnDat 2.1	Evaluation of analog Tracks/Protocol A/B and the data and clock track with the EnDat 2.1 protocol. Monitoring and comparison of Tracks/Protocol.
Hiperface	3109	Hiperface, 9.6 kBit/s	Evaluation of analog Tracks/Protocol A/B and the data tracks with the Hiperface protocol. Monitoring and comparison of Tracks/Protocol. The data track is transmitted at 9.6 kBaud.
	3119	Hiperface, 19.2 kBit/s	Like 3109. The data track is transmitted at 19.2 kBaud.
	3138	Hiperface, 38.4 kBit/s	Like 3109. The data track is transmitted at 38.4 kBaud.
SSI Gray code	5001	SSI, Gray code, 141 kBit/s	Evaluation of data and clock tracks with the SSI protocol (without TTL or SinCos track). The data track is transmitted at 140.625 kBaud in Gray code.
	5002	SSI, Gray code, 281 kBit/s	Like 5001. The data track is transmitted at 281.25 kBaud in Gray code.
	5005	SSI, Gray code, 563 kBit/s	Like 5001. The data track is transmitted at 562.5 kBaud in Gray code.
	5011	SSI, Gray code, 1125 kBit/s	Like 5001. The data track is transmitted at 1125 kBaud in Gray code.
	5101	SSI+SINCOS, Gray code, 141 kBit/s	Evaluation of Tracks/Protocol A/B as SINCOS track and the data and clock tracks with the SSI protocol. The data track is transmitted at 140.625 kBaud in Gray code.
	5102	SSI+SINCOS, Gray code, 281 kBit/s	Like 5101. The data track is transmitted at 281.25 kBaud in Gray code.
	5105	SSI+SINCOS, Gray code, 563 kBit/s	Like 5101. The data track is transmitted at 562.5 kBaud in Gray code.
	5111	SSI+SINCOS, Gray code, 1125 kBit/s	Like 5101. The data track is transmitted at 1125 kBaud in Gray code.
	5901	SSI+TTL, Gray code, 141 kBit/s	Evaluation of Tracks/Protocol A/B as TTL [RS-422] track and the data and clock tracks with the SSI protocol. The data track is transmitted at 140.625 kBaud in Gray code.
	5902	SSI+TTL, Gray code, 281 kBit/s	Like 5901. The data track is transmitted at 281.25 kBaud in Gray code.
	5905	SSI+TTL, Gray code, 563 kBit/s	Like 5901. The data track is transmitted at 562.5 kBaud in Gray code.
	5911	SSI+TTL, Gray code, 1125 kBit/s	Like 5901. The data track is transmitted at 1125 kBaud in Gray code.

	Tracks/Protocol **1184**		**Function**
SSI Binary code	6001	SSI, binary code, 141 kBit/s	Evaluation of data and clock tracks with the SSI protocol (without TTL or SinCos track). The data track is transmitted at 140.625 kBaud in binary code.
	6002	SSI, binary code, 281 kBit/s	Like 6001. The data track is transmitted at 281.25 kBaud in binary code.
	6005	SSI, binary code, 563 kBit/s	Like 6001. The data track is transmitted at 562.25 kBaud in binary code.
	6011	SSI, binary code, 1125 kBit/s	Like 6001. The data track is transmitted at 1125 kBaud in binary code.
	6101	SSI+SINCOS, binary code, 141 kBit/s	Evaluation of Tracks/Protocol A/B as SINCOS track and the data and clock tracks with the SSI protocol. The data track is transmitted at 140.625 kBaud in binary code.
	6102	SSI+SINCOS, binary code, 281 kBit/s	Like 6101. The data track is transmitted at 281.25 kBaud in binary code.
	6105	SSI+SINCOS, binary code, 563 kBit/s	Like 6101. The data track is transmitted at 562.25 kBaud in binary code.

Tracks/Protocol **1184**		Function
6111	SSI+SINCOS, binary code, 1125 kBit/s	Like 6101. The data track is transmitted at 1125 kBaud in binary code.
6901	SSI+TTL, binary code, 141 kBit/s	Evaluation of Tracks/Protocol A/B as TTL [RS-422] track and the data and clock tracks with the SSI protocol. The data track is transmitted at 140.625 kBaud in binary code.
6902	SSI+TTL, binary code, 281 kBit/s	Like 6901. The data track is transmitted at 281.25 kBaud in binary code.
6905	SSI+TTL, binary code, 563 kBit/s	Like 6901. The data track is transmitted at 562.25 kBaud in binary code.
6911	SSI+TTL, binary code, 1125 kBit/s	Like 6901. The data track is transmitted at 1125 kBaud in binary code.

For synchronous servomotors, an encoder with commutation track or absolute value will be required. Settings 100, 800 and 900 are only intended for operation with asynchronous motors for this reason. In the case of synchronous servomotors, set the *Offset* **1188** according to chapter 6.5.6.

Changeover of parameter *Tracks/Protocol* **1184** can only be done with the output stage disabled. After the parameter change, the new encoder type will have to be initialized. This may take up to 5 seconds.

After mains on, an initialization may have to be performed depending on the encoder type. This may take up to 5 seconds.

SSI encoder: The usable transmission rate depends on the length of the encoder cable. In case there are any transmission errors, reduce the transmission rate.

6.5.3 Power supply

Via parameter *Power supply* **1186**, you can activate the encoder power supply source.

The operation modes with meas. line "sense" (*Power supply* **1186** = "5 – intern, Sense") enable monitoring of the supply voltage of the encoder. In these settings, deviations will be compensated when the supply voltage of the encoder deviates from the set voltage level. To that end, the voltage is measured at the end of the supply line (at encoder).

In operation mode 1, the voltage is controlled at the EM-AUT module, power losses during energy transmission via the supply line will not be compensated.

The encoder can be powered as follows:

via contacts X412.6 (V_{Enc}) and X412.15 (0VL) of the female HD-Sub-D connector.

See chapters "Control terminals" and "EM-AUT: Speed Sensor Power supply".

CAUTION

Always set the *Supply voltage* **1187** first, and then set *Power supply* **1186**. Otherwise, the encoder might be destroyed by high voltage levels.

Power supply 1186	
0 -off	No power supply selected for the encoder. This setting is also used if the encoder is connected directly to an external power supply. **Factory setting**.
1 -Intern	power supply to encoder at terminals X410A.5 (5 … 12 VDC) and X410A.7 (GND) at contacts X412.6 (V_{Enc}: 5 … 12 VDC) and X412.15 (0VL). Voltage source is provided internally by the frequency inverter, max. 2 W.

5 - intern, Sense	power supply to encoder at terminals X410A.5 (5 … 12 VDC) and X410A.7 (GND) at contacts X412.6 (V_{Enc}: 5 … 12 VDC) and X412.15 (0VL). Voltage source is provided internally by the frequency inverter, max. 2 W. A measuring line "sense" of the encoder must be connected in order to monitor the supply voltage.

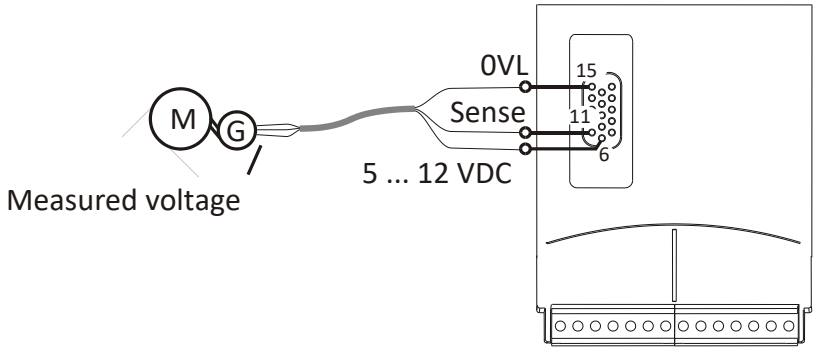
Even if the encoder features a measuring line "sense", you can chose operation mode 1 or 2.

In the case of Hiperface encoders, the sense line (settings "5-intern, Sense") is typically not used, as it is not defined in the Hiperface standard Specification. Thus, using the sense line is not required in the case of Hiperface encoders.

The maximum voltage of the power supply is DC 12 V. Via a sense line, the voltage can be monitored at the encoder, but the voltage output is limited to DC 12 V.

The voltage level can be set up via parameter *Supply voltage* **1187**. See chapter 6.5.4 "Supply voltage". Also see chapter 5.3.7.2.

Measuring line "sense": constant voltage level at encoder



G: encoder

The encoder supply voltage is measured at the encoder and kept constant at the adjusted value of *Supply voltage* **1187** (DC 5 … 12 V).

6.5.4 Supply voltage encoder X412

Via parameter *Supply voltage* **1187**, you can select the voltage level for encoder power supply X412.

The encoder 3 can be powered as follows by the ANG:

- via contacts X412.6 (V_{Enc}) and X412.15 (0VL) of the female HD-Sub-D connector.

The parameter setting is effective on the terminals and the contact of the female HD-Sub-D connector.

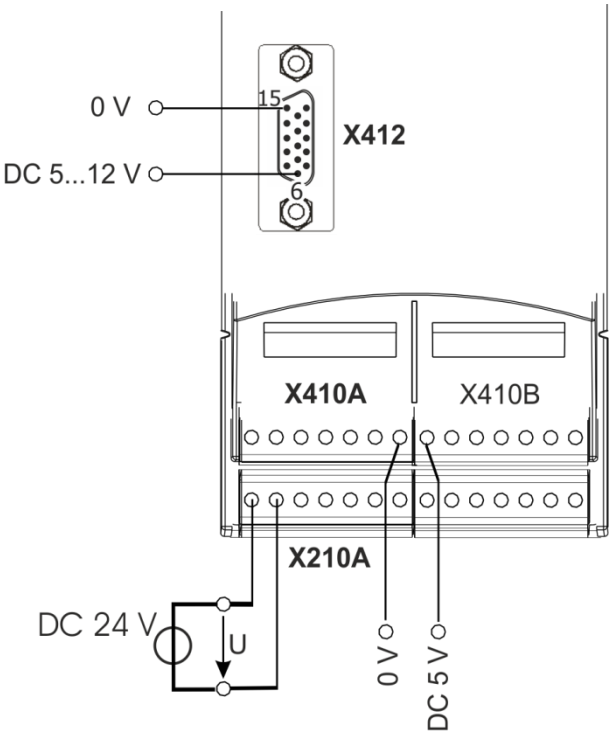
NOTICE

Note the encoder manufacturer's supply voltage specifications. Non-compliance may damage the encoder.

NOTICE

Always set the *Supply voltage* **1187** first and then set *Power supply* **1186**. Otherwise, the encoder might be destroyed by high voltage levels.

Parameters		Settings		
No.	Description	Min.	Max.	Factory setting
1187	Supply voltage	5.0 V	12.0 V	5.0 V



6.5.5 Filter time constant speed sensor 3

Via parameter *Abs. Encoder: Filter time constant* **1189**, you can filter high frequency of the encoder signals and limit the control band width.

Parameters		Settings		
No.	Description	Min.	Max.	Factory setting
1189	Abs. Encoder: Filter time constant	125 µs	8000 µs	125 µs

6.5.6 Offset Absolute encoder

In order to enable the start of a synchronous machine, the absolute position of the rotor must be known. This information is required in order to actuate the stator windings in the right order depending on the position of the rotor. The position of the rotary field in the synchronous machine must be controlled in order to obtain a continuous movement of the rotor. During first commissioning, the position of the rotor winding of the resolver is adjusted to the rotor displacement angle of the synchronous motor by adjusting the offset. For operating a synchronous machine with an encoder, the offset must be adjusted in order to obtain perfectly true running and a maximum torque.

The correct *Offset* **1188** is adjusted when the *flux-forming voltage* **235** reaches the value 0 (approximately) while the motor is turning and has approx. the same amount for both rotation senses.

Also note the information on finetuning at the ending of this chapter.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Fact. Sett.**
1188	Offset	-360.0°	360.0°	0

BONFIGLIOLI servo motors of types BMD, BCR and BTD are set up during the production with an offset of 0.0°. For these motors an offset adjustment is not necessary

6.5.6.1 Automatic setup

WARNING

In certain circumstances, the motor speed may reach high values. Decouple the motor from the load to avoid possible hazards (injury and damage to the machine). Lock or close off the motor shaft and make sure that no loose parts can be moved in an uncontrolled manner through a sudden acceleration of the motor shaft.

NOTICE

If a wrong direction is caused by an incorrect wiring, this is typically detected during the Automatic Offset setup. Always ensure before starting the setup, that the wiring is correct.

The offset can be determined and adjusted as follows:

- Set up parameter *SETUP Selection* **796** to "550 – Para-Ident. Offset, DS0" if the auto setup should be done for all data sets.
- Use for single data sets the corresponding following settings.
- After the start via *SETUP Selection* **796** the Auto-Tuning of the Offset determination is started. The status of the Auto-Tuning is displayed by *SETUP Status* **797**.
- For the Auto-Tuning a controller release via STO must be done. Switch the STO inputs when *SETUP Status* **797** shows "STO".

If a correct Offset was detected, this value is set up automatically in *Offset* **1188**. Additionally the device executes a Reset. The Absolute encoder is now tuned to the motor.

If U, V and W are connected correctly, the sense of rotation "clockwise" with a view from the front is defined on the motor shaft in accordance with DIN EN 60034-8.

Possible errors and corrections:

- If during the auto-tuning error "F1420" shows up, this is an indication of an incorrect direction of rotation of the absolute encoder in comparison to the motor.
  Execute one of the following actions to adjust the direction of rotation of the encoder to the motor
    - Swap two motor phases, for example U and V. Note the direction of rotation of the motor.

- Invert the direction of rotation of the resolver by exchanging Sin+ and Sin-. Ensure that the analog part and digital part of the encoder use the same sense of direction.

6.5.6.2 Manual setup

The offset can be determined and adjusted as follows:

- During first commissioning "SEtUP" will be displayed in the control unit. Press ESC to stop this operation. The guided commissioning ("SEtUP") is performed after adjusting the offset.
- Open the parameter menu "PARA" and enter the machine data indicated on the type plate or the data sheet of the motor.

Before adjusting the offset, take the following **safety precautions**:

- Disable the frequency inverter via STO (controller release).
- If possible, uncouple the motor from the load so that the motor shaft turns freely. If installed, release the mechanical brake.

If uncoupling is not possible, make sure that the motor is loaded as little as possible.

WARNING

In certain circumstances, the motor speed may reach high values. If the motor is not uncoupled from the load, personal and material damage may result. To avoid such damage, make the following settings in any case.

- Set the maximum permissible output frequency of the frequency inverter to a low frequency value via parameter *Switch-Off Limit* **417**. Select the frequency value such that uncontrolled acceleration of the motor ("overspeeding") is detected at an early stage. This limitation is necessary in order to avoid personal and material damage.
- Set parameter *Current Limit* **728** of the speed controller to a low current value (e.g. 10% of the rated motor current). In this way it is made sure that there are no excessive currents of the offset is set incorrectly.

WARNING

Unintended Starting!

If the Drive is supplied with voltage, it can suddenly start. This may lead to personal and material damage.

- Prior to starting the manual adjustments, disconnect the drive from voltage supply.
- Comply with the five safety rules.
- If possible, wear protective clothing.

- Turn motor shaft manually. Check the sense of rotation of the resolver via the actual value of parameter *Frequency Speed Sensor 3* **279**. In the case of a clock-wise rotation of the motor shaft, positive values are displayed for the actual frequency value. If the displayed sense of rotation does not correspond to the actual sense of rotation, swap the connections of the tracks A and B of the frequency inverter.

The *Offset* **1188** must be between 0° and 360°, divided by the number of motor pole pairs.

$$\text{Max. Offset} = \frac{360\,°}{\text{number of motor pole pairs}}$$

If the adjusted value is changed by the maximum offset, this does not affect the *flux-forming voltage* **235**.

- Adjust a low reference speed value (approx. 10% lower than the *Switch-off Limit Frequency* **417**), and enable the frequency inverter via digital input S1IND (controller release) and S2IND (start clock-wise operation) in order to accelerate the motor.
- If an overcurrent is detected or a fault message is issued due to an overload, the guided commissioning (setup) will start first. Confirm the machine and encoder data. After completion of the guided commissioning, adjust the parameter *Limit Current* **728** to a low value again because this value was overwritten during the guided commissioning.

Depending on the behavior of the motor after start, carry out the following steps:

– **Motor does not turn, or the motor shaft only turns to a new position and stops again:**

- Check if the parameters *No. of Pole Pairs* **373** for the motor is set correctly.

If these values are adjusted correctly, take the following measures complying with the safety instructions.

WARNING

The mains, direct voltage and motor sockets can be live with dangerous voltage after disconnection of the frequency inverter. Work only on the device after a waiting period of some minutes until the DC link capacitors have discharged.

- Before electrical installation work, de-energize the frequency inverter and take appropriate precautions to make sure it is not re-energized unintentionally. Make sure that the frequency inverter is de-energized.
- Exchange two motor phases (e.g. U and V) at the frequency inverter sockets because the senses of rotation of the motor and the encoder do not correspond to each other.
- Switch on the power supply again.
- As described above, adjust a low speed reference value and start the motor.

If the motor does not start despite the phase exchange:

- Increase the parameter value for *Offset* **1188** by 90°, divided by the no. of motor pole pairs.

If the motor still does not turn, exchange the two motor phases (e.g. U and V) again.

– The motor turns and accelerates until it reaches the *Frequency Switch-Off Limit* 417:

- Check the encoder lines and check the encoder connection contacts.
- In the case of fault message "Overfrequency" F1100: increase the parameter value for *Offset* **1188** by 180°, divided by the no. of motor pole pairs.

If the motor turns at the adjusted speed and in the right direction, carry out the fine adjustment of the offset:

- Adjust the parameter value for *Offset* **1188** in small steps (e.g. 2.5°) until the *flux-forming voltage* **235** is approximately 0.

– In case the flux-forming voltage deviates from 0 significantly, adjust the offset in bigger steps.

- In the case of a positive flux-forming voltage, increase the offset.
- In the case of a negative flux-forming voltage, reduce the offset.

- Adjust parameters *Frequency Switch-Off Limit* **417** and *Current Limit* **728** to the required values.
- Repeat the **fine adjustment** of the offset at 50% of the rated frequency.

  This completes the offset adjustment.
- Start the guided commissioning. This is required for optimum current control.

WARNING

Some absolute encoder types offer the possibility to "zeros" or change the position transmitted from the encoder. Do not use this functionality since otherwise the commutation angle for *Offset* **1188** is changed and the correct speed control cannot be guaranteed.

6.5.7 Bits/Turn

If an absolute value encoder is used (EnDat 2.1, Hiperface, SSI), the number of Bits/Turn (referred to encoder) must be configured in the frequency inverter. In the case of Hiperface and SSI encoders, the value specified in the data sheet of the encoder used must be entered in parameter *Bits/Turn* **1271**.

In the case of EnDat 2.1, the value is read automatically from the EnDat encoder and used internally. Parameter *Bits/Turn* **1271** is not evaluated in the case of EnDat encoders.

Parameters		Settings		
No.	Description	Min.	Max.	Factory setting
1271	Bits/Turn	0 bits/t	32 bits/t	13 bits/t

The internal resolution of one motor revolution is 16 bit. The resolution of *Bits/Turn* **1271** is converted to the internal resolution if the encoder is used as a motor encoder.

In the case of application encoders, the reference between motor and application encoder is parameterized through the gear factors *EC2 Gear Factor Numerator* **513** and *EC2 Gear Factor Denominator* **514**.

In the case of linear encoders, this value must be set according to chapter 6.4.5.

6.5.8 Bits Multiturn

If a multiturn absolute value encoder is used (EnDat 2.1, Hiperface, SSI), the number of Bits/Turn (referred to encoder) for the multiturn resolution must be configured in the frequency inverter. In the case of Hiperface and SSI encoders, the value specified in the data sheet of the encoder used must be entered in parameter *Bits Multiturn* **1272**.

In the case of EnDat 2.1, the value is read automatically from the EnDat encoder and used internally. Parameter *Bits Multiturn* **1272** is not evaluated in the case of EnDat encoders.

Parameters		Settings		
No.	Description	Min.	Max.	Factory setting
1272	Bits Multiturn	0 Bit	32 Bit	13 Bit

The position of the motor is resolved at a total of 31 bits + sign bit. The lower 16 bits are used for the motor position angle the higher 16 bits are used for the number of motor revolutions and the sign.

If the absolute value encoder is used as a motor encoder, the following shall apply:

If the number of *Bits Multiturn* **1272** is smaller than 16 bits, the missing bits are filled internally in the frequency inverter. These additional bits are used for overflow saving of the revolutions so that 2^{16} revolutions (including one sign bit) can be managed safe against zero voltage.

If the number of *Bits Multiturn* **1272** is greater than 16 bits, the accuracy of the encoder exceeds the accuracy of the inherent resolution of the frequency inverter.

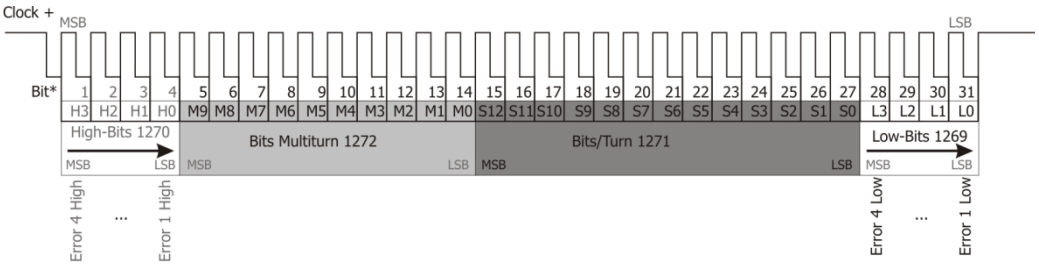
In the case of application encoders, the reference between motor and application encoder is parameterized through the gear factors *EC2 Gear Factor Numerator* **513** and *EC2 Gear Factor Denominator* **514**.

In the case of linear encoders, this value must be set according to chapter 6.4.5.

6.5.9 SSI: error/additional bits

If SSI encoders are used, the available error/additional bits of the encoder can be masked for evaluation. Many encoders use one or more bits for error signaling. In some cases, the bits are also used for transmitting additional information not required for encoder evaluation in the frequency inverter.

Arrangement SSI-Bits (number of individual bits as an example)



Bit*: The bits are shown from left to right corresponding to the time transmission, the most significant bit (MSB) is transmitted first, the least significant bit (LSB) last. The number of bits is shown as an example in the illustration. Multiturn bits are only present in the case of

Multiturn encoders. The additional bits "Low bits" are used by many encoder manufacturers with 1 or 3 bits. The additional "High bits" are only used very rarely by encoder manufacturers.

Depending on the function intended by the encoder manufacturer, an error bit "High" or "Low" may trigger an error.

Parameters **1269** *SSI: Error-/Extra Bits (Low)* and **1270** *Error-/Extra Bits (High)* can evaluate up to eight error bits each. SSI error MSBits is used for the definition the most significant bits, and SSI error LSBits is used for the less significant bits.

To determine the total data width, the two parameters must always be defined. This definition is also required if no evaluation is to take place. In this case, all bits must be masked as "Don't care" with an "X" in the string.

If no error bits or other bits are present ("empty string"), a dash "-" must be parameterized. The input always begins with the MSB.

The following values are permissible:

H: When the bit is "High", error F172A or F172B will be triggered.

L: When the bit is "Low", error F172A or F172B will be triggered.

X: No error will be triggered for the bit, regardless of its status.

-: Number of bits = 0 (use in this case only).

Lowercase letters can be used alternatively in the entry.

Note: This parameter cannot be entered by means of KP500.

Note: Other values cannot be entered.

Special case: Number of bits = 0:

SSI additional bits in the High range are not used by many encoder manufacturers. In these cases set the parameter to value "-" (dash).

Parameters		Settings		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
1269	SSI: Error-/Extra-Bits (Low)	Special, see text		„-"
1270	SSI: Error-/Extra-Bits (High)			„-"

Due to the shifting of the usable data by the error/additional bits, the number of error/additional bits must always be specified correctly.

Example 1

Additional bits (High)	Multiturn bits	Singleturn bits	Additional bits (Low)
0	8	16	Total 1 to be evaluated. "High" is an error situation.

SSI: Error-/Extra-Bits (High) **1270** = "-"
Bits Multiturn. **1272** = 8
Bits/Turn **1271** = 16
SSI: Error-/Extra-Bits (Low) **1269** = "-"

Example 2

Additional bits (High)	Multiturn bits	Singleturn bits	Additional bits (Low)
0	12	16	Total 4, the second one is to be evaluated. "Low" is an error situation.

SSI: Error-/Extra-Bits (High) **1270** = "-"
Bits Multiturn. **1272** = 12
Bits/Turn **1271** = 16
SSI: Error-/Extra-Bits (Low) **1269**= "XLXX"

Example 3

Additional bits (High)	Multiturn bits	Singleturn bits	Additional bits (Low)
Total 2, the first one is to be evaluated. "High" is an error situation.	8	16	Total 4, the second one is to be evaluated. "Low" is an error situation.

SSI: Error-/Extra-Bits (High) **1270** = "HX"
Bits Multiturn. **1272** = 8
Bits/Turn **1271** = 16
SSI: Error-/Extra-Bits (Low) **1269**= "XLXX"

Example 4

Additional bits (High)	Multiturn bits	Singleturn bits	Additional bits (Low)
0	8	16	Encoder has 4 toggle bits all of which are to be ignored.

SSI: Error-/Extra-Bits (High) **1270** = "-"
Bits Multiturn. **1272** = 8
Bits/Turn **1271** = 16
SSI: Error-/Extra-Bits (Low) **1269**= "XXXX"

6.5.10 SSI: Sampling interval

SSI frequency encoders often use a sampling rate in the millisecond range. In order for the evaluation in the device to work correctly, the sampling rate of the SSI absolute value encoder must be set up. If the sampling rate of the encoder cannot be adjusted, use the next higher, available setting. The parameter value is adjusted as a multiplier of 125 us.

Not all steps from 0 to 240 are available. The selection list limits the available options to reasonable settings.

Parameters		Settings		
No.	Description	Min.	Max.	Factory setting
1268	SSI: Sampling interval	0	240	0

NOTICE

For a good positioning behavior, the sampling rate is to be less than 1 ms.

In the case of higher sampling rates, unwanted high system vibration or even machine damage may occur, if the speed and position controller are configured improperly.

In the case of high sampling rates (> 2 ms), reduce the dynamics of the system via the speed controller and the position controller.

Positioning accuracy will be lower in the case of high sampling rates. For precise applications, use encoders with low sampling rates.

6.5.11 Gear factor speed sensor 3

If the speed sensor is coupled to the motor via one or more gears, the transmission ratio between the motor and the encoder must be configured via *EC3 Gear Factor Numerator* **1473** and *EC3 Gear Factor Denominator* **1474**.

Parameters		Settings		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
1473	EC3 Gear Factor Numerator	-300.00	300.00	1.00
1474	EC3 Gear Factor Denominator	0.01	300.00	1.00

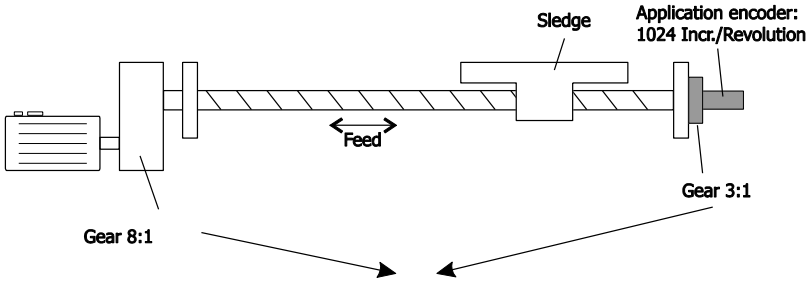
$$\frac{\text{Revolutions of the Motor shaft}}{\text{Revolutions of the EC3 encoder shaft}} = \frac{EC3\,Gear\,Factor\,Numerator\,\mathbf{1473}}{EC3\,Gear\,Factor\,Denominator\,\mathbf{1474}}$$

Gear factors *EC3 Gear Factor Numerator* **1473** and *EC3 Gear Factor Denominator* **1474** must always be referred to the motor.

In the case of linear encoders, this value must be set according to chapter 6.4.5.

Example

On a linear axis, the motor is flange-connected via a gear (transmission ratio 8:1) and the application connector is flange-connected via a second gear (transmission ratio 3:1).



EC3 Gear Factor Numerator **1473**
EC3 Gear Factor Denominator **1474**

1 motor revolution = 1/8 turn on output side
= 1/8x3 encoder turn

$$\frac{EC3\,Gear\,Factor\,Numerator\,\mathbf{1473}}{EC3\,Gear\,Factor\,Denominator\,\mathbf{1474}} = \frac{\text{Revolutions of the Motor shaft}}{\text{Revolutions of the EC3 encoder shaft}} = \frac{8}{3}$$

6.5.12 Warning Dig. Encoder

Via parameter *Warning Dig. Encoder* **1274**, the current warning status of EnDat 2.1 encoders is displayed. This information can be used for analyzing and eliminating application problems. Parameter *Warning Dig. Encoder* **1274** shows the current warning with an abbreviation. For evaluation via field bus, parameter *Warning Dig. Encoder* **1273** with the warning value in hexadecimal representation can be used. By addition of the values, several warnings can be displayed simultaneously.

EnDat 2.1 warnings			
Abbreviation in *Warning Dig. Encoder* **1274**	Bit code *Warning Dig. Encoder* **1273**		Meaning
	Bit	**Value**	
Fcoll	0	0x0001	Frequency collision

Temp	1	0x0002	Temperature exceeded
Illum	2	0x0004	Control reserve lighting
Batt	3	0x0008	Battery status
Ref	4	0x0010	Reference point

Warnings which are present at the same time are represented by the bit combination or mathematical addition.

Present warnings can be displayed via the application warning mask in Bit 9.

6.6 Instructions on speed-controlled configurations ("Not x40")

In the case of speed-controlled configurations, an encoder is typically installed. Normally, this encoder is connected to the motor.

An internal format (referred to as 16/16) is used for speed control. The 16 less significant bits represent the position angle on a motor revolution, the 16 more significant bits represent the number of motor revolutions.

If absolute value encoders are used, the absolute value encoder notation is converted to the internal notation. This is why, for proper function, the parameters of the absolute value encoder must be entered in accordance with the data sheet. In the case of other parameterizations, unwanted malfunction of the drive might occur.

6.7 Instructions on positioning (configuration x40)

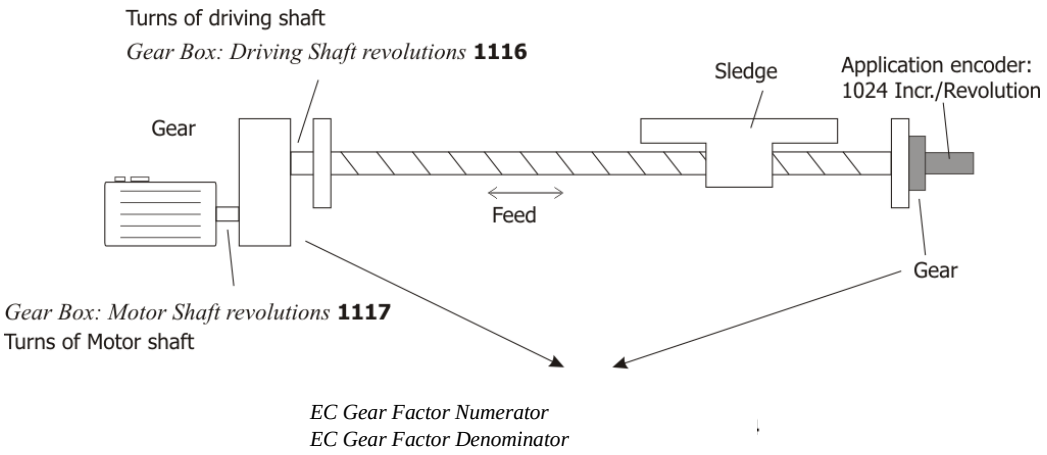
If positioning (configuration x40) and an absolute value encoder are used, a distinction is made for parameterization between "motor encoders" and "application encoders".

The motor encoder is always needed for speed control and can also be used for position control in the case of no-slip systems.

An application encoder for position control is used in systems where slip may occur for slip compensation. This encoder is also often referred to as an "External encoder" or "Synchronous encoder".

With the module, the following configurations are possible:

System slip	Motor type	Configuration
no-slip system, high speed precision: absolute value encoder at motor for speed control and position control	synchronous servomotor & asynchronous motor	540 & 240
no-slip system, low speed precision: absolute value encoder as application encoder for position control of motor model with speed control	synchronous servomotor	640
slipping system, high speed precision: absolute value encoder as application encoder for position control HTL encoder (ASM) or Resolver (PMSM) as motor encoder for speed control	synchronous servomotor & asynchronous motor	540 & 240
slipping system, low speed precision: absolute value encoder as application encoder for position control motor model for speed control	synchronous servomotor & asynchronous motor	640 & 440



An internal format (referred to as 16/16) is used for speed control and calculation of the positioning trajectory. The 16 less significant bits represent the position angle on a motor revolution, the 16 more significant bits represent the number of motor revolutions.

The positioning offers the user so-called "user units" (abbreviation [u]), which enable adjustment to any application via the reference system. In this way, the resolution of the smallest unit for positioning can be parameterized (e.g. 1 mm, 4 mm, 0.01 °, etc.).

For more information on the reference system, refer to the application manual "Positioning".

Parameters		Settings		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
1115	Feed constant	1 u/U	2^{31}-1 u/U	65536 u/U
1116	Gear Box: Driving Shaft Revolutions	1	65 535	1
1117	Gear Box: Motor Shaft Revolutions	1	65 535	1

For application encoders, a gear transmission between the application encoder and motor must be parameterized via a gear factor.

The conversions between the different reference systems are done automatically, the user sets the target values in user units referred to the distance.

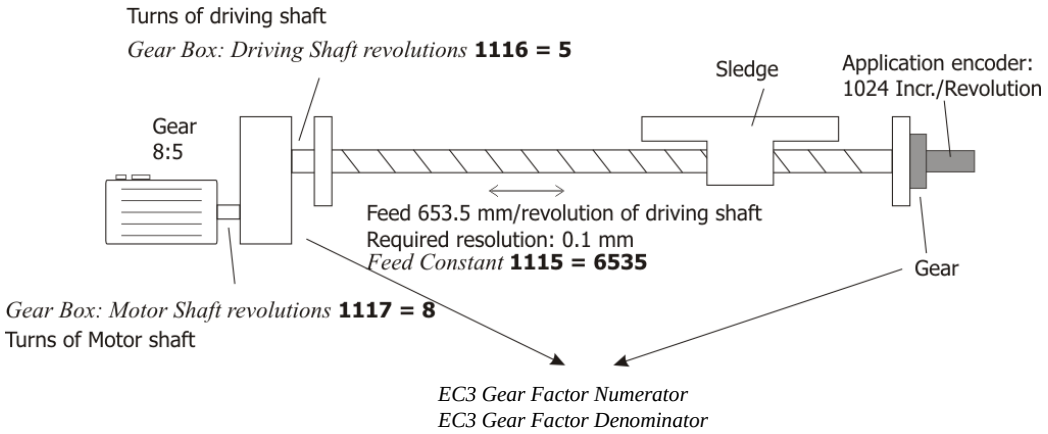
6.7.1 Example

For parameterization of a linear slide, the following properties are known:

Motor gear ratio: 8:5

Application encoder gear ratio: 7:3

Feed rate of linear axis: 635.5 mm/revolution of the output shaft



This results in the following parameterization:

Feed constant **1115** = 6535 rev

Gear shaft turns **1116** = 5

Gear motor turns **1117** = 8

EC3 Gear Factor Numerator **1473** = 24

EC3 Gear Factor Denominator **1474** = 35

In order to move by 1 mm, a positioning order of 10 u must be executed.

In the case of linear systems, the feed constant is typically specified in the data sheet. If this value is unknown, it must be determined empirically. For empirical determination of the feed constant, refer to application manual "Positioning".

6.7.2 Homing

When it comes to positioning, homing may be required or recommended, depending on the application. If no absolute value encoder is used, homing to a known point (e.g. reference cam or limit switch) will typically be performed first upon restoration of mains supply.

When an absolute value encoder is used, homing during operation is unwanted in many situations. If homing is not to be performed during operation, you can set *Operation mode* **1228** = "10 – No homing".

By using different frequency inverter data sets, you can configure a setup mode, including homing, and a normal operation mode.

6.8 Actual speed source

The rotary encoder is selected via *Actual Speed Source* **766**. In the default setting, speed sensor 1 is used as the source of actual speed.

Actual speed source **766**		Function
1 -	Speed sensor 1	The actual speed source is speed sensor 1 of the basic device.
2 -	Speed sensor 2	The actual speed source is speed sensor 2 (Resolver or TTL at X410) of the Automation Interface.
3 -	Motor model	The actual speed source is the motor model of the frequency inverter.
10 -	Speed sensor 3	The actual speed source is speed sensor 3 (X412) of the Automation Interface.

Setting "3-Motor model" is visible and available in configurations 4xx and 6xx only.

6.9 Actual position source

In positioning applications (configurations x40), the actual position source must be set. This is done via *Actual Position Source* **1141**. In the basic setting, the actual value source of the speed control is used as the actual position source.

Actual Position Source **1141**	Function
like 766 Actual speed source	The actual speed source is the actual position source at the same time (factory setting).
Encoder 1	The actual position source is speed sensor 1 of the basic device.
Encoder 2	The actual position source is speed sensor 2 (Resolver or TTL at X410) of the Automation Interface.
Encoder 3	The actual position source is speed sensor 3 (X412) of the Automation Interface.

7 First commissioning

For basic information on commissioning refer to the operating instructions document "**VEC1105**".

For first commissioning, you should be familiar with the followings steps and the described functions:

Selection of device control *Local/Remote* **412:** Chapter 12

Commissioning of device functions via PLC:

- Setting the station address: Chapter 7.2
- Setting the process data: Chapter 12
- Operating behavior at bus connection failure: Chapter 7.4
- Resetting errors: Chapter 8.12
- Parameter access: Chapter 10

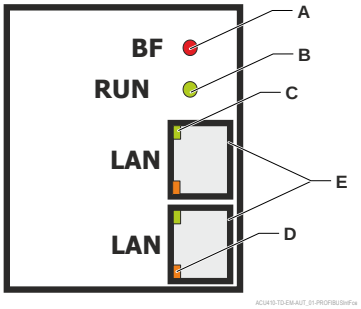
Setting reference values:

- Reference speed in speed-controlled configuration x10, x11, x15, x16, x30, x60: Chapter 12.3
- Reference value in position configuration x40: Chapter 11.2.1
- Velocity mode vl: Chapter 11.2.9
- Profile velocity mode pv: Chapter 11.2.10
- Profile position mode: Chapter 11.2.8
- Homing mode: Chapter 11.2.11
- Table travel record mode: Chapter 11.2.12
- Move Away from Limit Switch: Chapter 11.3
- Mode of Operation change: Chapter 11.2.3

Diagnosis: Chapter 8.9

7.1 Connector assignment

The PROFINET module is connected to the PLC or switch using RJ45 connectors (LAN).



A	BF-LED
B	RUN-LED
C	Activity indication
D	Link indication
E	RJ45 Connectors

Figure 7-1: PROFINET connector

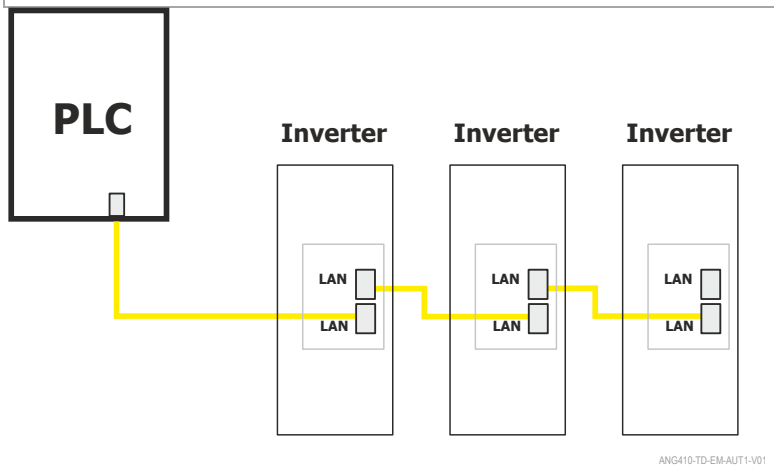


Figure 7-2: PROFINET topology

LED status indicators

The green RUN LED indicates the current status of the module.

LED Status	Module status
Off	Module is off.
On	Module is on and running.

The red BF-LED indicates the current status of the connection.

LED Status	Module status
On	Module has no Ethernet connection.
Flashing	Module has Ethernet connection, no cyclic exchange of data is taking place.
Off	Exchange of Cyclic data is taking place.

7.2 Setting the station address

A PROFINET IO controller accesses IO devices based on unique device names. The device name is assigned during system configuration using a PROFINET hardware configurator. The PROFINET IO controller can also assign the IP settings. During the hardware configuration, it

is set for each IO device if the local IP settings are used or the IP settings of the PROFINET IO controller are applied.

When the IP settings of the PROFINET IO controller are applied, the local IP settings on the frequency inverter are blocked. In this case, the VPlus configuration software shows "Zero" for IP address, Net mask and Gateway. The IP settings cannot be edited via VPlus. If you enter the "Apply" command, the settings entered before are reset to "Zero".

If a module is replaced, a special function of the PROFINET module enables assignment of a device name without the PROFINET configurator.

The TCP/IP configuration of VPlus shows the IP settings and, as the "Host name", the device name saved in the module.

If a PROFINET module must be replaced, the device name assigned before without PROFINET configurator can be assigned again.

- Start the TCP-IP configuration in VPlus and enter the device name as the "Host name".

The IP settings must also be re-set again.

7.3 Alarm messages

If there is a frequency inverter fault, the PROFINET EM-AUT module sends an alarm message. This function can be deactivated via parameter *Profibus/PROFINET Diagnostic/Alarm Message* **1444**.

Diagnostic/Alarm Message 1444	Function
0 - Off	No alarm message in the case of a frequency inverter fault.
1 - On	Alarm message in the case of a frequency inverter fault. Factory setting.

List of Alarm messages

Error Type	Error Text	Help Text
257	Ixt Overload	F01nn Inverter rated current exceeded
258	Heatsink temperature	F02nn Heatsink temperature too high
259	Inside temperature	F03nn Inside temperature too high
260	Motor connection	F04nn Motor temperature, protection switch, V-belt monitoring, phase failure
261	Output current	F05nn Overload, short circuit, earth fault, asymmetric current, phase monitoring
262	Internal Fault	F06nn Internal Fault
263	DC-Link voltage	F07nn DC-Link voltage too low/high, brake/motor chopper threshold too small
264	Electronic voltage	F08nn Electronic voltage DC 24V too low/high
265	Pre-charging relay	F09nn Pre-charging relay faulted
272	Brake chopper	F10nn Brake chopper faulted
273	Output frequency	F11nn Output frequency exceeded maximum frequency
274	Safety function STO	F12nn Diagnosis error of function STO, STOA/STOB monitoring
275	Motor load	F13nn Earth fault, IDC compensation limit, minimum current monitoring
276	Control connection	F14nn Encoder signals, external error
277	Table travel record	F15nn Table travel record, error in motion blocks
278	Parameter	F16nn Parameter error
279	Encoder	F17nn Encoder error

Error Type	Error Text	Help Text
289	CAN-Systembus slave error	F21nn CAN-Systembus slave node id = nn reports error
290	CAN-System bus	F22nn CAN-Systembus error
292	EM-Module	F24nn Unknown EM-Module
304	Application	F30nn Application error
511	Generic	Fxxxx Generic error

7.4 Operating behavior at bus connection failure

The operating behavior in the case of failure of the PROFINET systems can be parameterized. The required behavior can be set via parameter *Bus Error behavior* **388**.

Bus Error behavior 388		Function
0 -	no response	Operating point is maintained.
1 -	Error	"Fault" status will be activated immediately. Factory setting.
2 -	Stop	Control command "Disable voltage" and switch to "switch on disabled" status.
3 -	Quick stop	Control command "Quick stop" and switch to "switch on disabled" status.
4 -	Shutdown + Error	Control command "Disable operation" and switch to "Error" status once the drive has been shut down.
5 -	Quick stop + Error	Control command "Quick stop" and switch to "Error" status once the drive has been shut down.

The parameter settings *Bus Error Behaviour* **388** = 2…5 are evaluated depending on parameter *Local/Remote* **412**.

There are numerous options of parameterizing the fault and warning behavior of the frequency inverter. For details about possible faults, refer to Chapter "Error messages".

8 Systembus

This chapter describes the usage of Systembus on the CAN interface.

8.1 Baud rate setting/line lengths

The Baud rate settings must be the same in all subscribers. The maximum Baud rate depends on the necessary total cable length of the system bus. The Baud rate is set up via parameter *Baud-Rate* **903** and defines the available cable length.

Operation mode		Function	max. line length
3 -	50 kBaud	Transmission rate 50 kBaud	1000 meters
4 -	100 kBaud	Transmission rate 100 kBaud	800 meters
5 -	125 kBaud	Transmission rate 125 kBaud	500 meters
6 -	250 kBaud	Transmission rate 250 kBaud	250 meters
7 -	500 kBaud	Transmission rate 500 kBaud	100 meters
8 -	1000 kBaud	Transmission rate 1000 kBaud	25 meters

A baud rate under 50 kBaud, as defined according to CANopen, is not sensible for the system bus as the data throughput is too low.

The maximum line lengths stated are guidelines.

Depending on the number of subscribers, the baud rate is limited. There are the following restrictions:

Up to and including	250 kBit/s:	not more than 64 subscribers
	500 kBit/s:	not more than 28 subscribers
	1000 kBit/s:	not more than 10 subscribers

The bus load must be considered in the projecting phase.

8.2 Setting the node address

A maximum of 63 slaves or frequency inverters with system bus can be operated on the system bus. Each frequency inverter is given a node ID, which may only exist once in the system, for its unambiguous identification. The setting of the system bus node ID is done via the parameter *Node-ID* **900**.

Parameters		Settings		
No.	Description	Min.	Max.	Factory setting
900	Node-ID	-1	63	-1

Thus, the system bus possesses a maximum number of 63 subscribers (Network nodes), plus one frequency inverter as a master.

With the factory setting of parameter *Node-ID* **900** = -1, the system bus is deactivated for this frequency inverter.

If *Node-ID* **900** = 0 is set, the frequency inverter is defined as the master. Only one frequency inverter on the system bus may be defined as the master.

8.3 Functional overview

The system bus produces the physical connection between the frequency inverters. Logical communication channels are produced via this physical medium. These channels are defined via the identifiers. As CAN does not possess a subscriber-oriented, but a message-oriented addressing via the identifiers, the logical channels can be displayed via it.

In the basic state (factory setting) the identifiers are set according to the Predefined Connection Set of CANopen. These settings are aimed at one master serving all the channels.

In order to be able to build up process data movement via the PDO channels between individual or a number of inverters (transverse movement), the setting of the identifiers in the subscribers has to be adapted.

The exchange of data is done message-oriented. A frequency inverter can transmit and receive a number of messages, identified via various identifiers.

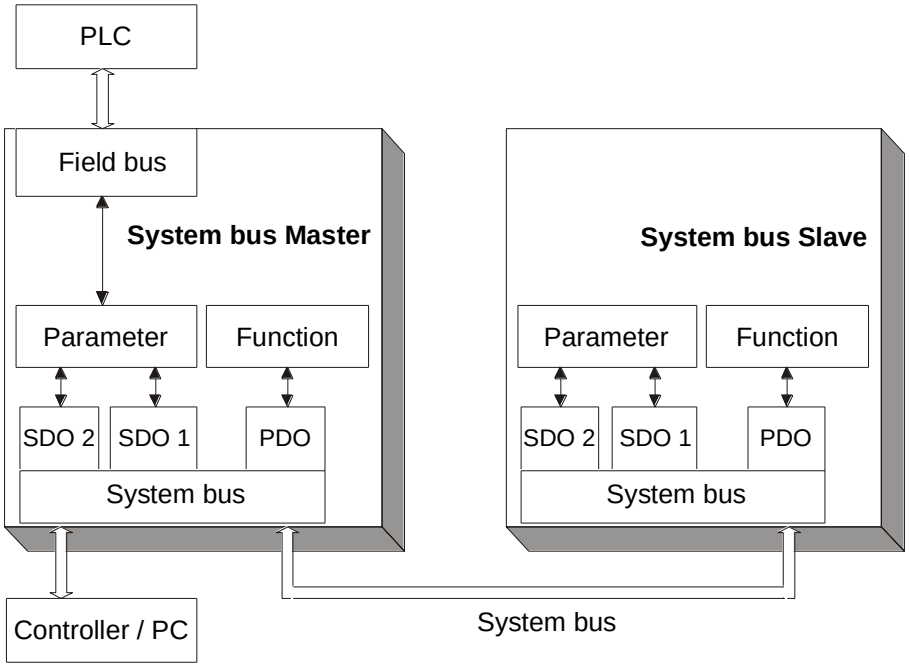
As a special feature, the properties of the CAN bus mean that the messages transmitted by one subscriber can be received by a number of subscribers simultaneously. The error monitoring methods of the CAN bus result in the message being rejected by all recipients and automatically transmitted again if there is a faulty reception in one receiver.

8.4 Network management

The network management controls the start of all subscribers to the system bus. Subscribers can be started or stopped individually or jointly. For subscriber recognition in a CAL or CAN open system, the slaves on the system bus generate a starting telegram (boot-up report).

In the event of a fault, the slaves automatically transmit a fault report (emergency message).

For the functions of the network management, the methods and NMT telegrams (network management telegrams) defined according to CAN open (CiA DS 301) are used.



8.4.1 SDO channels (parameter data)

Each frequency inverter possesses two SDO channels for the exchange of parameter data. In a slave device, these are two server SDOs, in a device defined as a master a client SDO and a server SDO. Attention must be paid to the fact that only one master for each SDO channel may exist in a system.

Only one master can initiate by the system bus an exchange of data via its client SDO.

The identifier assignment for the SDO channels (Rx/Tx) is done according to the Predefined Connection Set.

This assignment can be amended by parameterization, in order to solve identifier conflicts in a larger system in which further devices are on the CAN bus alongside the frequency inverters.

NOTICE

If a system in which a frequency inverter works as a master is produced, the identifier allocations for the SDO channel may not be altered.

In this way, an addressing of individual subscribers via the field bus/system bus path of the master frequency inverter is possible.

Parameters are read/written via the SDO channels. With the limitation to the SDO Segment Protocol Expedited, which minimizes the requirements of the parameter exchange, the transmittable data are limited to the uint / int / long types. This permits complete parameterization of the frequency inverters via the system bus, as all the settings and practically all the actual values are displayed via these data types.

8.4.2 PDO channels (process data)

Each frequency inverter possesses three PDO channels (Rx/Tx) for the exchange of process data.

The identifier assignment for the PDO channel (Rx/Tx) is done by default according to the Predefined Connection Set. This assignment corresponds to an alignment to a central master control.

In order to produce the logical channels between the devices (transverse movement) on the system bus, the amendment of the PDO identifiers for Rx/Tx is necessary.

Each PDO channel can be operated with time or SYNC control. In this way, the operation behavior can be set for each PDO channel:

The setting of the operation mode is done via the following parameters:

TxPDO1 Function **930**, *TxPDO2 Function* **932** and *TxPDO3 Function* **934**

RxPDO1 Function **936**, *RxPDO2 Function* **937** and *RxPDO3 Function* **938**

Operation mode	Function
0 - disabled	no exchange of data via the PDO channel (Rx and/or Tx)
1 - time-controlled	Tx-PDOs cyclically transmit according to the time specification Rx-PDOs are read in with Ta = 1 ms and forward the data received to the application
2 - SYNC controlled	Tx-PDOs transmit the data from the application that are then current after the arrival of the SYNC telegram. Rx-PDOs forward the last data received to the application after the arrival of the SYNC telegram.

For synchronous PDOs, the master (PC, PLC or frequency inverter) generates the SYNC telegram. The identifier assignment for the SYNC telegram is done by default according to the Predefined Connection Set. This assignment can be altered by parameterization.

8.5 Master functionality

An external control or a frequency inverter defined as a master (node ID = 0) can be used as a master. The fundamental tasks of the master are controlling the start of the network (boot-up sequence), generating the SYNC telegram and evaluating the emergency messages of the slaves.

Further, there can be access to the parameterization of all the frequency inverters on the system bus by means of a field bus connection via the client SDO of the master frequency inverter.

8.5.1 Control boot-up sequence, network management

The Minimum Capability Boot-Up method defined according to CANopen is used for the state control of the nodes.

This method knows the pre-operational, operational and stopped states.

After the initialization phase, all the subscribers are in the pre-operational state. The system bus master transmits the NMT command **Start-Remote-Node**. With this command, individual nodes or all the nodes can be started together. A frequency inverter defined as a master starts **all** the nodes with **one** command. After receipt of the Start Remote Node command, the subscribers change into the Operational state. From this time on, process data exchange via the PDO channels is activated.

A master in the form of a PLC/PC can start the subscribers on the system bus individually and also stop them again.

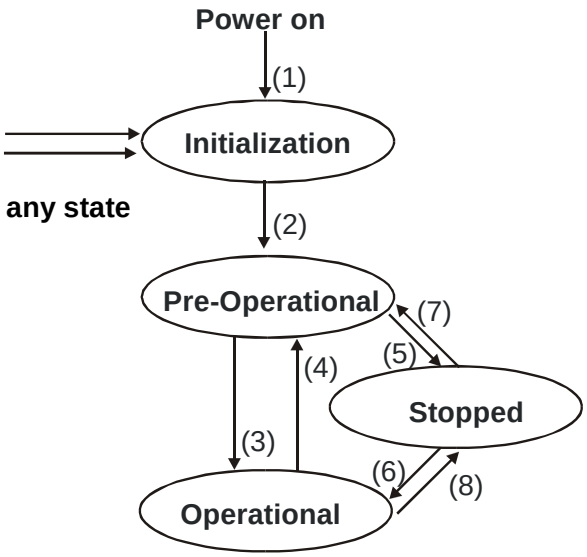
As the slaves on the system bus need different lengths of time to conclude their initialization phases (especially if external components exist alongside the frequency inverters), an adjustable delay for the change to Operational is necessary. The setting is done in a frequency inverter defined as a system bus master via *Boot-Up Delay* **904**.

Parameters		Settings		
No.	Description	Min.	Max.	Factory setting
904	Boot-up delay	3500 ms	50000 ms	3500 ms

Properties of the states:

State	Properties
Pre-Operational	Parameterization via SDO channel possible Exchange of process data via PDO channel not possible
Operational	Parameterization via SDO channel possible Exchange of process data via PDO channel possible
Stopped	Parameterization via SDO channel not possible Exchange of process data via PDO channel not possible

Start-Remote-Node is cyclically transmitted with the set delay time by a frequency inverter defined as a system bus master, in order to put slaves added with a delay or temporarily separated from the network back into the Operational state.



After Power On and the initialization, the slaves are in the Pre-Operational state.

The transition (2) is automatic. The system bus master (frequency inverter or PLC/PC) triggers the transition (3) to Operational state.

The transitions are controlled via NMT telegrams.

The identifier used for the NMT telegrams is "0" and may only be used by the system bus master for NMT telegrams. The telegram contains two data bytes.

Byte 0	Byte 1
CS (Command Specifier)	Node-ID

Identifier = 0

With the statement of the node ID ≠ 0, the NMT command acts on the subscriber selected via the node ID. If node ID = 0, all the subscribers are addressed. If Node-ID = 0, all nodes are addressed.

Transition	Command	Command Specifier
(3) , (6)	Start Remote Node	1
(4) , (7)	Enter Pre-Operational	128
(5) , (8)	Stop Remote Node	2
-	Reset Node	129
-	Reset Communication	130

A frequency inverter defined as a system bus master only transmits the command "Start Remote Node" with node ID = 0 (for all subscribers). Transmission of the command is done after completion of the initialization phase and the time delay *Boot-Up Delay* **904** following it.

8.5.2 SYNC telegram, generation

If synchronous PDO's have been created on the system bus, the master must send the SYNC telegram cyclically. If a frequency inverter has been defined as a system bus master, the latter must generate the SYNC telegram. The interval for the SYNC telegram of a frequency inverter defined as the system bus master is adjustable. The SYNC telegram is a telegram without data.

The default identifier = 128 according to the Predefined Connection Set.

If a PC or PLC is used as a master, the identifier of the SYNC telegrams can be adapted by parameterization on the frequency inverter.

The identifier of the SYNC telegram must be set identically in all clients on the system bus.

The setting of the identifier of the SYNC telegram is done via parameter *SYNC-Identifier* **918**.

Parameters		Settings		
No.	Description	Min.	Max.	Factory setting
918	SYNC identifier	0	2047	0

The setting "0" results in identifier assignment according to the Predefined Connection Set.

NOTICE

The identifier range 129...191 may not be used as the emergency telegrams can be found there.

The temporal cycle for the SYNCH telegram is set on a frequency inverter defined as the system bus master via parameter *SYNC-Time* **919**.

A setting of 0 ms for the parameter *SYNC-Time* **919** means "no SYNC telegram".

8.5.3 Emergency message, reaction

If a slave on the system bus suffers a fault, it transmits the emergency telegram. The emergency telegram marks the node ID for the identification of the failed node via its identifier and the existing fault message via its data contents (8 bytes).

After a fault has been acknowledged on the slave, the latter again transmits an emergency telegram with the data content zero.

The emergency telegram has the identifier 128 + node ID (= 129 ... 191)

The system bus master evaluates the emergency telegrams of the slaves. Its reaction to an emergency telegram can be set with *Emergency Reaction* **989**.

Operation mode		Function
0 -	Error	The system bus master receives the emergency telegram and switches-off.
1 -	No Error	The Emergency Telegram is displayed as a warning.
2 -	Ignore	The Emergency Telegram is ignored.

Operation mode - parameter 989 = 0 – Error

Behavior of the system bus master in the case of *Emergency Reaction* **989** = 0 - Error:

As soon as the system bus master receives an emergency telegram, it also switches to failure mode and reports the failed subscriber on the basis of its ID via the kind of error. Only the subscriber is reported, not the cause of the error.

The fault message on the system bus master via *Type of error* **260** is **21nn** with **nn = node ID** (hexadecimal) of the slave where a fault shutdown has occurred.

In addition, the system bus master reports the warning Sysbus (0x2000) via *Warning Status* **270** Bit 13.

If a fault shutdown occurs on a number of slaves, the first slave to transmit its emergency telegram is displayed on the system bus master.

Operation mode - parameter 989 = 1 – No Error

Behavior of system bus master in the case of *Emergency Reaction* **989** = 1 / No Error:

As soon as the system bus master receives an emergency telegram, it reports the warning Sysbus (0x2000) via *Warning status* **2**70 Bit 13.

In both cases, the Boolean variable SysbusEmergency with source number 730 is set to TRUE in the system bus master. It can be used in the system bus master and (in transmission via a TxPDO) in the slaves for a defined shutdown.

SysbusEmergency is also set if the system bus master breaks down.

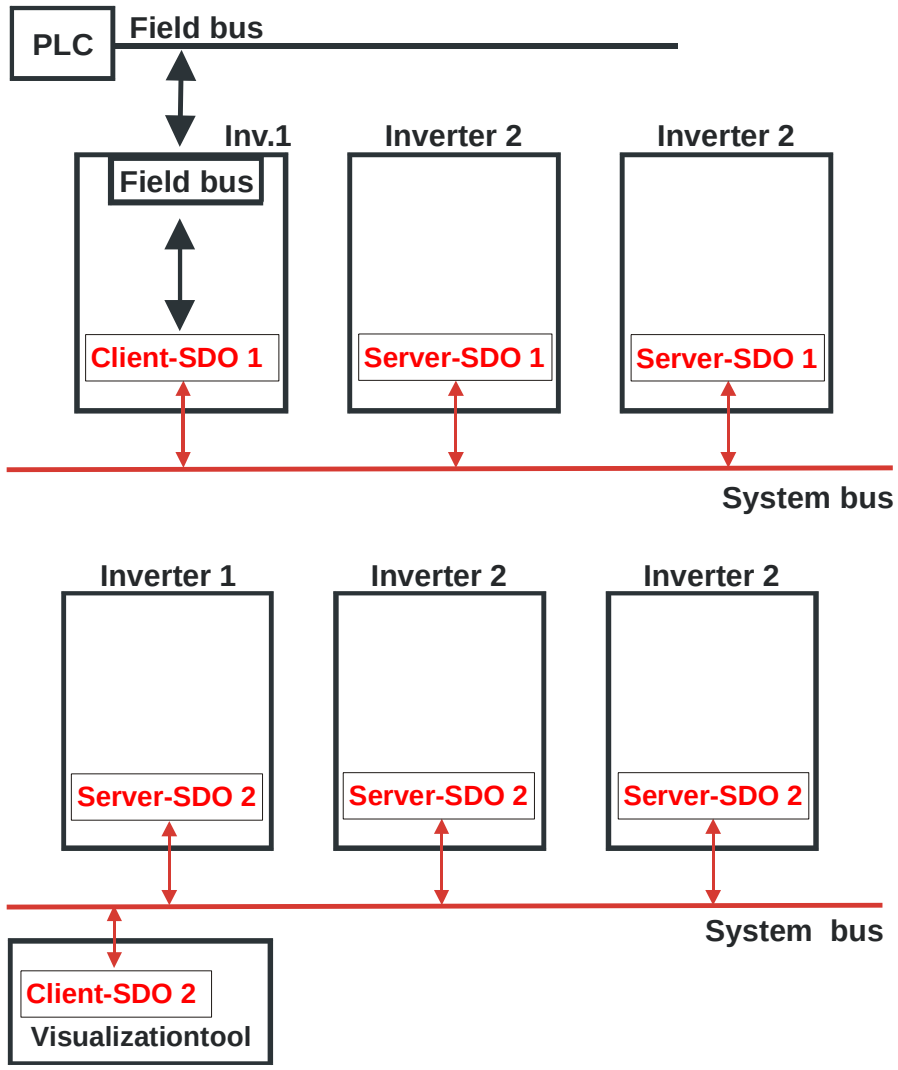
Resetting of SysbusEmergency is done with the fault acknowledgment.

8.5.4 Client SDO (system bus master)

Each subscriber on the system bus can be addressed via the SDO channels. In this way, each subscriber can be addressed and parameterized by one master via its client SDO1. All the parameters of the data types uint/int/long are accessible. String parameters **cannot** be processed. If a frequency inverter has been defined as a system bus master, each subscriber on the system bus in this frequency inverter can be addressed by means of a field bus connection (RS232, RS485, Profibus-DP) via its client SDO1.

The second SDO channel SDO2 of the frequency inverters is planned for the parameterization of the frequency inverters via a visualization tool on the system bus.

The service used is SDO Segment Protocol Expedited according to CANopen. A frequency inverter defined as a system bus master automatically generates the correct telegrams. If the SDO channel is operated via a PLC/PC on the system bus, the telegrams must be generated according to the specification.



8.6 Slave functionality

8.6.1 Implement boot-up sequence, network management

Boot-up message

After the initialization, each slave on the system bus transmits its boot-up message (heartbeat message).

The boot-up telegram has the identifier 1792 + node ID and a data byte with contents = 0x00.

This telegram is irrelevant if a PLC/PC with CANopen functionality is used as a master. A frequency inverter defined as a system bus master **does not** evaluate the boot-up message.

State control

The identifier used for the NMT telegrams is "0" and may only be used by the system bus master for NMT telegrams. The telegram contains two data bytes.

Byte 0	Byte 1
CS (Command Specifier)	Node-ID

Transition	Command
(3),(6)	Start Remote Node
(4),(7)	Enter Pre-Operational
(5),(8)	Stop Remote Node
-	Reset Node
-	Reset Communication

The reset node and reset communication command specified according to DS 301 lead to a change to Pre-Operational via Initialization in the frequency inverters. There is a new boot-up message.

8.6.2 Process SYNC telegram

If synchronous PDO's have been created in a frequency inverter, their processing is synchronized with the SYNC telegram. The Sync event can either by a SYNC telegram or a RxPDO telegram and is set up via **1180** *Operation mode* synchronization.

The SYNC telegram is generated by the system bus master and is a telegram without data or 1 byte data. The data byte is ignored.

The identifier is 128 according to the Predefined Connection Set.

If a PC or PLC is used as a master, the identifier of the SYNC telegrams can be adapted by parameterization on the frequency inverter. The identifier of the SYNC telegram must be set identically in all clients on the system bus.

NOTICE

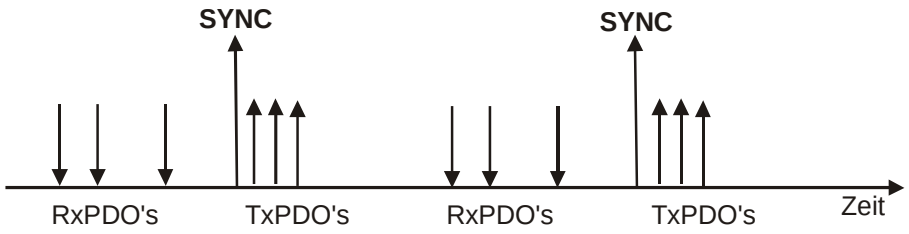
The identifier range 129...191 may not be used as this range is used for the emergency telegrams.

The setting of the identifier of the SYNC telegram is done via parameter *SYNC-Identifier* **918**.

Parameters		Settings		
No.	Description	Min.	Max.	Factory setting
918	SYNC identifier	0	2047	0

The setting "0" results in identifier assignment according to the Predefined Connection Set.

The data of the Rx-PDO's are forwarded to the application after the arrival of the SYNC telegram. At the same time, the Tx-PDO's with the currently available data from the application are sent.



This method enables pre-occupancy of set points in the system bus subscribers and a synchronous / parallel take-over of the data.

8.6.3 Emergency-Message, fault shutdown

As soon as a fault shutdown occurs in a slave frequency inverter, the emergency telegram is transmitted. The emergency telegram marks the node ID for the identification of the failed node via its identifier and the existing fault message via its data contents (8 bytes).

The emergency telegram has the identifier 128 + node ID.

After a fault acknowledgment, another emergency telegram is transmitted, with the data content (Byte 0 ...7) being set to "0" this time. This identifies the subscriber's repeated readiness for operation. If a further fault occurs subsequently, it is transmitted in a new emergency telegram.

The acknowledgment sequence is based on the definitions according to CANopen.

Data contents of the emergency telegra

Emergency telegram		
Byte	Value	Meaning
0	0x00	low-byte error code
1	0x10	high-byte error code
2	0x80	Error register
3	0x00	-
4	0x00	-
5	0x00	-
6	0xnn	internal error code, low-byte
7	0xmm	internal error code, high-byte

Bytes 0, 1 and 2 are firmly defined and compatible with CANopen.

Bytes 6/7 contain the product specific VECTRON error code.

Error code	= 0x1000	= general error
Error register	= 0x80	= manufacturer-dependent error

The explanation and description of the product-specific VECTRON error code can be found in the annex "Error messages".

8.6.4 Server-SDO1/SDO2

The communication channel for the exchange of parameter data is the SDO channel. Communication works according to the client/server model. The server is the subscriber holding the data (here the frequency inverter), the client the subscriber requesting or wanting to alter the data (PLC, PC or frequency inverter as system bus master).

For the frequency inverter, two server SDO channels have been implemented.

The first SDO channel **SDO1** is used for the parameterization of the PLC/PC as a master or frequency inverter with field bus connection as a system bus master.

The second SDO channel **SDO2** is reserved for a visualization tool for parameterization. An exchange of data can only be implemented by the master via a client SDO.

The SDO channels are stipulated for the server SDO's via identifiers according to the Predefined Connection Set to CANopen. As CANopen only provides for and defines one SDO channel in the Predefined Connection Set, the second SDO channel can be deactivated.

In addition, the number of system bus subscribers and the adjustable node ID are limited to 63.

Identifier assignment according to the Predefined Connection Set:

Identifier Rx-SDO = 1536 + Node-ID	(Node ID = 1 ... 127, Identifier = 1537 ... 1663)
Identifier Tx-SDO = 1408 + Node ID	(Node ID = 1 ... 127, Identifier = 1409 ... 1535)

Identifier assignment for SDO1/SDO2 compatible with the Predefined Connection Set:

Identifier Rx-SDO1 = 1536 + Node ID	(Node ID = 1 ... 63, Identifier = 1537 ... 1599)
Identifier Tx-SDO1 = 1408 + Node ID	(Node ID = 1 ... 63, Identifier = 1409 ... 1471)
Identifier Rx-SDO2 = 1600 + Node ID	(Node ID = 0 ... 63, Identifier = 1600 ... 1663)
Identifier Tx-SDO2 = 1472 + Node ID	(Node ID = 0 ... 63, Identifier = 1472 ... 1535)

This corresponds to the factory settings of the frequency inverters for the SDO's.

The node ID = 0 for SDO2 is the system bus master.

NOTICE

The SDO2 must be deactivated in a CANopen system in order not to generate any compatibility problems.

If a frequency inverter has been defined as the system bus master, the above settings for the SDO1 must be maintained in all the frequency inverters. In this way, access to the parameterization of the frequency inverters via a field bus connection on the master frequency inverter is possible.

The client SDO1 in the master frequency inverter addresses the server SDO1 of the slaves via the above identifiers.

The identifiers for a visualization tool on the second SDO channel SDO2 cannot be changed.

If a PC or a PLC is used as a master, the identifiers of the **Rx/Tx-SDO1** can be adapted by parameterization on the frequency inverter.

NOTICE

Identifiers may only be assigned once, i.e. no double assignments.

The identifier range 129...191 may not be used as the emergency telegrams can be found there.

The setting of the identifiers of the RxSDO1 is done via the parameter *RxSDO1-Identifier* **921**.

Parameters		Settings		
No.	Description	Min.	Max.	Factory setting
921	RxSDO1 identifier	0	2047	0

The setting of the identifiers of the TxSDO1 is done via parameter number **922**.

Parameters		Settings		
No.	Description	Min.	Max.	Factory setting
922	TxSDO1 identifier	0	2047	0

The setting "0" results in identifier assignment according to the Predefined Connection Set.

The second SDO channel can be deactivated via the *SDO2 Set Active* **923**.

Operation mode Function	
0 - SDO2 deactivated	Communication channel deactivated
1 - SDO2 activated	Communication channel activated for the visualization tool

The identifier assignment for the second SDO channel is always to the specification:

Identifier Rx-SDO2 = 1600 + Node ID

Identifier Tx-SDO2 = 1472 + Node ID

In this way, firm identifiers via which communication takes place are available for the visualization tool.

8.7 Communication channels, SDO1/SDO2

8.7.1 SDO telegram (SDO1/SDO2)

The service used for the exchange of parameter data is **SDO Segment Protocol Expedited**. The data (type uint, int, long) are exchanged in a telegram.

Access to the parameters in the frequency inverters with a statement of parameter number and data set is displayed via the addressing defined for object access pursuant to the specifications of CANopen via Index/Sub-Index.

Index = parameter number / Sub index = data set.

The data to be transmitted have a length of 2 bytes for uint/int and 4 Bytes for long. For simplification and standardization, 4 bytes are always transmitted.

The data are on bytes 4...7 of the SDO telegram.

-uint/int variables are transmitted in bytes 4 and 5

with bytes 6 und 7 = 0.

-long variables are transmitted in bytes 4...7.

Writing parameters:

Client ➔ Server, SDO Download (expedited)

0	1	2	3	4	5	6	7
Control byte	Parameter number		Data Set	Data			
0x22	LSB	MSB	0xnn	LSB			MSB
uint/int				LSB	MSB	0x00	0x00
long				LSB	...	...	MSB

Server ➔ Client

Download Response ➔ writing process free of errors

0	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Control byte	Parameter number		Data Set	Data			
0x60	LSB	MSB	0xnn	0			

Server ➔ Client

Abort SDO Transfer ➔ writing process with error

0	1	2	3	4	5	6	7
Control byte	Parameter number		Data Set	Data			
0x80	LSB	MSB	0xnn	Code	0	0	0

The error code is stated in byte 4 in a faulty reading process. (See table, failure codes).

Control byte 0x22 for the identification "SDO Download expedited" does not consider the bits "s" (data size indicated) and "n" (number of bytes not containing data). If set, they are ignored. The user is responsible for the number of bytes matching the type of data.

Reading parameters:

Client ➔ Server

SDO Upload (expedited)

0	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Control byte	Parameter number		Data Set	Data			
0x40	LSB	MSB	0xnn	0			

Server ➔ Client

Upload Response ➔ reading process without errors

0	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Control byte	Parameter number		Data Set	Data			
0x42	LSB	MSB	0xnn	LSB			MSB
uint/int				LSB	MSB	0x00	0x00
long				LSB	...	...	MSB

Server ➔ Client

Abort SDO Transfer ➔ reading process faulty

0	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Control byte	Parameter number		Data Set	Data			
0x80	LSB	MSB	0xnn	Code	0	0	0

The error code is stated in byte 4 in a faulty reading process. (See table, failure codes).

Error codes	
Code	Description
1	inadmissible parameter value
2	inadmissible data set
3	Parameter not readable
4	Parameter not writeable
5	read error EEPROM
6	write error EEPROM
7	checksum error EEPROM
8	parameter cannot be written while the drive is running
9	values of the data sets differ from one another
10	wrong parameter type
11	unknown parameter
12	BCC error in VECTRON bus protocol
15	unknown error
20	system bus subscriber not available only in access via field bus connection
21	string parameter not admissible only in access via VECTRON bus protocol

8.8 Process data channels, PDO

This chapter describes the PDO usage of Systembus.

8.8.1 Identifier assignment process data channel

The process channel for the exchange of process data under CANopen and Systembus is the PDO channel. Up to three PDO channels with differing properties can be used in one device.

The PDO channels are defined via identifiers according to the Predefined Connection Set to CANopen:

Identifier 1. Rx-PDO = 512 + Node ID

Identifier 1. Tx-PDO = 384 + Node ID

Identifier 2. Rx-PDO = 768 + Node ID

Identifier 2. Tx-PDO = 640 + Node ID

Identifier 3. Rx-PDO = 1024 + Node ID

Identifier 3. Tx-PDO = 896 + Node ID

This corresponds to the factory settings of the frequency inverters for the Rx/Tx-PDO‘s. This occupancy is aligned to an external master (PLC/PC) serving all the channels.

If the PDO channels are used for a connection of the frequency inverters amongst one another, the identifiers are to be set accordingly by parameterization.

NOTICE

Identifiers may only be assigned once, i.e. no double assignments.

The identifier range 129...191 may not be used as the emergency telegrams can be found there.

Setting of the identifiers of the Rx/TxPDOs:

Parameters		Settings		
No.	Description	Min.	Max.	Factory setting
924	RxPDO1 Identifier	0	2047	0
925	TxPDO1 Identifier	0	2047	0
926	RxPDO2 Identifier	0	2047	0
927	TxPDO2 Identifier	0	2047	0

928	RxPDO3 Identifier	0	2047	0
929	TxPDO3 Identifier	0	2047	0

The setting "0" results in identifier assignment according to the Predefined Connection Set.

8.8.2 Operation modes process data channel

The sending/receiving behavior can be time-controlled or controlled via a SYNC telegram. The behavior can be parameterized for each PDO channel.

Tx-PDOs can work time-controlled or SYNC-controlled. Time-controlled TxPDO sends its data at the set time intervals. A SYNC-controlled TxPDO will send its data once a SYNC-telegram is received.

RxPDOs in the time controlled setting forward the received data to the application immediately. If an RxPDO has been defined as SYNC controlled, it forwards its received data to the application after the arrival of a SYNC telegram.

Settings TxPDO1/2/3

Parameters		Settings		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
931	TxPDO1 Time	1 ms	50000 ms	8 ms
933	TxPDO2 Time	1 ms	50000 ms	8 ms
935	TxPDO3 Time	1 ms	50000 ms	8 ms

The setting of the operation mode is done via the following parameters:

TxPDO1 Function **930**, *TxPDO2 Function* **932** and *TxPDO3 Function* **934**

Operation mode		Function
0 -	Not Active	No data are sent.
1 -	Controlled by time	In the cycle of the adjusted time interval the data are sent.
2 -	Controlled by SYNC	To arrival of a SYNC telegram the data are sent.

Settings RxPDO1/2/3

The setting of the operation mode is done via the following parameters:

RxPDO1 Function **936**, *RxPDO2 Function* **937** and *RxPDO3 Function* **938**

Operation mode		Function
0 -	Controlled by time	The received data are passed on immediately.
1 -	Controlled by SYNC	After arrival of a SYNC telegram the received data are passed on

In the "controlled by time" operation mode, there is a polling of the received data with the trigger cycle of Ta = 1 ms.

8.8.3 Timeout monitoring process data channel

Each frequency inverter monitors its received data for whether they are updated within a defined time window.

The monitoring is done onto the SYNC telegram and the RxPDO channels.

Monitoring SYNC / RxPDOs

Parameters		Settings		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
939	SYNC timeout	0 ms	60000 ms	0 ms
941	RxPDO1 Timeout	0 ms	60000 ms	0 ms
942	RxPDO2 Timeout	0 ms	60000 ms	0 ms
945	RxPDO3 Timeout	0 ms	60000 ms	0 ms

Setting "0" means no timeout monitoring.

Attention:

There is only monitoring for the SYNC telegram if at least one RxPDO or one TxPDO channel is defined as SYNC controlled.

If a timeout period is exceeded, the frequency inverter switches to failure mode and reports one of the faults:

F2200 System bus Timeout SYNC
F2201 System bus Timeout RxPDO1
F2202 System bus Timeout RxPDO2
F2203 System bus Timeout RxPDO3

8.8.4 Communication relationships of the process data channels

Regardless of the process data to be transmitted, the communication relationships of the process data channels must be defined. The connection of PDO channels is done via the assignment of the identifiers. The identifiers of Rx-/Tx-PDO must match in each case.

Generally, there are two possibilities:

- **one** Rx-PDO to **one** Tx-PDO (one to one)
- connect **several** Rx-PDO's to **one** TxPDO (one to many)

This process is documented in a tabular form via a **communication relationship list**.

Example:

Frequency inverter 1		Frequency inverter 2		Frequency inverter 3	
PDO	Identifier	PDO	Identifier	PDO	Identifier
TxPDO1	**385**	TxPDO1		TxPDO1	
RxPDO1		**RxPDO1**	**385**	**RxPDO1**	**385**
TxPDO2	**641**	TxPDO2		**TxPDO2**	**642**
RxPDO2		**RxPDO2**	**641**	RxPDO2	
TxPDO3		TxPDO3		TxPDO3	
RxPDO3		**RxPDO3**	**642**	RxPDO3	

All the TxPDOs used must have different identifiers !!!

The Identifier must be clear in the system bus network.

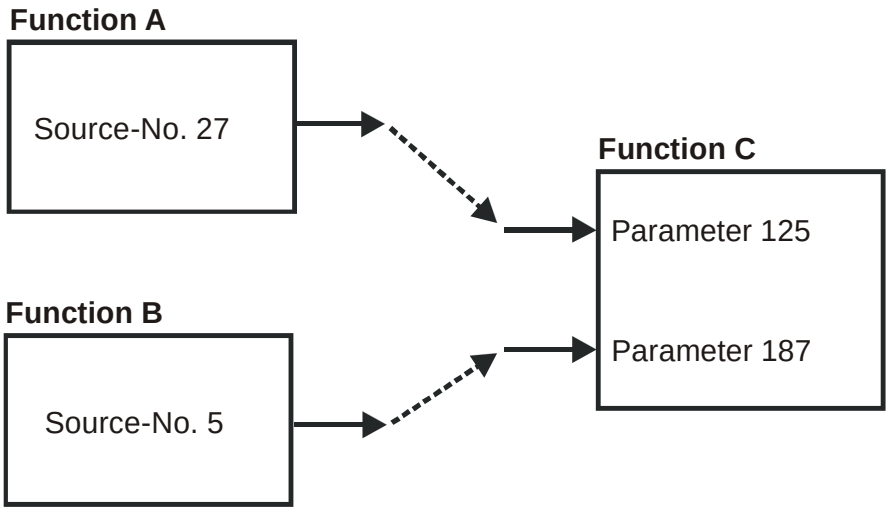
8.8.5 Virtual links

A PDO telegram contains 0 ...8 data bytes according to CANopen. A mapping for any kind of objects can be done in these data bytes.

For the system bus, the PDO telegrams are firmly defined with 8 data bytes. The mapping is not done via mapping parameters as with CANopen, but via the method of sources and links.

Each function provides its output data via a source. These sources are defined via source numbers. The input data of functions are defined via parameters. The link of a data input to a data output is done via the assignment of parameters to source numbers.

Example 1:



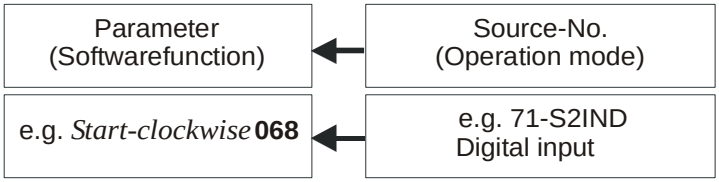
In example 1, the two inputs of function C are linked to the outputs of the functions A and B. The parameterization for this connection is thus:

Function C

Parameter 125 = Source-No. 27

Parameter 187 = Source-No. 5

Example of a virtual connection in VPlus:

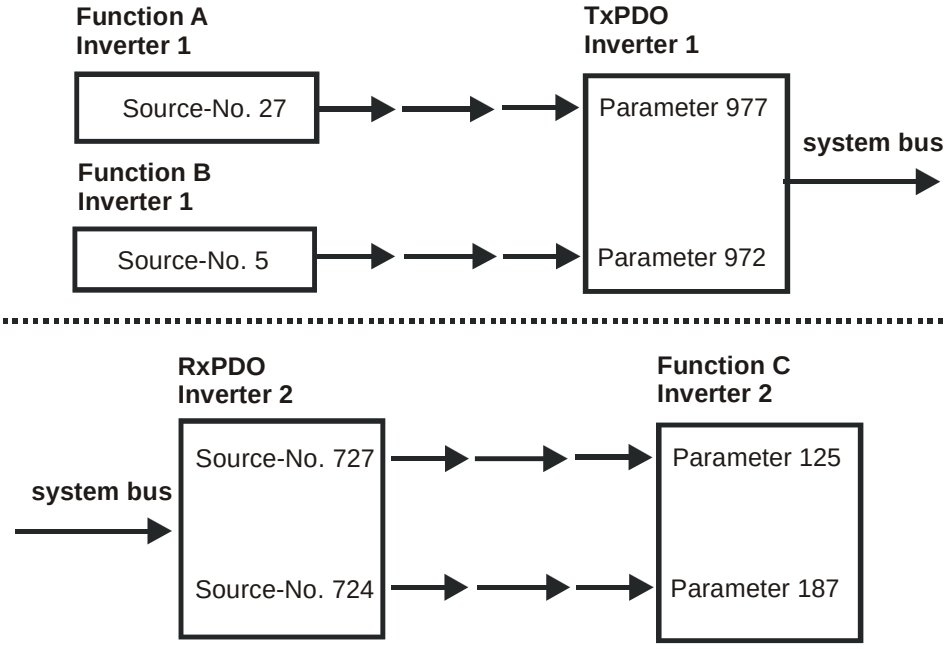


The assignment of the operation modes to the software functions available can be adapted to the application in question.

For more information on VPlus, see chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**.

For the system bus, the input data of the TxPDOs are also displayed as input parameters and the output data of the RxPDOs as sources.

Example 2:



Example 2 displays the same situation as Example 1. But now, the functions A and B are in frequency inverter 1 and function C in frequency inverter 2. The connection is done via a TxPDO in frequency inverter 1 and a RxPDO in frequency inverter 2. Thus, the parameterization for this connection is:

Frequency inverter 1

Parameter 977 = Source-No. 27

Parameter 972 = Source-No. 5

Frequency inverter 2

Parameter 125 = Source-No. 727

Parameter 187 = Source-No. 724

As the links with the system used exceed the device limits, they are termed "virtual links".

The virtual links with the possible sources are related to the Rx/TxPDO channels. For this purpose, the eight bytes of the Rx-/TxPDOs are defined structured as inputs and sources. This exists for each of the three PDO channels.

Each transmit PDO and receive PDO can be occupied as follows:

4 Boolean variables

or

4 uint/int variables

or

2 long variables

or

a mixture paying attention to the eight bytes available

Assignment data type / number of bytes:

Assignment	
Data type	**Length**
Boolean	2 Bytes
uint/int	2 Bytes
long	4 Bytes

Input parameters of the TxPDOs for data to be transmitted

The listed parameters can be used for determining the data that are to be transported there for each position in the TxPDO telegrams. The setting is done in such a way that a source number is entered for the required data in the parameters.

TxPDO1 Byte	**P. No. Boolean input**	**TxPDO1 Byte**	**P. No. uint/int input**	**TxPDO1 Byte**	**P. No. long input**
0	**946**	0	**950**	0	
1	**Boolean1**	1	**Word1**	1	**954**
2	**947**	2	**951**	2	
3	**Boolean2**	3	**Word2**	3	**Long1**
4	**948**	4	**952**	4	
5	**Boolean3**	5	**Word3**	5	**955**
6	**949**	6	**953**	6	
7	**Boolean4**	7	**Word4**	7	**Long2**

TxPDO2 Byte	P. No. Boolean input	TxPDO2 Byte	P. No. uint/int input	TxPDO2 Byte	P. No. long input
0	**956**	0	**960**	0	
1	**Boolean1**	1	Word1	1	**964**
2	**957**	2	**961**	2	
3	**Boolean2**	3	Word2	3	**Long1**
4	**958**	4	**962**	4	
5	**Boolean3**	5	Word3	5	**965**
6	**959**	6	**963**	6	
7	**Boolean4**	7	Word4	7	**Long2**

TxPDO3 Byte	P. No. Boolean input	TxPDO3 Byte	P. No. uint/int input	TxPDO3 Byte	P. No. long input
0	**966**	0	**972**	0	
1	**Boolean1**	1	**Word1**	1	**976**
2	**967**	2	**973**	2	
3	**Boolean2**	3	**Word2**	3	**Long1**
4	**968**	4	**974**	4	
5	**Boolean3**	5	**Word3**	5	**977**
6	**969**	6	**975**	6	
7	**Boolean4**	7	**Word4**	7	**Long2**

Depending on the selected data information the percentages values are displayed via the uint/int inputs.

With this method, there are up to three possibilities for a meaning of the contents of the individual bytes. Each byte may only be used for one possibility.

To ensure this, the processing of the input links is derived from the setting.

If an input link has been set to the fixed value of zero, it is **not** processed.

The settings for the fixed value zero are:

Source =	7 (FALSE)	for Boolean variables
Source =	9 (0)	for uint, int, long variables

This is, at the same time, the factory setting.

Examples Boolean source

Boolean source	
Source	**Data**
6	TRUE
7	FALSE
70	Contact input 1
71	Contact input 2
72	Contact input 3
161	Run signal
163	Reference value reached
164	Set frequency reached (P. 510)

Examples uint/int source

unit/int source	
Source	**Data**
9	0
63	Reference Percentage 1
64	Reference Percentage 2
52	Percentage MFE1
133	Output percentage ramp
137	Output reference percentage channel
138	Output actual percentage channel
740	Control word
741	Status word

Examples long source

long source	
Source	**Data**
9	0
0	Output frequency ramp
1	Fixed frequency 1
5	Reference line value
62	Output Frequency reference value channel
50	Reference Frequency MFE1

Source numbers of the RxPDOs for received data

Equivalent to the input links of the TxPDOs, the received data of the RxPDOs are displayed via sources or source numbers. The sources existing in this way can be used in the frequency inverter via the local input links for the data targets.

RxPDO1 Byte	Source no. Boolean value	RxPDO1 Byte	Source no. uint/int value	RxPDO1 Byte	Source no. long Value
0	**700**	0	**704**	0	
1	**Boolean1**	1	**Word1**	1	**708**
2	**701**	2	**705**	2	
3	**Boolean2**	3	**Word2**	3	**Long1**
4	**702**	4	**706**	4	
5	**Boolean3**	5	**Word3**	5	**709**
6	**703**	6	**707**	6	
7	**Boolean4**	7	**Word4**	7	**Long2**

RxPDO2 Byte	Source no. Boolean value	RxPDO2 Byte	Source no. uint/int value	RxPDO2 Byte	Source no. long value
0	**710**	0	**714**	0	
1	**Boolean1**	1	**Word1**	1	**718**
2	**711**	2	**715**	2	
3	**Boolean2**	3	**Word2**	3	**Long1**
4	**712**	4	**716**	4	
5	**Boolean3**	5	**Word3**	5	**719**
6	**713**	6	**717**	6	
7	**Boolean4**	7	**Word4**	7	**Long2**

RxPDO3 Byte	Source no. Boolean value	RxPDO3 Byte	Source no. uint/int value	RxPDO3 Byte	Source no. long value
0	**720**	0	**724**	0	
1	**Boolean1**	1	**Word1**	1	**728**
2	**721**	2	**725**	2	
3	**Boolean2**	3	**Word2**	3	**Long1**
4	**722**	4	**726**	4	
5	**Boolean3**	5	**Word3**	5	**729**
6	**723**	6	**727**	6	
7	**Boolean4**	7	**Word4**	7	**Long2**

With this method, there are up to three possibilities for a meaning of the contents of the individual bytes. Each byte may only be used for one possibility.

Depending on the selected data information the percentages values are displayed via the uint/int inputs.

Examples of virtual links

Example 1:

Frequency inverter 1				Frequency inverter 2		
Source no.	**Input link**	**TxPDO1 Byte**		**RxPDO1 Byte**	**Source No.**	**Target**
Control word	950	0		0	704	Control input,

740		1	→	1		Control word **99**
		2		2		
		3		3		
Output reference frequency channel **62**	955	4		4	709	Ramp input, Line set value **137**
		5	→	5		
		6		6		
		7		7		

Parameter **950** = Source-No. 740
Parameter **99** = Source-No. 704
Parameter **955** = Source-No. 62
Parameter **137** = Source-No. 709

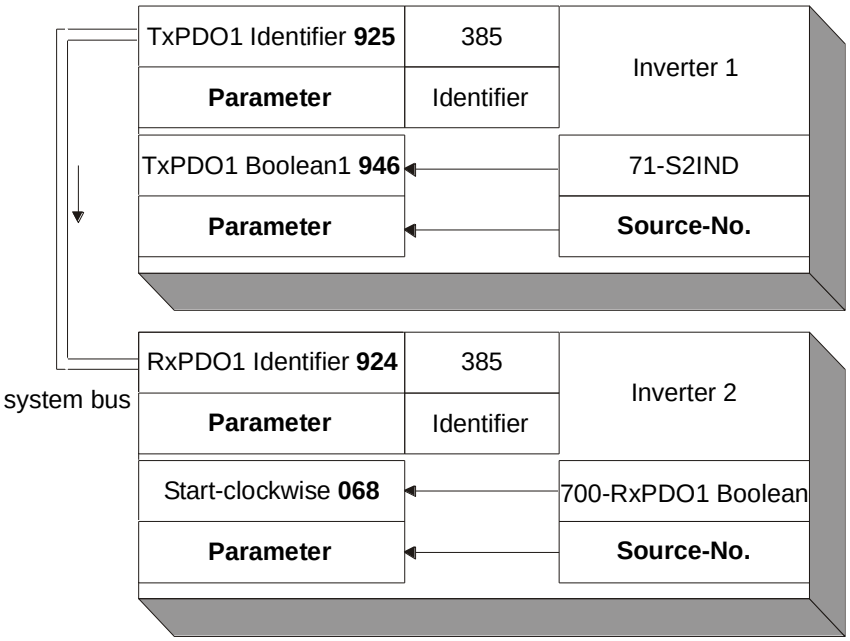
The control word of frequency inverter 1 is linked with the control word of frequency inverter 2. In this way, both frequency inverters can be operated synchronously via the remote control. The output of the reference value channel of frequency inverter 1 is laid onto the output of the ramp of frequency inverter 2. In this way, both frequency inverters have a joint source of reference values and are given reference values in the internal notation.

As an extension, a number of frequency inverters can also exist on the receive side (Rx), these then being supplied with data parallel and simultaneously.

The input link not used in the TxPDO1 of frequency inverter 1 is on ZERO and is thus not served.

Example 2:

Example of a virtual link with transmission via the system bus:



8.9 Diagnosis parameters

For the monitoring of the system bus and the display of the internal states, two control parameters are provided. There is a report of the system bus state and a report of the CAN state via two actual value parameters.

The *Node State* **978** parameter gives information about the Pre-Operational, Operational, Stopped state. A PDO transfer is only possible in the Operational state. The state is controlled by the system bus master (PLC / PC / frequency inverter) via NMT telegrams.

The *CAN-State* **979** parameter gives information about the state of the physical layer. If there are transmission errors, the state changes from OKAY to WARNING until the cancellation of the communication with BUS-OFF. After BUS-OFF, the CAN controller is automatically re-initialized and the system bus started again.

If the BUS-OFF state occurs, the frequency inverter breaks down with "F2210 BUS-OFF".

After Bus-OFF, the system bus in the frequency inverter is completely reinitialized. There is a new boot-up message from the subscriber and an emergency telegram with the Bus-OFF message is transmitted. The change of state of the subscriber to Operational is done by the Start-Remote-Node telegram cyclically sent by the system bus master.

Actual values of the system bus		
No.	**Description**	**Display**
978	Node state	1 - Pre-Operational 2 - Operational 3 - Stopped
979	CAN state	1 - OKAY 2 - WARNING 3 - BUS-OFF

8.10 OS Synchronization

The operating system (OS) of the frequency inverter can be synchronized with a PLC or other device. Synchronization of the operating system will improve the operating characteristics of the machine. Synchronization is used to eliminate CPU **phase** shifting between master and slave devices to make sure that calculations are carried out at the same time. Note, that only small deviations of the CPU clock frequencies between devices (i.e. different CPU Quartz cock frequencies) of ± 1 ‰ can be compensated.

OS_SyncSource **1452**	
Operation mode	**Function**
0 - Auto	The synchronization source is selected automatically by the frequency inverter. **Factory setting.**
2 - Systembus	The OS is synchronized via Systembus.
99 - Off	The OS is not synchronized with other devices.

Auto mode: Selection is done based on the decision table:

Fieldbus active	Systembus active	Synchronization
Yes	Yes	Synchronisation via Fieldbus
Yes	No	
No	Yes	Synchronization via Systembus
No	No	No Synchronization activated.

Status "Synchronization via CANopen active" is identified via parameter setting **387** *CAN Node Number* >1 and a running synchronous PDO.

Status "Synchronization via system bus active" is identified via parameter setting **900** *System bus node ID* >1. In addition, parameter **1180** *Synchronization* must be set to SYNC or RxPDO.

1453 *OS SyncSource Act* shows the active Synchronization source

The parameter **1451** *OS Synctime* can be used to shift the point of the synchronization inside of 1 ms. When you experience noises from a motor, shifting the CANopen *OS Synctime* can result in a better behavior.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
1451	OS Synctime	700 us	900 us	800 us

8.10.1 Synchronization via Systembus

The source of the operating system (OS) synchronization is set via **1180** *Operation mode*. This defines the Sync event (RxPDO or SYNC telegram), which will be used for synchronization of PDOs:

930 *TxPDO1 Function*
936 *RxPDO1 Function*
932 *TxPDO2 Function*
937 *RxPDO2 Function*
934 *TxPDO3 Function*
938 *RxPDO3 Function*

Synchronization *Operation mode* 1180		
Operation mode		**Function**
0 -	Off	Synchronization via system bus is deactivated. **Factory setting.**
1 -	RxPDO1	Synchronization via system bus is activated via RxPDO1.
2 -	RxPDO2	Synchronization via system bus is activated via RxPDO2.
3 -	RxPDO3	Synchronization via system bus is activated via RxPDO3.
10 -	SYNC	Synchronization via system bus is activated via SYNC.

8.10.2 Settings for electronic gear in configuration x40

If the function "electronic gear" of the positioning in ANG (configuration x40) is used in a slave, synchronization via SYNC or RxPDO1 must be set via system bus. Please check the following settings:

Use of RxPDO A Master Identifier must correspond to the Slave Identifier.	
Master	**Slave**
925 *TxPDO1 Identifier* **926** *TxPDO2 Identifier* **927** *TxPDO3 Identifier*	**924** *RxPDO1 Identifier*

930 *TxPDO1 Function* **932** *TxPDO2 Function* **934** *TxPDO3 Function*	**936** *RxPDO1 Function* = 1 – controlled by SYNC (recommended)
	1180 *Operation mode* = 1- RxPDO

Use of SYNC The Master Sync Identifier must correspond to the Slave Sync Identifier (e.g. 0 → Predefined Set 0x80 = 128).	
Master	**Slave**
	936 *RxPDO1 Function* = 1 – controlled by SYNC (recommended)
918 *Sync Identifier* **919** *Sync Time*	**918** *Sync Identifier* **1180** *Operation mode*= 10-SYNC

Operation mode **1180** ensures synchronization of the operating systems of different devices and must be set up in configuration x40 in one of the two ways described.

RxPDO1 Function **936** should be set to "1 – controlled by SYNC" in order to synchronize the master position with the OS in the slave. Although this setting is optional, BONFIGLIOLI VECTRON recommends setting this parameter accordingly.

8.10.3 Scope sources

For the Vplus Scope function, the following sources are available for diagnosis:

Operation mode		Function
731 -	B: Sync. OS <→ Sysbus Ok	1 = Synchronization OS to system bus OK, 0 = Synchronization OS to system bus not OK
852-	SysBus SYNC time [us]	Represents the synchronization time cycles. Should show the set SYNC time or TxPDO of the transmitting master.
853	SysBus SYNC position 1ms Task [us]	Represents the synchronization time within 1 ms. Should be constant with minor deviations.
854-	B: Sync. OS <→ CANopen Ok	1 = Synchronization OS to CANopen OK, 0 = Synchronization OS to CANopen not OK
848-	SYNC time [us]	Represents the synchronization time cycles. Should show the SYNC time of object 0x1006.
849-	CANopen SYNC position 1ms Task [us]	Represents the synchronization time within 1 ms. Should be constant with minor deviations.

For more information on VPlus, see chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**.

8.11 SDO Error code table

If an error occurs in reading or writing, the server SDO of the frequency inverter replies with the SDO abort message.

Error codes			
Abort code high	**Abort code low**	**Description as per CANopen®**	**Product-specific allocation**
0x0601	0x0000	Unsupported access to an object	Parameter cannot be written or read
0x0602	0x0000	Object does not exist	Parameter does not exist
0x0604	0x0047	General internal incompatibility in the device	Data sets differ

Error codes			
Abort code high	**Abort code low**	**Description as per CANopen®**	**Product-specific allocation**
0x0606	0x0000	Access failed due to a hardware error	EEPROM Error (Read/write/checksum)
0x0607	0x0010	Data type does not match	Parameter has a different data type
0x0607	0x0012	Data type does not match or length of Service telegram too big	Parameter has a different data type or telegram length not correct.
0x0607	0x0013	Data type does not match or length of Service telegram too small	Parameter has a different data type or telegram length not correct.
0x0609	0x0011	Subindex does not exist	Data set does not exist
0x0609	0x0030	Value range of parameter exceeded	Parameter value too large or too small
0x0609	0x0031	Value of parameter written too high.	Parameter value too large
0x0609	0x0032	Value of parameter written too low.	Parameter value too small
0x0800	0x0020	Data cannot be transmitted or saved	Invalid value for operation
0x0800	0x0021	Data cannot be transferred because of local control	Parameter cannot be written in operation
0x0800	0x0022	No data transfer because of present device state	NMT state machine is not in correct state

8.12 Resetting errors

Depending on the settings and operating state of the device, errors can be reset in various ways:

– When using control via parameter *Local/Remote* **412** = `1-Statemachine`:

- Set bit 7 in 0x6040 Control word = `0x0080`.
- By pressing the stop button of the control panel.

– Resetting by pressing the STOP button is only possible if Parameter *Local/Remote* **412** permits control via the control panel.

– via parameter *Error Acknowledgement* **103** which is assigned a logic signal or a digital input

– A reset via a digital signal can only be carried out when parameter *Local/Remote* **412** permits this or when an input with the addition (hardware) is selected in the case of physical inputs.

Some errors will occur again after an error reset. In such cases, it may be necessary to take certain measures (e.g. moving from a limit switch in the non-disabled direction).

8.13 Ancillaries

For the planning of the system bus according to the drive tasks in question, there are ancillaries in the form of tables.

The planning of the system bus is done in three steps:

- 1. Definition of the communication relationships
- 2. Production of the virtual links
- 3. Capacity planning of the system bus

The priority assignment of the identifiers is relevant for the definition of the communication relationships. Data that are to be transmitted with a higher priority must be given low identifiers. This results in the message with the higher priority being transmitted first with a simultaneous access of two subscribers to the bus.

The recommended identifier range for the communication relationships via the PDO channels is 385 ...

The identifiers below 385 are used for the NMT telegrams (boot-up sequence, SYNC telegram) and emergency message.

The identifiers above 1407 are used for the SDO channel for parameterization.

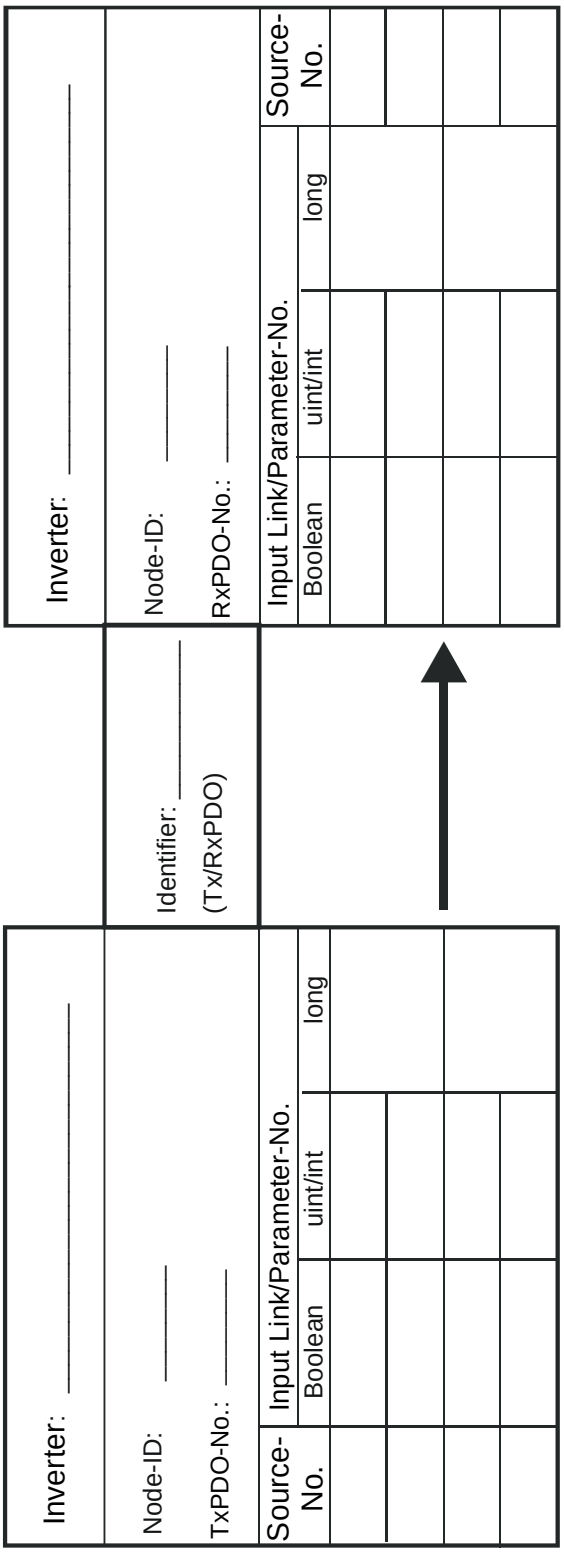
8.13.1 Definition of the communication relationships

The communication relationships are planned and documented with the help of the table. The table is available as a Microsoft Word document "kbl.doc" upon request.

Inverter: ______		Inverter: ______		Inverter: ______		Inverter: ______		Inverter: ______	
Node-ID: ______		Node-ID: ______		Node-ID: ______		Node-ID: ______		Node-ID: ______	
PDO	Identifier	PDO	Identifier	PDO	Identifier	PDO	Identifier	PDO	Identifier
TxPDO1		TxPDO1		TxPDO1		TxPDO1		TxPDO1	
RxPDO1		RxPDO1		RxPDO1		RxPDO1		RxPDO1	
TxPDO2		TxPDO2		TxPDO2		TxPDO2		TxPDO2	
RxPDO2		RxPDO2		RxPDO2		RxPDO2		RxPDO2	
TxPDO3		TxPDO3		TxPDO3		TxPDO3		TxPDO3	
RxPDO3		RxPDO3		RxPDO3		RxPDO3		RxPDO3	

8.13.2 Production of the virtual links

The virtual links are planned and documented with the help of the table. The table is available as a Microsoft Word document "vvk.doc" upon request.



8.13.3 Capacity planning of the system bus

Each PDO telegram possesses a constant useful data content of 8 Bytes. According to worst case, this results in a maximum telegram length of 140 bits. The maximum telegram run time of the PDOs is thus stipulated via the set baud rate.

Capacity planning	
Baud rate kBaud	**Telegram runtime µs**
1000	140
500	280
250	560
125	1120
100	1400
50	2800

As a function of the set baud rate and the transmission interval of the TxPDOs selected, the following bus loads results:

Capacity of the system bus										
Baud rate / kBaud	**Bus load as a function of the transmission for one TxPDO in %**									
	1ms	**2ms**	**3ms**	**4ms**	**5ms**	**6ms**	**7ms**	**8ms**	**9ms**	**10ms**
1.000	14	7	4,7	3,5	2,8	2,3	2	1,8	1,6	1,4
500	28	14	9,3	7	5,6	4,7	4	3,5	3,1	2,8
250	56	28	18,7	14	11,2	9,3	8	7	6,2	5,6
125	112	56	37,3	28	22,4	18,7	16	14	12,4	11,2
100	140	70	46,7	35	28	23,3	20	17,5	15,6	14
50	280	140	93,3	70	56	46,7	40	35	31,1	28

NOTICE

A bus load >100% means that a telegram cannot be dispatched completely between two transmission times.

Such a setting is not admissible!

This observation must be done for each TxPDO. The sum of all the TxPDOs decides on the entire bus load. The bus load must be designed in such a way that any telegram repetitions for transmission errors are possible without exceeding the bus capacity.

To facilitate capacity planning, a Microsoft Excel file with the name "Load_Systembus.xls" is available.

The capacity planning are planned and documented with the help of the table. The work sheet is available as a Microsoft Excel document "Load_Systembus.xls" on request.

Load system bus

Baud rate [kBaud]: 50, 100, 125, 250, 500, 1000	1000

Frequency inverter	TxPDO Number	Ta [ms]	Workload [%]
1	1	0	0
	2	0	0
	3	0	0
2	1	0	0
	2	0	0
	3	0	0
3	1	0	0
	2	0	0
	3	0	0
4	1	0	0
	2	0	0
	3	0	0
5	1	0	0
	2	0	0
	3	0	0
6	1	0	0
	2	0	0
	3	0	0
7	1	0	0
	2	0	0
	3	0	0
8	1	1	14
	2	1	14
	3	1	14
9	1	1	14
	2	1	14
	3	0	0
10	1	0	0
	2	0	0
	3	0	0
Total workload [%]			70

≤ 80 % ➔ OKAY
80 ... 90 % ➔ CRITICAL
> 90 % ➔ NOT POSSIBLE

9 Setting process data

Depending on the application used, different process data objects with various lengths and contents are required for data exchange. The PROFINET module enables a wide range of settings. Using a hardware configurator, the user can design the process data objects required for the relevant application.

Two types of process data objects are available:

The required objects must be created during the hardware configuration of the PROFINET IO controller. On the frequency inverter side it is not possible to set up the required object. The frequency inverter adjusts itself to the created object automatically.

Process data objects		
Object	**Object length / bytes**	**Object length / words**
PKW	8	4
PZD	4	2

For more information on the contents of the objects, refer to Chapter "Managing objects".

The PKW object is used for read and write access to frequency inverter parameters. The object will produce additional bus load because it will send its contents with each data exchange cycle, no matter if it is actually needed or not. As an alternative to the PKW object, the PROFINET module supports read and write access to data sets.

The function is described in Chapter "Parameter access through reading/writing of data sets".

Each PZD object contains two Word data type input and output objects. For information on how to handle this object, refer to Chapter "Data types of OUT/IN objects".

9.1 Configuration using ProfiNET-IO controller

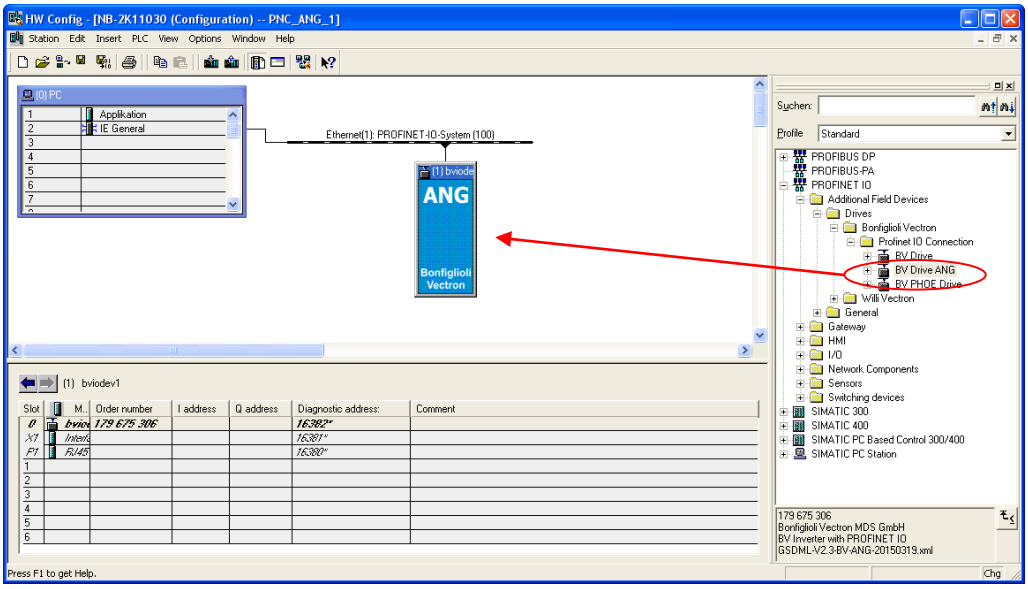
The following chapter describes the configuration procedure of a frequency inverter with the PROFINET communication module EM-AUT using the example of the Siemens STEP7 hardware configurator. Generally, the procedure is the same for other configurations.

First, the device description file is installed in the hardware configurator (if not done already). This is done in the menu `Options\Install GSD file`. Here, enter the path and name of the GSD file.

Once the GSD file is installed, the frequency inverter will appear on level:

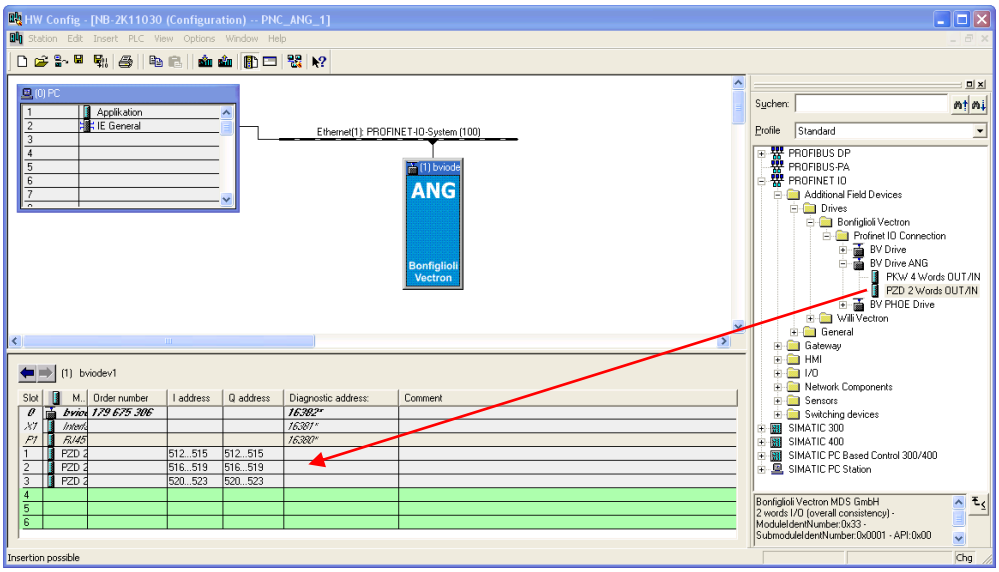
`PROFINET IO\` **Additional Field Devices** `\Drives\Bonfiglioli Vectron\ PROFINET IO Connection`

From this position, a frequency inverter **BV Drive ANG** can be connected to the PROFINET system (drag & drop).



The two possible objects PKW and PZD are available in the `BV Drive ANG` menu. The required object can be assigned to the frequency inverter (drag & drop).

The screen shot of the STEP7 hardware configurator shows a frequency inverter configured with 3 PZD objects connected to the PROFINET IO system.



The data flow direction IN/input and OUT/output is given from the PLC's point of view.

Each configured PZD object comprises two word objects (4 bytes) PZDn and PZDn+1, one for input and one for output.

Restrictions for user-defined configuration settings:

- The PKW object is allowed only once at slot 1.
- At least one PZD object must be configured.
- The total number of bytes must be less than or equal to 24 bytes (12 words).

If the restrictions are not observed, a configuration error is signaled by the controller (PLC) upon PROFINET startup.

9.2 Available objects

The configured data exchange objects generally have two components which are available either fully, partly or not at all in the different object configurations. These components are the communication channel and the process channel.

The **communication channel** (PKW object) is used for access (write/read) to any parameters in the frequency inverter. The string parameters to which no access is possible form an exception. The communication follows a defined handshake procedure and includes several cyclic data exchange cycles.

The **process data channel** (PZD object) is processed in each cycle. Reference values are taken over and actual values are handed over. Thus, the data is updated with each cyclic data exchange.

Transmission direction IO controller ➔ IO device (OUT)

Communication channel				**Process data channel**					
PKW range				PZD range					
PKE	**IND**	**PWE**	**PWE**	**PZD 1**	**PZD 2**	**PZD x**	**PZD x**	**PZD x**	**PZD x**
		PWEh	PWEl	STW	HSW	Outx	Outx	Outx	Outx

PKW Parameter ID Value

PZD Process data channel STW = Control word HSW = Main reference value

Outx = User defined

Transmission direction IO device ➔ IO controller (IN)

Communication channel				**Process data channel**					
PKW range				PZD range					
PKE	**IND**	**PWE**	**PWE**	**PZD 1**	**PZD 2**	**PZD x**	**PZD x**	**PZD x**	**PZD x**
		PWEh	PWEl	ZSW	HIW	Inx	Inx	Inx	Inx

PKW Parameter ID Value

PZD Process data channel ZSW = Status word HIW = Main actual value

Inx = User defined

Process data channel objects PZD1/PZD2 are fixed and cannot be edited. This definition also applies to user-defined configurations.

The contents of process data channels PZD3 through PZD12 (maximum, without communication channel PKW) are user-defined.

In the data transmission, it is assumed that the **Motorola format** is used as supported by a PLC type Siemens S7.

10 Managing objects

10.1 Parameter access via communication channel PKW

The communication channel (PKW range) has the following structure:

Designation	PKW range							
	PKE		IND		PWE-high		PWE-low	
Contents	Parameter ID		Index		Parameter value high word		Parameter value low word	
	High Byte	Low Byte	High Byte	Low Byte	High Byte	Low Byte	High Byte	Low Byte
			Data set	System-bus				
Byte no.	0	1	2	3	4	5	6	7

The data is transmitted in the Motorola format as used by the S7 PLC from Siemens, for example. Thus, the high byte is on the lower byte of the message, and the low byte is on the higher byte.

The data set is always on the high byte of "Index" (data set/byte no. 2). If system bus is used, a system bus address is set on the low byte of "Index" (Systembus/byte no. 3). With this parameter, access to a Systembus client is possible. See Systembus instructions.

Structure of parameter ID (PKE):

PKE	High byte								Low byte							
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	AK				0	PNU										

AK: Order / response ID (value range 0 … 15)

PNU: Parameter number (value range 1 … 1599)

The order and response IDs are stored in the AK range. If no parameter processing is to be performed, the function type "`No Order`" must be selected.

The PNU range transmits the number of the parameter to be edited.

Parameter values (= data) of type Integer/Unsigned Integer (16 Bit) and Long (32 Bit) can be written and read. The data type is specified in the order ID. In the case of data set switchable parameters (array), the required data set is given under the index byte (byte 2).

An Excel file containing the required information about the parameters as regards the data type and data set switchability can be made available upon request.

10.1.1 Order ID

Structure of order ID AK (in output data set, Master ➔ Slave)		
Order ID AK	**Data type**	**Function**
0	-	**no order**
1	int/uint , long	read parameter value
2	int/uint	write int/uint parameter value
3	long	write long parameter value
6	int/uint , long array	read array parameter value
7	int/uint array	write int/uint array parameter value
8	long array	write long array parameter value

Array: Applies to data set switchable parameters. In Data set/INDEX, you will have to specify the required data set, otherwise Data set/INDEX = 0.

10.1.2 Response ID

Structure of response ID AK (in input data set, Slave➔ Master)		
Response ID	**Data type**	**Function**
0	-	**no order**
1	int/uint	transmit int/uint parameter value
2	long	transmit long parameter value
4	int/uint array	transmit int/uint array parameter value
5	long array	transmit long array parameter value
7	-	Order cannot be executed
8	-	no control rights for PKW interface

If the order ID = 7 (order not executable), an error message is shown in PWE-low (byte 6/7).

If response code = 8 (no control rights), the master is not entitled to write to the slave.

10.1.3 Error message

Encoding of error messages in response data set PWE-Low/Low-Byte in byte 7 (Slave ➔ Master):

Error no. (decimal) according to PROFIDRIVE	Meaning
0	non-permissible parameter number PNU
1	Parameter value cannot be edited
2	lower or upper parameter value limit exceeded
3	faulty data set
4	no data set switchable parameter
5	wrong data type
18	other error
20	system bus does not respond

Extension	Meaning
101	Parameter cannot be read:
103	Error when reading EEPROM
104	Error when writing EEPROM
105	EEPROM checksum error occurred
106	Parameter must not be written in operation
107	Values of data sets are different
108	Unknown order

Error number "20" may have different causes.

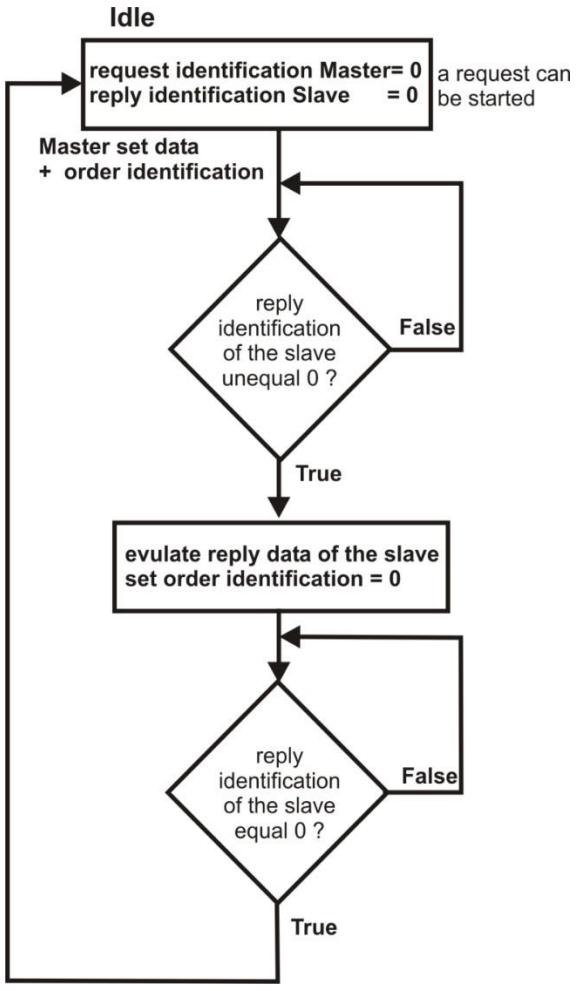
- If you do not use System Bus: Check if the low byte is "0" (zero). With values greater than zero, an attempt is made to address a System Bus client instead of the PROFINET client.
- If you use System Bus (e.g. via an EM-SYS module), the addressed device is not responding. Check if the addressed device is connected to power supply and the System Bus node addresses in the index low byte and in the parameter settings of the device to be addressed correspond to one another.

10.1.4 Communication procedure

An order from the master will **always** be answered by a slave response. Each parameter request or response can only accept one order/response at a time. For this reason, a defined handshake procedure must be followed between the master and slave.

In the initial situation, the order **and** response ID must be = 0. The master sets its order ID and waits until the slave changes the response ID from 0 to ≠ 0. Now, the slave's response is available and can be evaluated. Then, the master sets its order ID = 0 and waits until the slave changes the response ID from ≠ 0 to 0. This completes the communication cycle and a new cycle can start.

The slave will only respond to new orders once it has reacted to order ID = 0 with response ID = 0.



10.1.5 Parameters, data set selection and cyclic writing

For the parameters to be set, refer to the Operating Instructions according to the chosen configuration. The parameter list specifies if a parameter is switchable (Data set/INDEX = 1 through 4) or is available once only (Data set/INDEX = 0).

The parameter list also provides information about the display format of a parameter and its type (int/uint/long). String parameters cannot be transmitted due to the possible number of bytes.

The transmitted values are always integer numbers. In the case of decimal values, the decimal point is not transmitted.

The IND word hands over the required data set of the parameter. In the present application, the existing parameters are assigned data set number 0; to enable switching among multiple parameters (switchable), a number from 1 through 4 is assigned.

The actual parameter value is transmitted in the PWE range; as 16-bit value (int/uint), it occupies PWEl, as 32-bit value (long) PWE-high and PWE-low, with the high-word being in PWE-high.

If parameters are set to data set = 0, each of the four data sets is set to the same value. A read access with data set = 0 to such parameters is only successful if all four data sets are set to the same value. Otherwise, an error message will be displayed.

NOTICE

Risk of component damage!

If a maximum number of write cycles for the EEPROM is exceeded, it will be destroyed.

The values are entered automatically in the EEPROM of the controller. However, only a limited number of write cycles is permissible for the EEPROM (approx. 1 million cycles).

- If cyclic writing of data is required, use the RAM.

In the RAM, the data is not protected against loss of power. Once power supply is disrupted, the data must be written again.

- To activate this procedure increase the target data set is by five while specifying the data set (IND).

Enter in RAM only	
EEPROM	**RAM**
Entry in data set = 0	Data set (IND)= 5:
Entry in data set = 1	Data set (IND)= 6:
Entry in data set = 2	Data set (IND)= 7:
Entry in data set = 3	Data set (IND)= 8:
Entry in data set = 4	Data set (IND)= 9:

When writing to data set switchable parameters, note:

Via data set (IND) = 0, data set switchable parameters can be set to the same value in all data sets.

Communication examples

Parameters					Settings		
No.	**Description**	**Type**	**Write/ read**	**Format**	**Min.**	**Max.**	**Factory settings**
400	Switching frequency	P-W	S/L	x	1	8	2
480	Fixed frequency 1	P[I]-D	S/L	xxxx.xx Hz	-599.00	599.00	5.00

Example 1

Parameter 400 is a type int word (P-W), is not data set switchable and is to be read.

Order from master:

AK = 1 (order code = read parameter value)

PNU = 400 (= 0x190)

IND = 0

PWEh = 0

PWEl = 0

PKW range								
Designation	**PKE**		**IND**		**PWE-high**		**PWE-low**	
Contents	**Parameter ID**		**Index**		**Parameter value high word**		**Parameter value low word**	
	High Byte	Low Byte	High Byte	Low Byte	High Byte	Low Byte	High Byte	Low Byte
	0x11	0x90	0	0	0	0	0	0
Byte no.	0	1	2	3	4	5	6	7

Response from slave:

AK = 1 (response code = transmit int/uint parameter value)

PNU = 400 (= 0x190)

IND = 0

PWEh = 0

PWEl = value

PKW range								
Designation	**PKE**		**IND**		**PWE-high**		**PWE-low**	
Contents	**Parameter ID**		**Index**		**Parameter value high word**		**Parameter value low word**	
	High Byte	Low Byte	High Byte	Low Byte	High Byte	Low Byte	High Byte	Low Byte
	0x11	0x90	0	0	0	0	0	Value
Byte no.	0	1	2	3	4	5	6	7

Example 2

Parameter 480 is a type long double word (P[I]-D), is data set switchable and is to be written. The target data set is Data set 3.

Reference value = -300.00 Hz (-30000 is transmitted)

According to integer arithmetic, the negative value is represented as follows: 0xFFFF8AD0

Order from master:

AK = 8 (order code = write long array parameter value)

PNU = 480 (= 0x1E0)

IND = 3

PWEh = 0xFFFF

PWEl = 0x8AD0

PKW range								
Designation	**PKE**		**IND**		**PWE-high**		**PWE-low**	
Contents	**Parameter ID**		**Index**		**Parameter value high word**		**Parameter value low word**	
	High Byte	Low Byte	High Byte	Low Byte	High Byte	Low Byte	High Byte	Low Byte
	0x81	0xE0	3	0	0xFF	0xFF	0x8A	0xD0
Byte no.	0	1	2	3	4	5	6	7

Response from slave:

AK = 5 (order code = transmit long array parameter value)

PNU = 480 (= 0x1E0)

IND = 3

PWEh = 0xFFFF

PWEl = 0x8AD0

PKW range								
Designation	**PKE**		**IND**		**PWE-high**		**PWE-low**	
Contents	**Parameter code**		**Index**		**Parameter value high word**		**Parameter value low word**	
	High Byte	Low Byte	High Byte	Low Byte	High Byte	Low Byte	High Byte	Low Byte
	0x51	0xE0	3	0	0xFF	0xFF	0x8A	0xD0
Byte no.	0	1	2	3	4	5	6	7

10.1.6 Handling of index parameters / cyclic writing

Index parameters are used for various ANG functions. Here, 16 or 32 indexes are used instead of the 4 data sets. For each function, the individual indexes are addressed separately via an index access parameter. Via the indexing parameter, you can select if the data is to be written to EEPROM or RAM.

Function	Parameters	Index range		Indexing parameter
		EEPROM write/read	Write RAM	
Positioning	**1202** *Target position / distance* **1203** *Speed* **1204** *Acceleration* **1205** *Ramp Rise time* **1206** *Deceleration* **1207** *Ramp Fall time* **1208** *Motion mode* **1209** *Touch-Probe Window* **1210** *Touch-Probe-Error: Next Motion Block* **1211** *No. of Repetitions* **1212** *Delay* **1213** *Delay: Next Motion Block* **1214** *Event 1* **1215** *Event 1: Next Motion Block* **1216** *Event 2* **1217** *Event 2: Next motion block* **1218** *Digital signal 1* **1219** *Digital signal 2* **1247** *Digital signal 3* **1248** *Digital signal 4* **1260** *Interrupt-Event 1* **1261** *Int.-Event 1: Eval.-Mode* **1262** *Int. event 1: Next motion block* **1263** *Interrupt-Event 2* **1264** *Int.-Event 2: Eval.-Mode* **1265** *Int. event 2: Next motion block*	0[1)]; 1…32	33[1)]; 34…65	**1200** Write **1201** Read
PLC function (Function Table)	**1343** *FT-Instruction* **1344** *FT-Input 1* **1345** *FT-Input 2* **1346** *FT-Input 3* **1347** *FT-Input 4* **1348** *FT-Parameter 1* **1349** *FT-Parameter 2* **1350** *FT-Target Output 1* **1351** *FT-Target Output 2* **1352** *FT-Commentary*	0[1)]; 1…32	33[1)]; 34…65	**1341** Write **1342** Read
Multiplexer	**1252** *Mux Input*	0[1)]; 1…16	17[1)]; 18…33	**1250** Write **1251** Read
CANopen multiplexer	**1422** *CANopen Mux Input*	0[1)]; 1…16	17[1)]; 18…33	**1420** Write **1421** Read

1) When the indexing parameter = 0, all indexes will be written upon parameter access in EEPROM. 17 (for 16 indexes) or 33 (for 32 indexes) will write all indexes in RAM.

NOTICE

Risk of component damage!

If a maximum number of write cycles for the EEPROM is exceeded, it will be destroyed.

The values are entered automatically in the EEPROM of the controller. However, only a limited number of write cycles is permissible for the EEPROM (approx. 1 million cycles).

- If cyclic writing of data is required, use the RAM.

In the RAM, the data is not protected against loss of power. Once power supply is disrupted, the data must be written again.

- To activate this procedure increase the target data set is by five while specifying the data set (IND).

Enter in RAM only	
EEPROM	**RAM**
Entry in data set = 0	Data set (IND)= 5:
Entry in data set = 1	Data set (IND)= 6:
Entry in data set = 2	Data set (IND)= 7:
Entry in data set = 3	Data set (IND)= 8:
Entry in data set = 4	Data set (IND)= 9:

When writing to data set switchable parameters, note:

Via data set (IND) = 0, data set switchable parameters can be set to the same value in all data sets.

10.2 Parameter access through reading/writing of data sets

The EM-AUT module features the "PROFINET data set access" function. This feature can be used as an alternative to the PKW communication object in the data exchange object. The PKW object is always sent to the bus, regardless of whether it is currently being used or not. Thus, it produces unnecessary bus load.

Data set access messages for parameter access are special PROFINET messages which are sent only if a parameter is required. Unlike with the PKW objects, data access messages can access all parameter types, including string type parameters.

The S7 PLC uses two special functions, SFC58 WR_REC and SFC59 RD_REC, for data set access. Addressing is based on the diagnosis address of the device to be accessed (Slot 0 / Sub-slot 1 / Index). "Index" addresses the accessed parameters using the following code:

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	0	Data set				Parameter number										

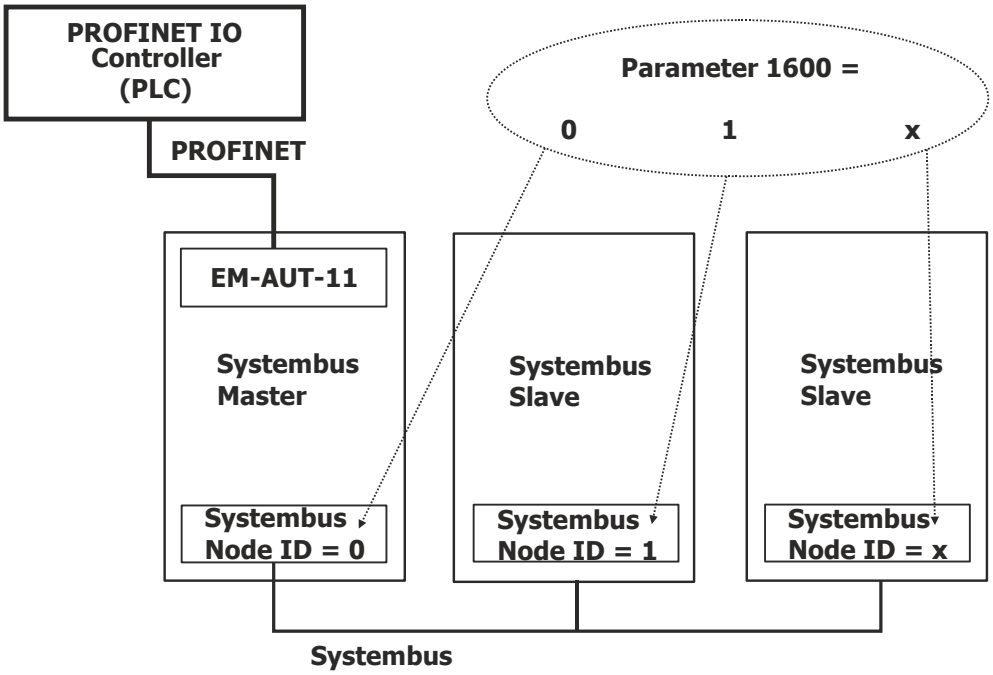
Permissible index range = 0 ... 0x7FFF

Data types and byte arrangement

Byte	0	1	2	3	4	5	...	....	max. 98
Data type	uint/int								

Contents	high byte	low byte							
Data type	long								
Contents	high byte	low byte							
Data type	string								
Contents	first char.								

uint/int = 2 bytes
long = 4 bytes
string = 1 ... 99 bytes



ACUx10-TD-EM-AUT11_Profibus-V00

In order to access the parameters of the individual frequency inverters through System Bus, Parameter **1600** is set to the ID of the relevant System bus node.

The data type of **P.1600** is an unsigned integer, value range `0…63`.

Parameter **1600** can be read and written.

10.3 Process data channel

This chapter describes how to manage the PZD objects. For a description of the required process data objects PZD1/2, refer to Chapters "Control via contacts/remote contacts", "Control via state machine" and "Reference value/actual value".

Objects PZD 3 … 12 can be used application-specifically. In the frequency inverter, these objects are represented as sources for `PZD Out` objects (data received from PROFINET controller) and as input parameters for sources (data to be sent to the master).

10.3.1 Data types of OUT/IN objects

10.3.1.1 Data type "Boolean"

Permissible values of "Boolean" are FALSE/0x0000 and TRUE/0xFFFF.

Data type – Boolean		
	Boolean value	**Data contents Hexadecimal**
OUT/IN-PZDn Boolean	FALSE	0x0000
OUT/IN-PZDn Boolean	TRUE	0xFFFF

n = 3 … 12

10.3.1.2 Data type "Word"

The "Word" data type can be used for percentage, current and torque variables. Current and torque variables are possible in applications with field-oriented control. The standardization is described below.

10.3.1.3 Word data type "Percentage"

The range for percentage values is `-300.00% … +300.00%`. The values in OUT/IN-PZDn are shown with a factor of 100.

Word data type – Percentage			
	Data contents Hexadecimal	**Data contents Decimal**	**Logical interpretation**
OUT/IN-PZDn word	0x8AD0	- 30000	- 300.00%
OUT/IN-PZDn word	0x0000	0	0.00%
OUT/IN-PZDn word	0x7530	+ 30000	+ 300.00%

n = 3 … 12

10.3.1.4 Word data type "Current"

A device-internal standardization conversion is performed for the current data type.

The standardization calculation is done as follows:

$$Reference\ value\ = \left(\frac{Reference\ current\ [A]}{Standard\ current\ [A]}\right) \cdot\ 2^{13}$$

2^{13} = 8192 (decimal) = 0x2000 (hexadecimal)

10.3.1.5 Word data type "Torque"

A device-internal standardization conversion is performed for the torque data type. The standardization of a reference torque corresponds to that of a reference current (see "Word data type: Current"). If the machine is operated with a rated flux value, a reference torque corresponds to a reference current.

The specified equation for reference current and reference torque applies to operation with the rated flux value. This must be considered when a machine is operated in the field weakening range.

The device-internal standard must be considered when current or torque variables are used.

10.3.1.6 Data type "Long"

The "Long" data type can be used for frequency and position variables.

Frequencies use the internal representation of the frequency inverter (xxx Hz / 4000 Hz) * 2^{31}.

Examples:

50.00 Hz → (50.00 / 4000.00) * 2^{31} = 0x01999999

-80.00 Hz → (-80.00 / 4000.00) * 2^{31} = 0xFD70A3D8

The position information depends on the settings of the Motion Control Systems (see "Positioning" application manual).

Data type – Long			
	Data contents Hexadecimal	**Data contents Decimal**	**Logic reproduction**
OUT/IN-PZDx/y Long	0xnnnnmmmm	Application specific	Application specific

x/y = 3/4, 5/6, … 11/12

10.3.2 PROFINET output sources (OUT-PZD x)

In the table below, the available output sources of the PZD-Out objects are listed. The content of the sources depends on the application. For the different data types, the relevant sources must be linked to the input parameters of the frequency inverter.

Availability of output sources depends on the number of configured PZD objects.

Each configured PZD object comprises either two Boolean, two Word or one Long output object(s).

A PZD output object can only be used for one data type (depending on the requirements of the application).

The first PZD object configured (obligatory) represents PZD1/2 with fixed contents and functions.

Number of configured PZD objects	**Boolean sources**		**Word sources**		**Long sources**	
	Identification	**Source no.**	**Identification**	**Source no.**	**Identification**	**Source no.**
2	Out-PZD3 Boolean	640	Out-PZD3 Word	656	Out-PZD3/4 Long	672
	Out-PZD4 Boolean	641	Out-PZD4 Word	657		
3	Out-PZD5 Boolean	642	Out-PZD5 Word	658	Out-PZD5/6 Long	673
	Out-PZD6 Boolean	643	Out-PZD6 Word	659		
4	Out-PZD7 Boolean	644	Out-PZD7 Word	660	Out-PZD7/8 Long	674
	Out-PZD8 Boolean	645	Out-PZD8 Word	661		
5	Out-PZD9 Boolean	646	Out-PZD9 Word	662	Out-PZD9/10 Long	675
	Out-PZD10 Boolean	647	Out-PZD10 Word	663		
6	Out-PZD11 Boolean	648	Out-PZD11 Word	664	Out-PZD11/12 Long	676
	Out-PZD12 Boolean	649	Out-PZD12 Word	665		

Each source can be linked to an input parameter of the frequency inverter of the same data type. The method is the same as the method used for the System Bus receive objects.

- Boolean sources represent Boolean objects.
- Word sources represent percentage, current or torque objects.
- Long sources represent frequency or position objects.

The sources are typically linked to the sources using the linking function of the Motion Control interface. For an example, refer to Chapter "Motion Control Mapping for PROFINET".

10.3.3 PROFINET input parameters (IN-PZD x)

In the table below, the available input parameters of the PZD In objects are listed. The content of the sources depends on the application. For the different data types, the relevant input parameters must be linked to the sources of the frequency inverter.

Availability of input sources depends on the number of configured PZD objects.

Each configured PZD object comprises either two Boolean, two Word or one Long input parameter(s).

A PZD input object can only be used for one data type (depending on the requirements of the application).

The first PZD object configured (obligatory) represents PZD1/2 with fixed contents and functions.

Number of configured PZD objects	Boolean parameter		Word parameter		Long parameter	
	Identification	Parameter no.	Identification	Parameter no.	Identification	Parameter no.
2	In-PZD 3 Boolean	1300	In-PZD 3 Word	1302	In-PZD 3/4 Long	1304
	In-PZD 4 Boolean	1301	In-PZD 4 Word	1303		
3	In-PZD 5 Boolean	1305	In-PZD 5 Word	1307	In-PZD 5/6 Long	1309
	In-PZD 6 Boolean	1306	In-PZD 6 Word	1308		
4	In-PZD 7 Boolean	1310	In-PZD 7 Word	1312	In-PZD 7/8 Long	1314
	In-PZD 8 Boolean	1311	In-PZD 8 Word	1313		
5	In-PZD 9 Boolean	1315	In-PZD 9 Word	1317	In-PZD 9/10 Long	1319
	In-PZD 10 Boolean	1316	In-PZD 10 Word	1318		
6	In-PZD 11 Boolean	1320	In-PZD 11 Word	1322	In-PZD 11/12 Long	1324
	In-PZD 12 Boolean	1321	In-PZD 12 Word	1323		

By default, the input parameters are set to `Off` or `Zero`, except Parameters **1302**, **1303**, **1307** and **1308**.

The default settings of input parameters **1302**, **1303**, **1307** and **1308** is compatible with the PDP (Profibus Distributed Periphery) module:

In-PZD 3 Word **1302** = 770 PDP Effective Current

In-PZD 4 Word **1303** = 771 PDP Active Current

In-PZD 5 Word **1307** = 772 Warning Status

In-PZD 6 Word **1308** = 773 Error Status

When an object is set to a certain source number, it must be ensured that the relevant objects have the preset values at the same place. This method is the same as is the one used in the case of objects for Systembus transmission (transmit objects).

- Boolean inputs represent Boolean objects.
- Word inputs represent percentage, current or torque objects.
- Long inputs represent frequency or position objects.

The displayed PDP active current depends on the type of control. In the case of field-oriented controls, the torque-forming current is displayed. In applications with U/f characteristic control, the active current also measured for the torque will be displayed.

The PDP effective current will always be positive. The torque-forming current and the active current are signed.

- A positive current sign corresponds to motor operation mode.
- A negative current sign corresponds to generator operation mode.

10.3.3.1 Current standardization

Standardization			
Reference Value	**Binary**	**Decimal**	**Hexadecimal**
+ 100%	+ 2^{14}	16384	0x4000

Possible range = ±200% = +32768 to -32768 = 0x8000 through 0x7FFF

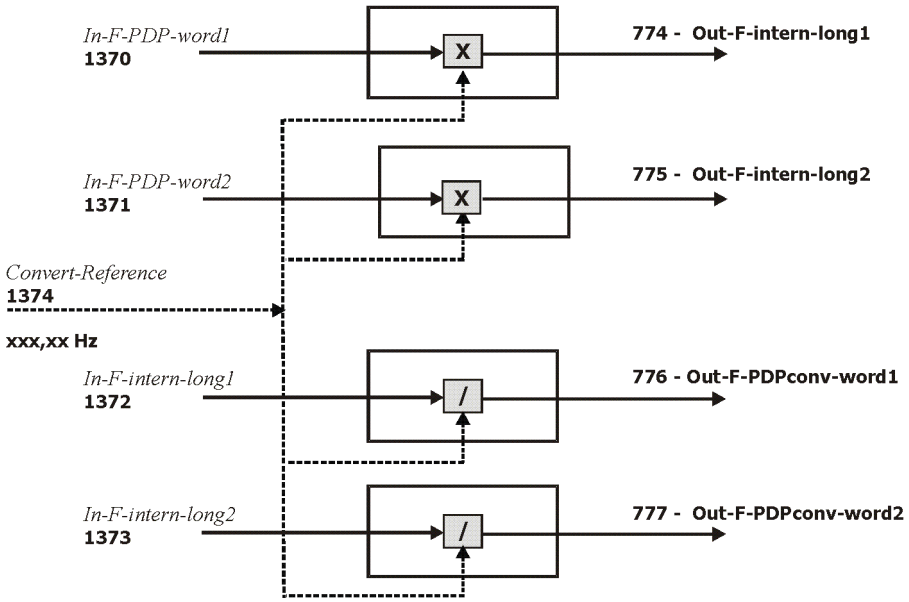
For internal standardization, the data set switchable parameter *Rated Current* **371** is used as the reference value.

Parameters		Settings		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
371	Rated current	0.01 · I_{FUN}	10 · I_{FUN}	I_{FUN}

10.4 Frequency conversion PDP-Word to internal representation

If the frequency inverter is equipped with a PROFINET module the Convert PDP/internal function will be available. It converts frequency values with Profibus representation to frequency values with device-internal representation and vice versa, see Chapter "Reference value/actual value".

Frequency conversion Profibus representation/ Internal representation



The standardization for In-F-PDP-word1/2 and Out-F-PDPconv-word1/2 is:

Standardization			
Reference Value	**Binary**	**Decimal**	**Hexadecimal**
+ 100%	+ 2^{14}	16384	0x4000
- 100%	- 2^{14}	49152	0xC000

Possible range = ±200% = +32768 to -32768 = 0x7FFF through 0x8000

The function uses its own reference value *Convert Reference* **1374** for data conversion. The advantage of this function is the fact that the "Word" data type is used for frequency values instead of the "Long" data type.

11 Motion Control Interface (MCI)

The Motion Control Interface (MCI) is a defined interface of the ANG device for positioning control via Field Bus. Typically, this interface is used by field bus systems such as PROFINET. With the Motion Control Interface, the user can carry out a positioning operation via a field bus using a positioning profile typically including the target position, speed, acceleration, deceleration, quick stop and mode-specific information.

The Motion Control Interface uses *S.Modes of Operation* **1292** for switching between the different modes. The supported modes as per CANopen® Standard DS402 are:

- 1 – Profile Position mode
- 2 – Velocity mode [rpm]
- 3 – Profile Velocity mode [u/s]
- 6 – Homing

Bonfiglioli Vectron specific mode

- -1 (or 0xFF) – Table Travel record mode
- -2 (or 0xFE) – Move Away from Limit Switch
- -3 (or 0xFD) – Electronic Gear: Slave (electronic gear as slave)

The current mode is shown via *IN-PZD 11 Word* **1322** = `742 - MCI: Modes of operation` (see chapter "Modes of operation display" for details).

The mode of operation can be switched in any operating state of the ANG.

It is recommended that a currently active movement be stopped by the PLC first, then to switch the mode of operation and restart in the new mode.

In order to use the Motion Control Interface, **412** *Local/Remote* = "`1 - Control via statemachine`" must be set. In configurations without Motion control (*Configuration* **30** ≠ x40), only velocity mode vl is available.

For a description of the positioning parameters, please refer to the "Positioning" application manual.

11.1 Object and parameter relationships

Depending on the selected mode of operation, various objects and parameters are used. The various objects and parameters must be set specifically for the different modes of operation.

Use of "Deceleration" and "Quick Stop" depends on the modes of operation, control commands and behavior in the case of communication errors (see *Bus Error Behaviour* **388**).

The following tables provide an overview of the different objects and parameters. The object / parameter mentioned first in a cell will typically be used. If an object is related to a parameter, the parameter will be specified.

Parameters **1292** *Modes of Operation* and following (**1293**, **1294**, **1295**, **1296** & **1297**) and **1285** *S.Target velocity pv [u/s]* are used for linking the internal functions to CANopen® objects. Usually, these need not to be changed when using CANopen®. For PROFINET, they will have to be changed. Please check chapter "Motion Control Mapping for PROFINET" for a setup proposal.

Mode	Homing	Velocity Mode	Profile Velocity Mode
Modes of Operation [1)2)]	6	2	3
Target position			
Speed	**1132** & **1133** *Fast speed / Creep speed*	**1297** *S.reference speed vl [rpm]*[2)]	**1285** *S.reference speed pv [u/s]*[2)]

Limitation[3)]	**418** *Minimum frequency* **419** *Maximum Frequency*	**418** *Minimum frequency* **419** *Maximum Frequency*	**418** *Minimum frequency* **419** *Maximum Frequency*
Acceleration	**1134** *Acceleration*	**420** *Acceleration (clockwise)* **422** *Acceleration anticlockwise*	**1295** *S.Acceleration* [2)]
Deceleration	**1134** *Acceleration*	**421** *Deceleration (clockwise)* **423** *Deceleration anticlockwise*	**1296** *S.Deceleration* [2)]
Emergency stop [4)] Quick Stop	**1179** *Emergency stop ramp*	**424** *Emergency stop clockwise* **425** *Emergency stop anticlockwise*	**1179** *Emergency stop ramp*
Homing Method	**1130** *Homing type*		

Mode	Profile Positioning mode
Modes of Operation [1)2)]	1
Target position	**1293** *S. target position* [2)]
Speed	**1294** *S. Pos.speed.* [2)]
Limitation [3)]	**418** *Minimum frequency* **419** *Maximum Frequency*
Acceleration	**1295** *S. Acceleration*[2)]
Deceleration	**1296** *S. Deceleration* [2)]
Emergency stop [4)] Quick Stop	**1179** *Emergency stop ramp*

1) The mode of operation is set via **1292** *S. Modes of Operation*.
Factory setting: `801 - Obj. 0x6060 modes of operation`.

2) Parameters **1285**, **1292**, **1293**, **1294**, **1295**, **1296** & **1297** are used for linking the CANopen® objects and internal functions. For CANopen®, they don't have to be changed. For PROFINET, refer to Chapter "Motion Control Mapping for PROFINET".

3) The limitation results from *Minimum frequency* **418** and *Maximum Frequency* **419**. Through *Limitation* **1118** of the position controller in Configuration x40, an increase above the Maximum Frequency can occur, because the output of the position controller is added to the Maximum Frequency.

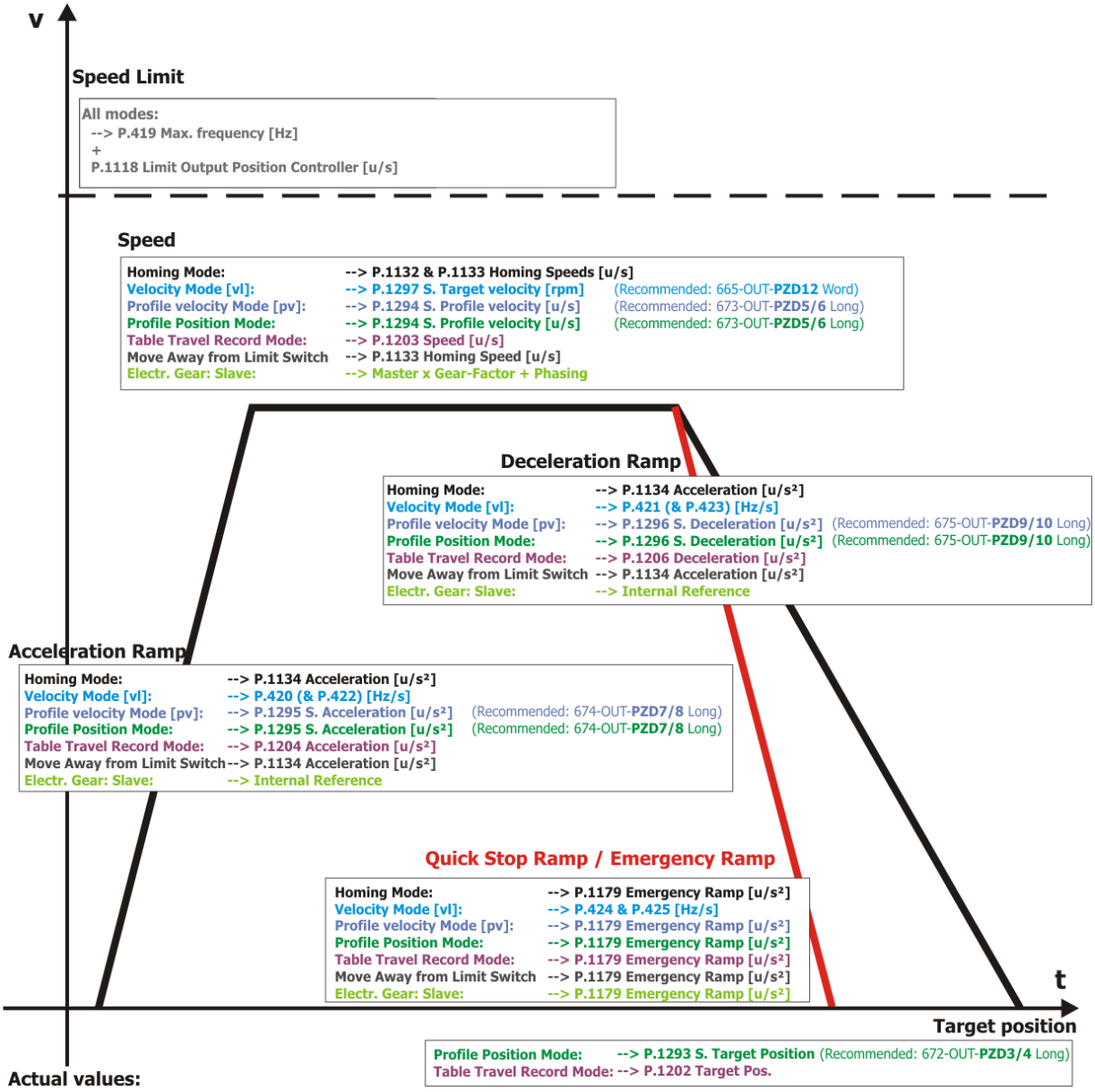
4) `Emergency stop` or `Deceleration` is used depending on the stopping behavior *Operation Mode* **630** or the behavior in the case of communication errors *Bus Error Behaviour* **388**.

Mode	Table travel record mode	Move away from limit switch	Electronic gear – Slave
Modes of Operation [1)2)]	**-1**	**-2**	**-3**
Target position	**1202** *Target position*		
Speed	**1203** *Speed*	**1132** *Fast speed* **1133** *Creep speed*	**1285** *S.reference speed pv [u/s]* [2)]
Limitation [3)]	**418** *Minimum frequency* **419** *Maximum Frequency*	**418** *Minimum frequency* **419** *Maximum Frequency*	**418** *Minimum frequency* **419** *Maximum Frequency*
Acceleration	**1204** *Acceleration*	**1134** *Acceleration*	**1295** *S.Acceleration* [2)]
Deceleration	**1205** *Deceleration*	**1134** *Acceleration*	**1296** *S.Deceleration* [2)]
Emergency stop [4)] Quick Stop	**1179** *Emergency stop ramp*	**1179** *Emergency stop ramp*	**1179** *Emergency stop ramp*
Motion block	Selected via control word		
Gear factor			**1123** *Gear factor Numerator* **1124** *Gear factor denominator*
Phasing [5)]			**1125** *Phasing: Offset* **1126** *Phasing: Speed* **1127** *Phasing: Acceleration*

1) The mode of operation is set via **1292** *S. Modes of Operation*.
Factory setting: `801 - Obj. 0x6060 modes of operation`.

2) Parameters **1285**, **1292**, **1293**, **1294**, **1295**, **1296** & **1297** are used for linking the CANopen® objects and internal functions. For CANopen®, they don't have to be changed. For PROFINET, refer to Chapter "Motion Control Mapping for PROFINET".
3) The limitation results from *Minimum frequency* **418** and *Maximum Frequency* **419**. Through *Limitation* **1118** of the position controller in Configuration x40, an increase above the Maximum Frequency can occur, because the output of the position controller is added to the Maximum Frequency.
4) `Emergency stop` or `Deceleration` is used depending on the stopping behavior *Operation Mode* **630** or the behavior in the case of communication errors *Bus Error Behaviour* **388**.

Relationships between objects, parameters and conversions



Velocity [vl] → Velocity mode [rpm]
Velocity [pv] → Profile Velocity mode [u/s]

The graphical overview shows the most important objects which are used. Other objects are available in the different modes; for additional information, refer to the descriptions of the objects and modes.

The Motion Control Interface is a defined interface of the ANG devices for position control. This interface is typically used in combination with a field bus such as PROFINET.

11.2 Functions of the Motion Control Interface (MCI)

Via the Motion Control Interface, various positioning functions can be addressed directly by a PLC.

11.2.1 Reference system

In many modes, the Motion Control Interface uses user units [u]. These user units [u] result from the conversion of the gear factor parameters **1115**, **1116**, **1117** and *No. of pole pairs* **373**.

Conversion between "user units" [u] and frequencies [Hz]

$$f\,[\mathrm{Hz}] = v\left[\frac{u}{s}\right] \cdot \frac{\textit{No.of pole pairs}\ \mathbf{373} \cdot \textit{Gear Box : Driving shaft revolutions}\ \mathbf{1116}}{\textit{Feed Constant}\ \mathbf{1115}\ \frac{[u]}{U} \cdot \textit{Gear Box : Motor shaft revolutions}\ \mathbf{1117}}$$

$$v\left[\frac{u}{s}\right] = f\,[\mathrm{Hz}] \cdot \frac{\textit{Feed Constant}\ \mathbf{1115}\ \frac{[u]}{U} \cdot \textit{Gear Box : Motor shaft revolutions}\ \mathbf{1117}}{\textit{No.of pole pairs}\ \mathbf{373} \cdot \textit{Gear Box : Driving shaft revolutions}\ \mathbf{1116} \cdot}$$

Feed constant **1115**	≙ 0x6092/1 feed
Gear Box: Driving Shaft Revolutions **1116**	≙ 0x6091/1 motor shaft revolutions
Gear Box: Motor Shaft Revolutions **1117**	≙ 0x6091/2 driving shaft revolutions

The same formulas can be used for converting acceleration values from a[Hz/s] to a[u/s²] and vice versa.

- To do that, in the formulas, replace speeds f[Hz] and v[u/s] by accelerations a[Hz/s] and a[u/s²].

11.2.2 Homing

When the drive is started, a defined starting position must be specified for absolute positioning modes. In a homing operation, the point of reference of the positioning operation is determined. All positioning data relates to this point of reference. Once the homing operation is started, the drive moves until it reaches a home switch or limit switch and stops there. The limit switches limit the motion path. The direction of movement (search direction) at the start of the homing operation is defined by the homing mode. Additionally, the reaching of a limit switch will change the direction of the drive (dependent on the homing mode). The limit switches can also be used as the point of reference. You can find a description of homing operations in Chapter "Homing modes".

Relative positioning and velocity operations are possible without homing.

Homing can be started:

- via a digital input
- by a control word via system bus or field bus (Expansion module with system bus or field bus interface required)
- automatically before the start of a motion block positioning operation

When using an Absolute Encoder a Homing after power on is not necessary. This is defined by parameter *Operation Mode* **1220**.

Start position after homing

After homing:

P.1185 = -1 → Drive remains in "coast to stop" position

P.1185 ≠ -1 → Drive is moved actively to set position.

Flying homing

The Flying homing can be used to update the reference position during a running motion. This function is described in the application manual "Positioning".

11.2.3 Modes of operation

In *Modes of operation*, you can define the operation mode of the frequency inverter.

The available options depend on the frequency inverter configuration.

Modes of operation must be assigned to an OUT-PZD via parameter *S.Modes of Operation* **1292**. The mode of operation is switched via the assigned OUT-PZD.

Available values for *Modes of operation* in frequency inverter configurations with Motion control (Parameter *Configuration* **30** = x40):

Modes of operation		
1	–	Profile position mode
2	–	Velocity mode [rpm]**(factory setting)**
3	–	Profile velocity mode [u/s]
6	–	Homing mode
-1	–	Table travel record mode (manufacturer-specific mode of operation)
-2	–	Move away from limit switch (manufacturer-specific mode of operation)
-3	–	Electronic Gear: Slave (manufacturer-specific mode of operation)

Available values for *Modes of operation* in frequency inverter configurations without Motion control ((Parameter *Configuration* **30** ≠ x40):

Modes of operation		
2	–	Velocity mode [rpm]

In configurations without Motion Control, any settings other than value `2` will be ignored by the frequency inverter.

11.2.4 Modes of operation display

Modes of operation display confirms the configured mode of operation by displaying the value of *Modes of operation*.

Modes of operation must be assigned to an IN-PZD.

Example: *IN-PZD 11 Word* **1322** = `742 - MCI: Modes of operation`

After setting *Modes of operation*, the PLC will have to wait for this confirmation before another command can be transmitted to the frequency inverter.

11.2.5 Current position and contouring errors

Parameter *Act. position value* **1108** returns the actual position in user units.

Using an IN-PZD, the actual position can be transmitted to the PLC cyclically.

Example: *IN-PZD 3/4 Long* **1304** = `743 - Act. position value` [user units]

The parameter *Act. contouring error* **1109** returns the actual contouring error.
Using an IN-PZD, the actual contouring error can be transmitted to the PLC cyclically.

Example: *IN-PZD 3/4 Long* **1304** = `747 - Act. contouring error` [user units]

The contouring error can be monitored internally in order to trigger a device error once a threshold is reached. For details on parameters *Fault reaction* **1120**, *Warning threshold* **1105**, *Error threshold* **1106** and *Contouring error time* **1119**, refer to the "Positioning" application manual.

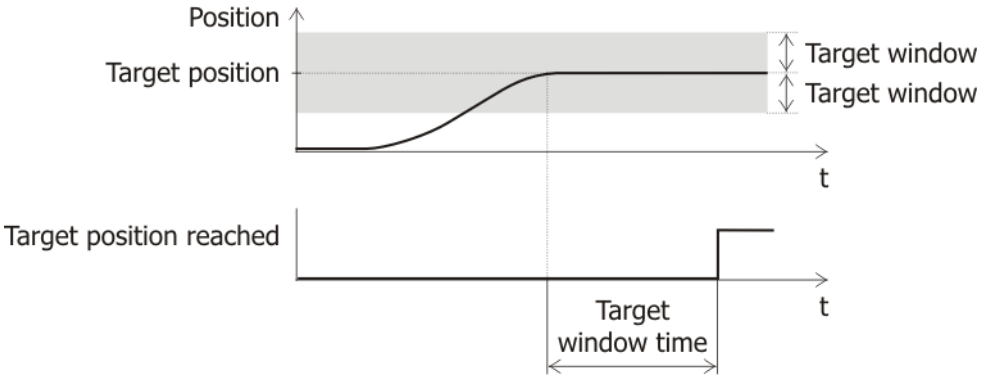
11.2.6 Target window

The target window monitors the current position after completion of a positioning operation. A positioning operation is complete as soon as the current position is in the target window. Via parameter *Target Window* **1165**, you can define at which distance from the target position the signal "`Target Reached`" is set. This setting is valid both for the positive and negative direction.

If the parameter value is set to `0`, the operation will be complete as soon as the Position reference value reaches the target position. For the Position reference value an internal value is used, that is calculated anew depending on the profile data for each internal cycle step.

Via parameter *Target Window Time* **1166**, you can define how long the axis must be in the target window before "`Target Reached`" is signaled.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
1165	Target Window	0 u	2^{20} u	182 u
1166	Target Window Time	1 ms	65 535 ms	1 ms



The size of the target window affects the automatic sequence of motion blocks because the positioning operation requires a higher precision in the case of a small target window (small tolerance). The following motion block is started when the target window is reached.

11.2.7 Position Controller

The position controller evaluates the positioning operation (target/actual position) and tries to control the drive such that it comes as close as possible to the specifications. For this purpose, an additional frequency is calculated for compensation of position deviations. By setting the corresponding parameter, this frequency can be limited. The parameter settings of the position controller determine how quick and to what extent position deviations are to be compensated.

Via Time Constant **1104**, you can define the maximum time in which the position deviation is to be compensated.

Via parameter *Limitation* **1118**, you can define to which value the speed is limited for compensation of the position deviation.

Parameters		Settings		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
1104	Time constant	0.00 ms	300.00 ms	10.00 ms [1)] 100.00 ms [2)]
1118	Limit	0 u/s	2^{31}-1 u/s	327 680 u/s

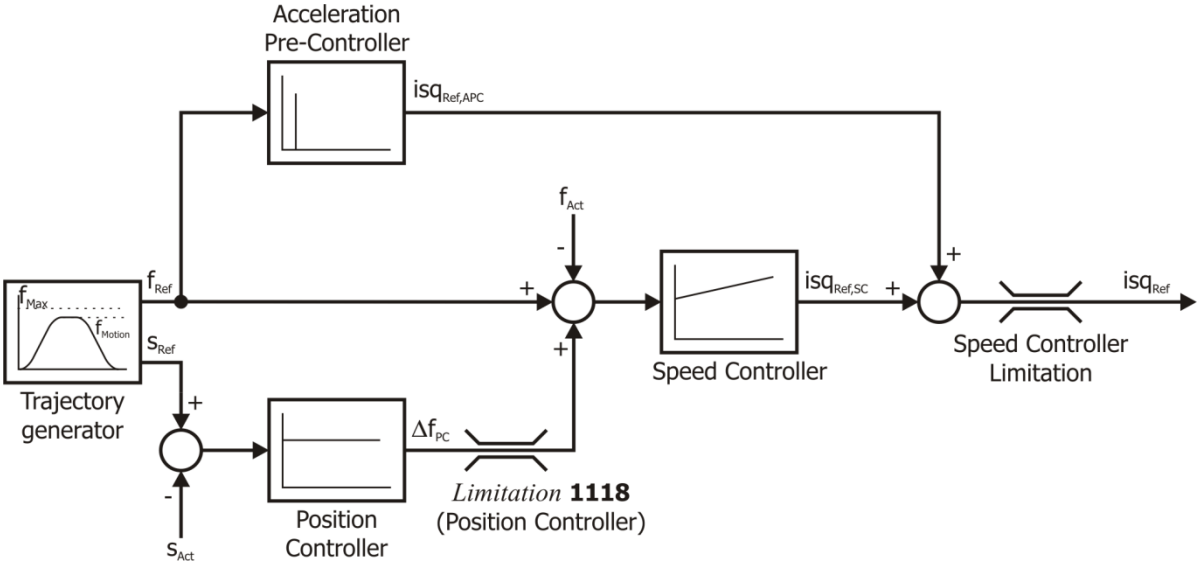
[1)] Factory parameter setting *Configuration* **30** = 240 or 540

[2)] Factory parameter setting *Configuration* **30** = 440

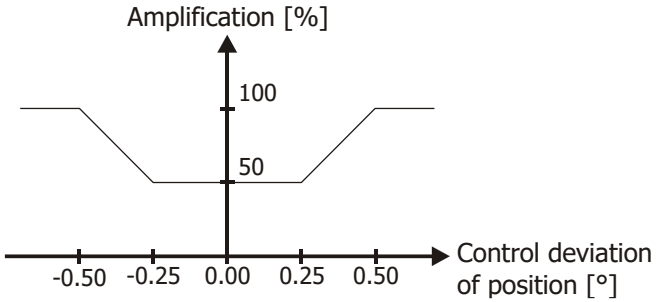
Example:

Position deviates by 1 motor shaft revolution, time constant is set to 1 ms. The position controller will increase the motor frequency by 1000 Hz in order to compensate the position deviation. Parameter *Limitation* **1118** must be set sufficiently.

Controller block diagram



In order to avoid oscillations of the drive while it is at standstill, amplification is reduced to 50 % of the parameterized value for small position deviations.



The following behavior may indicate that the controller parameters are not configured properly:

- drive is very loud
- drive vibrates
- frequent contouring errors
- inexact control

For the setting options of other control parameters, e.g. speed controller and acceleration pre-controller, refer to the operating instructions of the frequency inverter.

Optimize the settings in actual operating conditions, as control parameters for speed controller and acceleration pre-controller depend on the actual load. Optimize with different types of load to obtain good control behavior in all situations.

11.2.8 Profile position mode

Target position:

The target position [u] is evaluated in positioning mode and must be set via a PZD object.

Example: *S. Target position* **1293** = `672 – OUT-PZD3/4 Long`.

Positioning speed:

The positioning speed [u/s] for positioning mode is typically set via a PZD object.

Example: *S. Positioning speed* **1294** = `674 – OUT-PZD5/6 Long`.

If *S. Positioning speed* **1294** is set to "9-Zero", the value from *Fixed speed 1* **1170** is used.

Acceleration:

The acceleration [u/s²] for positioning mode is typically set via a PZD object.

Example: *S. Acceleration* **1295** = `675 – OUT-PZD7/8 Long`.

If *S. Acceleration* **1295** is set to "9-Zero, the value from *Acceleration* **1175** is used.

Deceleration:

The deceleration [u/s²] for positioning mode is typically set via a PZD object.

Example: *S. Deceleration* **1296** = `676 – OUT-PZD9/10 Long`.

If *S. Deceleration* **1296** is set to "9-Zero", the value from *Deceleration* **1177** is used.

Ramp times - acceleration and deceleration:

The ramp times of the acceleration and deceleration ramps [ms] in positioning mode are set via parameters *Ramp Rise Time* **1176** and *Ramp Fall Time* **1178**.

Emergency stop ramp:

The emergency stop ramp [u/s²] for positioning mode is set via parameter *Emergency ramp* **1179** .

11.2.9 Velocity mode vl

Speed:

The reference speed vl is evaluated in velocity mode vl and must be set via a PZD object.

Example: *S. Target Velocity vl [rpm]* **1297** = `665 – OUT-PZD12 Word`.

Acceleration:

The acceleration [Hz/s] for velocity mode vl is set via parameters *Acceleration (clockwise)* **420** and *Acceleration anticlockwise* **422** .

Deceleration:

The deceleration [Hz/s] for velocity mode vl is set via parameters *Deceleration (clockwise)* **421** and *Deceleration anticlockwise* **423** .

Ramp times - acceleration and deceleration:

The ramp times for the acceleration and deceleration ramps [ms] are set, for velocity mode vl, via parameters *Ramp rise time clockwise* **430**, *Ramp fall time clockwise* **431**, *Ramp rise time anticlockwise* **432** and *Ramp fall time anticlockwise* **433** .

Emergency stop ramp:
The emergency stop ramp [Hz/s] for velocity mode vl is set via parameters *Emergency stop clockwise* **424** and *Emergency stop clockwise* **425** .

11.2.10 Profile velocity mode pv

Speed:
The reference speed vl is evaluated in velocity mode vl and must be set via a PZD object.
Example: *S.Reference speed pv [u/s]* **1285** = `665 – OUT-PZD12 Word`.

Acceleration:
The acceleration [Hz/s] for velocity mode vl is set via parameter *S. Acceleration* **1295**.

Deceleration:
The deceleration [Hz/s] for velocity mode vl is set via parameter *S.Deceleration* **1296.**

Ramp times - acceleration and deceleration:
The ramp times of the acceleration and deceleration ramps [ms] in positioning mode are set via parameters *Ramp Rise time* **1176** and *Ramp Fall time* **1178**.

Emergency stop ramp:
The emergency stop ramp [u/s²] for positioning mode is set via parameter *Emergency ramp* **1179**.

11.2.11 Homing mode

The homing mode is set via parameter *Homing mode* **1130**. For a description of the homing modes, refer to Chapter "Homing modes".

Home offset:
Via parameter *Home offset* **1131**, you can define a home offset.

Speed:
The speeds during homing are set via parameters *Fast speed* **1132** and *Creep speed* **1133**.

Acceleration and Deceleration:
The acceleration and deceleration during homing are set via parameter *Acceleration* **1134**.

Ramp times - acceleration and deceleration:
The ramp times of the acceleration and deceleration ramps for homing are set via parameter *Ramp Rise time* **1135**.

Start position after homing:
After homing:

P.1185 = `-1` → Drive remains in "coast to stop" position

P.1185 ≠ `-1` → Drive is moved actively to set position.

Flying Homing:
The Flying homing can be used to update the reference position during a running motion. This function is described in the application manual "Positioning".

11.2.12 Table travel record mode

Motion block:
The motion blocks are controlled via control word PZD1:

- Select start motion block with bits `11…15`
- Select sequence mode with bit `4`
- Start motion block with bit `9`

- Continue motion block with bit 6.

For details on the functions of the motion blocks in table travel record mode, refer to the "Positioning" application manual.

11.3 Move away from Hardware limit switches

When a hardware limit switch is triggered, an error message will be triggered depending on the settings of parameter *Fault reaction* **1143** and the relevant direction of rotation will be disabled.

After an error reset, it is possible to move in the direction that is still enabled. Generally, any mode of operation can be used for clearing, as long as the travel command has the enabled direction.

As long as the limit switch is triggered, the limit switch warning in the status word and actual value parameters *Warnings* **269**, *Warnings Application* **273** and *Controller status* **275** will remain. Once the limit switch is cleared, the warning will be deleted in the status word and actual value parameters.

For simple clearing of the limit switches, you can use mode "-2 Move away from limit switch" (see Chapter "Move away from limit switch mode").

11.4 Motion Control Mapping for PROFINET

With the Motion Control Interface, the user can edit the sources which the Motion Control Interface accesses. By default, the sources are set to CANopen®. In order to use PROFINET, they have to be changed. The following table shows recommended settings for transmission direction PLC→ANG.

Parameters		Settings		
No.	**Description**	**Min.**	**Max.**	**Recommended settings for PROFINET**
1292	S. Modes of Operation	Selection		664 – OUT-PZD11 Word
1293	S. Target position	Selection		672 – OUT-PZD3/4 Long
1294	S. Profile Velocity	Selection		673 – OUT-PZD5/6 Long
1295	S. Acceleration	Selection		674 – OUT-PZD7/8 Long
1296	S. Deceleration	Selection		675 – OUT-PZD9/10 Long
1297	S. Target Velocity vl [rpm]	Selection		665 – OUT-PZD12 Word
1299	S. Special Function Generator	Selection		9-Zero
1285	S. Target Velocity pv [u/s]	Selection		673 – OUT-PZD5/6 Long

1) If *S. Profile Velocity* **1294** is set to "9-Zero", the value from *Fixed speed 1* **1170** is used.

2) If *S.Acceleration* **1295** is set to "9-Zero", the value from *Acceleration* **1175** is used.

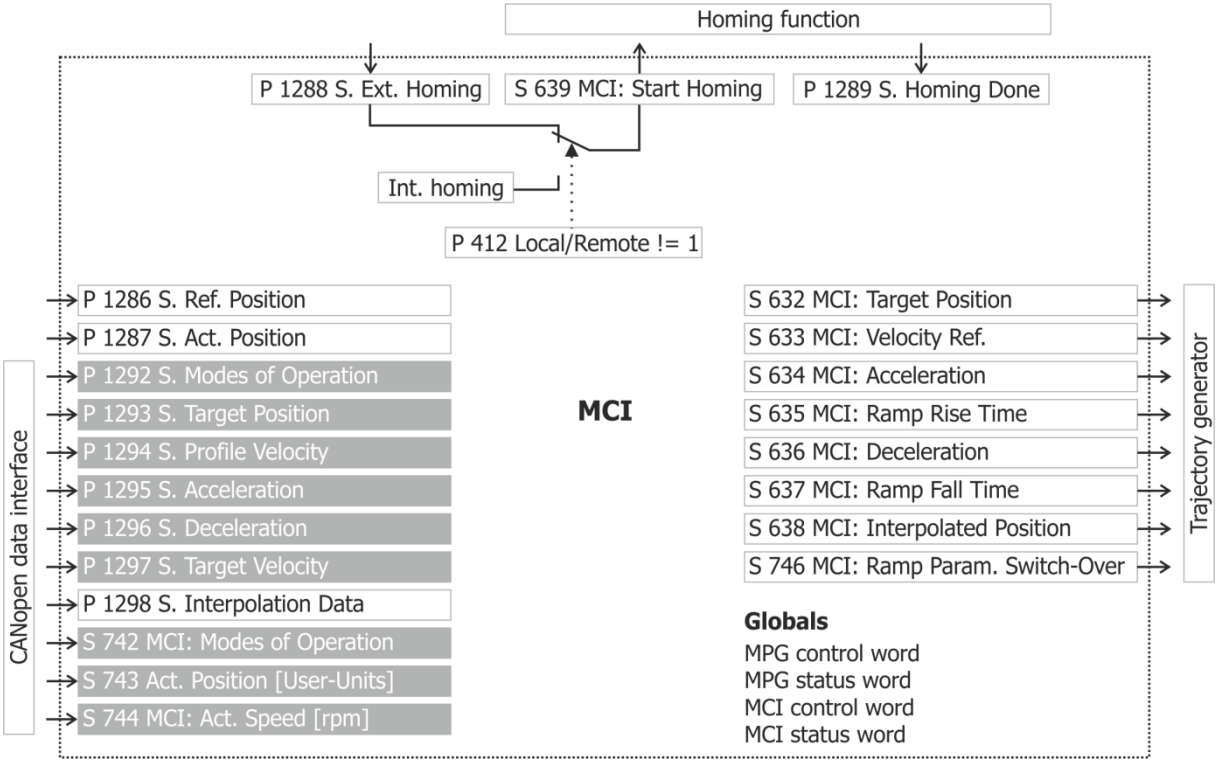
3) If *S.Deceleration* **1296** is set to "9-Zero", the value from *Deceleration* **1177** is used.

The following table shows recommended settings for transmission direction PLC←ANG.

Parameters		Recommended setting
1300	In-PZD 3 Boolean	= 7-Off
1301	In-PZD 4 Boolean	= 7-Off
1302	In-PZD 3 Word	= 9-Zero
1303	In-PZD 4 Word	= 9-Zero
1304	**In-PZD 3/4 Long**	**= 743 – Actual position value [user units]**
1305	In-PZD 5 Boolean	= 7-Off
1306	In-PZD 6 Boolean	= 7-Off
1307	**In-PZD 5 Word**	**= 927 – Output MUX**
1308	**In-PZD 6 Word**	**= 120 – Udc**
1309	In-PZD 5/6 Long	= 9 – Zero
1310	In-PZD 7 Boolean	= 7-Off
1311	In-PZD 8 Boolean	= 7-Off

1312	**In-PZD 7 Word**	**= 772 – Warning status**
1313	**In-PZD 8 Word**	**= 773 – Error status**
1314	In-PZD 7/8 Long	= 9 – Zero
1315	In-PZD 9 Boolean	= 7-Off
1316	In-PZD 10 Boolean	= 7-Off
1317	**In-PZD 9 Word**	**= 79 – Contact assignment word (hardware)**
1318	**In-PZD 10 Word**	**= 125 – Absolute current value**
1319	In-PZD 9/10 Long	= 9 – Zero
1320	In-PZD 11 Boolean	= 7-Off
1321	In-PZD 12 Boolean	= 7-Off
1322	**In-PZD 11 Word**	**= 742 – MCI: Modes of operation**
1323	**In-PZD 12 Word**	**= 744 – MCI: Speed [rpm]**
1324	In-PZD 11/12 Long	= 9 – Zero

The following graph shows the parameters (P) and sources (S) which are used for defining the Motion Control Interface.



11.5 Motion Control Override

The Motion Control Override feature can be used for specifying a travel profile via serial communication (VABus or Modbus). This enables testing of a travel profile in the VPlus user software for Windows when the controller has not yet been completely programmed. This function can also be used as a simulation mode.

The Function Motion Control Override does not support the following modes:

- Interpolated Mode
- Cyclic Synchronous Position Mode
- Cyclic Synchronous Velocity Mode

Parameters		Settings		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
1454	Override Modes Of Operation	Selection		0

1455	Override Target Position	-231-1…231-1 u	-1 u
1456	Override Profile Velocity	-1…231-1 u/s	-1 u/s
1457	Override Profile Acceleration	-1…231-1 u/s²	-1 u/s²
1458	Override Profile Deceleration	-1…231-1 u/s²	-1 u/s²
1459	Override Target Velocity vl [rpm]	-32768…32767 rpm	-1 rpm
1460	Override Target Velocity pv [u/s]	-231-1…231-1 u/s	-1 u/s

Based on the recommended settings of the Motion Control Interface (parameters **1292**…**1297**) as described in Chapter "Motion Control Mapping for PROFINET" the override parameters and PZD objects are used as follows:

1454 *Override Modes Of Operation*	**or**	PZD11 Modes of Operation
1455 *Override Target Position*	**or**	PZD3/4 Target Position
1456 *Override Profile Velocity*	**or**	PZD5/6 Profile Velocity
1457 *Override Profile Acceleration*	**or**	PZD7/8 Profile Acceleration
1458 *Override Profile Deceleration*	**or**	PZD9/10 Profile Deceleration
1459 *Override Target Velocity vl [rpm]*	**or**	PZD12 Target Velocity
1460 *Override Target Velocity pv [u/s]*	**or**	PZD5/6 Profile Velocity

With the default settings "-1" in parameters **1455**…**1460** and "0" in parameter **1454** *Override Modes Of Operation*, the values of the Motion Control from the links of parameters **1292**…**1297** are used. If the parameter settings deviate from the factory settings, the value of the relevant parameter will be used. It is possible to define certain ranges of the trajectory via the override function and other values via the Motion Control Interface.

The target position "`-1 u`" cannot be used as target position, because **1455** *Override Target Position* = `-1` deactivates the Override Function.

12 Control of frequency inverter

The master sends its control commands (control word) via the output object PZD1 to the frequency inverter and receives feedback about its status via a status word (status word).

The frequency inverter can generally be controlled via three operation modes. The operation modes can be selected via the data set switchable parameter *Local/Remote* **412**.

Parameters		Settings		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
412	Local/Remote	0	44	44

For operation with PROFINET, only operation modes 0, 1 and 2 are relevant. The other settings refer to the control option via the KP500 control unit.

Operation mode	Function
0 – Control via contacts (Chapter 9.1)	The Start and Stop commands as well as the direction of rotation are controlled via digital signals.
1 – Control via state machine (Chapters 9.2, 9.4)	The frequency inverter is controlled via the control word. **Only this setup supports positioning functions via the** control word **and** modes of operation**.**
2 – Control via remote contacts (Chapter 9.1)	The Start and Stop commands as well as the direction of rotation are controlled via virtual digital signals of the control word.

Parameter *Local/Remote* **412** is dataset switchable, i.e. you can switch between the different operation modes by selecting another data set. For example, a frequency inverter can be controlled via the bus, and emergency mode can be activated locally when the bus master fails. This switch-over is also identified by the status word (remote bit).

Data set switching can be effected locally via control contacts at the digital inputs of the frequency inverter or via the bus. For data set switching via the bus, parameter *Data set selection* **414** is used.

Parameters		Settings		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
414	Data set selection	0	5	0

With *Data set selection* **414** = 0, data set switching via contact inputs will be active. If *Data set selection* **414** is set to 1, 2, 3 or 4, the selected data set is activated and data set switching via the contact inputs is deactivated.

If *Data set selection* **414** is set to 5, data set switching via contact inputs will be active if the frequency inverter is not enabled.

Via parameter *Active data set* **249**, the currently selected data set can be read. *Active data set* **249** indicates the active data set (value 1, 2, 3 or 4). This is independent of whether the data set switching was done via contact inputs or *Data set selection* **414**.

12.1 Control via contacts/remote contacts

In PZD1, the master sends its control words, via the output data set, to the frequency inverter and receives information about the frequency inverter (status words) via the input data set.

In operation mode "Control via contacts" or "Control via remote contacts" (Parameter *Local/Remote* **412** = 0 or 2), the frequency inverter is controlled directly via digital inputs S1IND (STOA and STOB), S2IND through EM-S3IND or via the individual bits of the virtual digital

signals in the control word. The function of these inputs is described in the frequency inverter operating instructions.

Control word (Local/Remote 412 = 2)	
Bit	
0	S1IND (=STOA und STOB)
1	S2IND
2	S3IND
3	S4IND
4	S5IND
5	S6IND
6	MF1ID
7	MF4ID
8	REMOTE-1
9	REMOTE-2
10	MF3ID
11	MF2ID
12	
13	
14	
15	

Status word	
Bit	
0	Ready to switch on
1	Switched on
2	Operation enabled
3	Fault
4	Voltage enabled
5	Quick stop (Low active)
6	Switch on disabled
7	Warning
8	
9	Remote
10	Target reached
11	Internal limit active
12	
13	
14	
15	Warning 2

The digital inputs set via the control word can be monitored using parameter *Digital inputs* **250**. Digital input S1IND will only be displayed, if controller release is switched on at STOA and STOB **and** the control word (Bit 0) are set. If the data set switching function is used, please ensure that Parameter *Local/Remote* **412** is set to "`2 - Control via remote contacts`" in all data sets used.

If operation mode "Control via remote contacts" is used, controller release must be turned on at STOA (Terminal X210A.3) and STOB (Terminal X210B.2) **and** Bit 0 of the control word must be set in order to be able to start the drive.

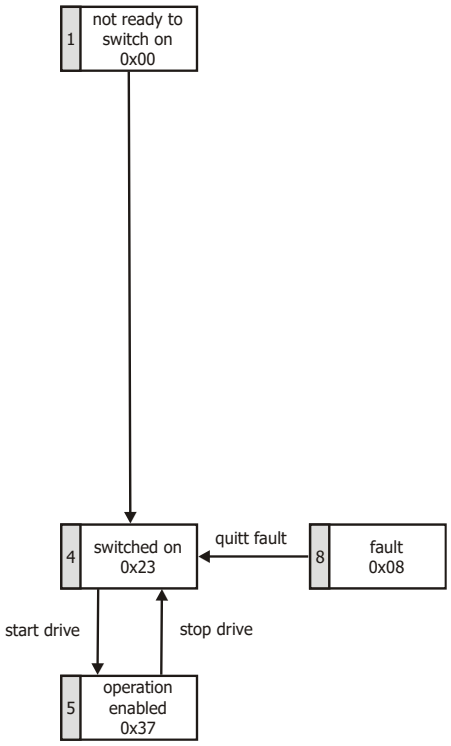
Operation modes "Control via contracts" and "Control via remote contacts" support operation mode "Speed vl" (*modes of operation* = "`velocity mode`").

ANG frequency inverters support an external 24 V power supply for the inverter control electronics. Even when mains voltage is disconnected, communication between the controller (PLC) and the frequency inverter is still possible.

Bit 4 "Voltage enabled" of the status word shows the current mains power supply status:

- Bit 4 "Voltage enabled" = `0` signals "No mains voltage", starting of drive not possible.
- Bit 4 "Voltage enabled" = `1` signals "Mains voltage on", drive ready for start.

Device state machine



Status word	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Switched on	1	0	0	0	1	1
Operation enabled	1	1	0	1	1	1
Fault	x	x	1	x	x	x

x means any value

Bit 7 "Warning" can display a device-internal warning message at any time. The current warning is evaluated by reading the warning status with parameter *Warnings* **270**.

Bit 10 "Target reached" is set when the specified reference value is reached. In the special case of power failure regulation, the bit is also set when the power failure regulation reaches the frequency 0 Hz (see frequency inverter Operating Instructions).

For "Target reached", there is a hysteresis (tolerance range) which can be set via the parameter *Max. control deviation* **549** see frequency inverter operating instructions).

Bit 11 "Internal limit value active" indicates that an internal limit is active. This may be the current limit, the torque limit or the overvoltage control. All functions will result in the reference value being left or not reached.

Bit 15 "Warning 2" signals a critical operating state which will result in a fault switch-off of the frequency inverter within a short time. This bit is set if there is a delayed warning relating to the motor temperature, heat sink/inside temperature, Ixt monitoring or mains phase failure.

12.2 Control via state machine

In the operation mode "Control via state machine (*Local/Remote* **412** = 1), the frequency inverter is controlled via the control word of the state machine.

Transition 4 to status "Operation enabled" is only possible:

- if, in a configuration for Motion Control (parameter *Configuration* **30** = x40), the controller release is set via STOA and STOB,
- if, in other configurations (parameter Configuration 30 ≠ x40) the controller release is set via STOA and STOB and if one of the digital inputs S2IND or S3IND is set. (Typically: S2IND = Start clockwise/S3IND = Start anticlockwise)

PZD1 / Parameter *Control word* **410** is applicable to the frequency inverter if parameter *Local/Remote* **412** is set to "1 – Control via state machine".

Control word 410	
Bit	
0	Switch on
1	Enable voltage
2	Quick stop (Low active)
3	Enable operation
4	Operation mode specific
5	Operation mode specific
6	Operation mode specific
7	Fault reset
8	Halt
9	Operation mode specific
10	
11	MF2ID
12	Manufacturer specific
13	Manufacturer specific
14	Manufacturer specific
15	Manufacturer specific

Status word 411	
Bit	
0	Ready to switch on
1	Switched on
2	Operation enabled
3	Fault
4	Voltage enabled
5	Quick stop (Low active)
6	Switch on disabled
7	Warning
8	Manufacturer specific
9	Remote
10	Target reached
11	Internal limit active
12	Operation mode specific
13	Operation mode specific
14	Manufacturer specific
15	Manufacturer specific Warning 2

Bits 9 … 15 are used depending on the configuration and on Mode of Operation.

Control word bits 4, 5, 6 `operation mode specific` and bit 8 `Halt` are used in motion control configurations (Parameter *Configuration* **30** = `x40`) only.

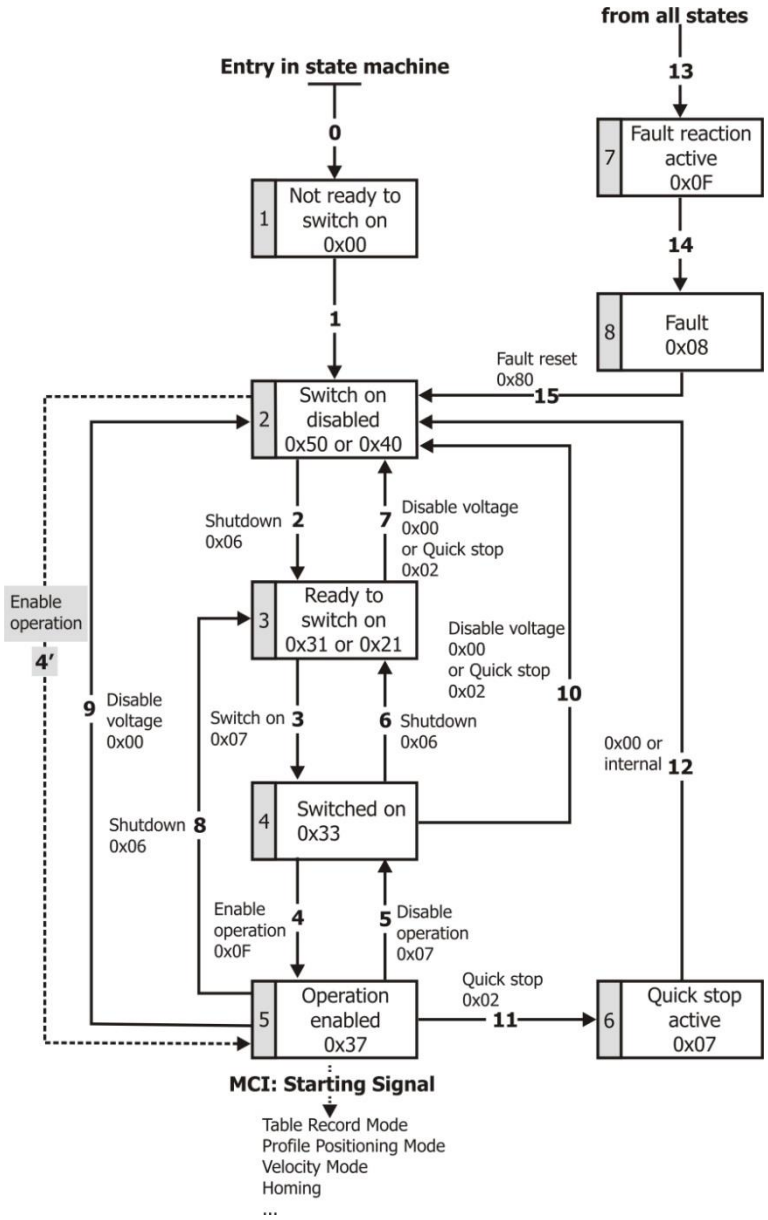
Status word bits 12 and 13 "`Operation mode specific`" are only used in positioning control configurations (Parameter *Configuration* **30** = `x40`).

ANG frequency inverters support an external 24 V power supply for the inverter control electronics. Even when mains voltage is disconnected, communication between the controller (PLC) and the frequency inverter is still possible.

Bit 4 "Voltage enabled" of the status word shows the current mains power supply status:

- Bit 4 "Voltage enabled" = `0` signals "No mains voltage", starting of drive not possible.
- Bit 4 "Voltage enabled" = `1` signals "Mains voltage on", drive ready for start.

State machine diagram



Control word:

The device control commands are triggered by the following bit patterns in the Control word.

Control word						
Command	Bit 7 Fault reset	Bit 3 Enable operation	Bit 2 Quick stop (Low active)	Bit 1 Enable voltage	Bit 0 Switch on	Transitions
Shutdown	X	X	1	1	0	2, 6, 8
Switch on	X	0	1	1	1	3
Enable operation	X	1	1	1	1	4
Disable voltage	X	X	X	0	X	7, 9, 10, 12
Quick stop (Low active)	X	X	0	1	X	7, 10, 11
Disable operation	X	0	1	1	1	5
Fault reset	0 → 1	x	x	x	x	15

x means any value

Transition 3 (command "Switch On" [0x07]) will only be processed if Bit 4 "Voltage enabled" of the Status word is set.

Transition 4 (Command "Enable operation" [0xF]) will only be processed if the release is set via the hardware contacts STO.

If the hardware release via STO is not set, the frequency inverter will remain in status "Switched On" [0x33] until the hardware release via STO is present.

In status "Operation enabled" [0x37], the device will switch to status "Switched On" [0x33] internally once the hardware release via STO is reset.

In configurations **with** Motion Control (parameter *Configuration* **30** = x40), the following must be noted:

Transition 4 is **not** available.

- In status "5-Operation enabled [0x37]" an additional start signal must be provided via bits from the "High Byte" of the control word in order to start a movement of the motor. For a description of the start signal for this "Motion Control Interface" (MCI), refer to Chapter 9.4. The "*Modes of operation*" function is available for switching to other MCI modes.
- Digital inputs (STOA and STOB) must be set. Start clockwise and Start anticlockwise have no function in these configurations.

In configurations **without** Motion Control (parameter *Configuration* **30** ≠ x40), the following must be noted:

- Transition 4 will only be processed if Bit 4 "Voltage enabled" of the status word is set. This feature is downward-compatible with older software versions.
- The frequency inverter can only be controlled if the logic operation is true. The logic inputs for Start Clockwise and Start anticlockwise can be connected directly with "On" or "Off" (parameter *Start Clockwise* **68** and *Start Anticlockwise* **69**).
- Digital inputs (STOA and STOB) must be set.
- This results in:
  Release: (= STOA and STOB) **AND** (Start clockwise **OR** Start Anticlockwise)

Status word:

The status word indicates the current operating state.

Status word						
State	**Bit 6**	**Bit 5**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
	Switch on disabled	**Quick stop (Low active)**	**Fault**	**Operation enabled**	**Switched on**	**Ready to switch on**
Switch on disabled	**1**	X	**0**	**0**	**0**	**0**
Ready to switch on	**0**	**1**	**0**	**0**	**0**	**1**
Switched on	**0**	**1**	**0**	**0**	**1**	**1**
Operation enabled	**0**	**1**	**0**	**1**	**1**	**1**
Quick stop active	**0**	**0**	**0**	**1**	**1**	**1**
Fault reaction active	**0**	X	**1**	**1**	**1**	**1**
Fault	**0**	X	**1**	**0**	**0**	**0**

`x` means any value

Bit 7 "`Warning`" can be set at any time. It reports a device-internal warning. The cause of the warning is evaluated by reading the warning status with parameter *Warnings* **270**.

Bit 9 "`Remote`" is set if the operation mode is set to "`Control via state machine`" (*Local/Remote* **412** = `1`) and controller release is turned on.

Bit 10 "`Target reached`" is set when the specified reference value is reached.

In configurations without Motion Control (parameter *Configuration* **30** ≠ `x40`) "`Target reached`" refers to the reference speed from OUT-PZD220. In the special case of power failure regulation, the bit is also set when the power failure regulation reaches the frequency 0 Hz (see frequency inverter operating instructions).

For "`Target reached`", there is a hysteresis (tolerance range) which can be set via the parameter *Max. control deviation* **549** see frequency inverter Operating Instructions).

Bit 11 "`Internal limit value active`" indicates that an internal limit is active. This may be the current limit, the torque limit or the overvoltage control. All functions will result in the reference value being left or not reached.

Bit 15 "`Warning 2`" signals a critical operating state which will result in a fault switch-off of the frequency inverter within a short time. This bit is set if there is a delayed warning relating to the motor temperature, heat sink/inside temperature, Ixt monitoring or mains phase failure.

12.3 Configurations without Motion Control

In speed-controlled configurations (including Technology Controller, Electronic Gear and Torque Control → all configurations, except for "x40"), various control modes are available. The control mode is set via Parameter *Local/Remote* **412**.

In speed-controlled configurations, the reference speed is set via PZD2.

In configurations without Motion Control (*Configuration* **30** ≠ `x40`) *Modes of operation* is set permanently to "`2 - velocity mode`" (velocity mode vl). *Modes of operation display* will also be "`2 - velocity mode`" (velocity mode vl). These settings cannot be changed individually.

Relevant objects:

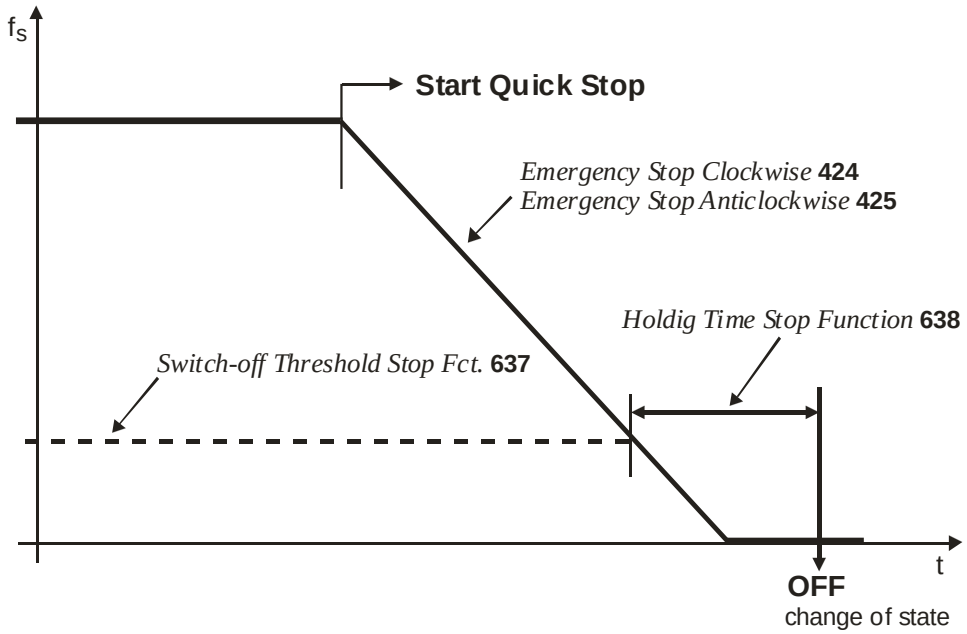
OUT-PZD1	Control word	IN-PZD1	Status word
OUT-PZD2	Target velocity	IN-PZD2	Control effort
P.418	Minimum frequency	**P.420 (& P.422)**	Acceleration
P.419	Maximum Frequency	**P.421 (& P.423)**	Deceleration
		P.424 (& P.425)	Emergency stop

The ramp times are specified via parameters **430...433**.

12.3.1 Behavior in the case of a quick stop

In quick stop, the parameters *Switch-off threshold* **637** (percent of parameter *Maximum Frequency* **419**) and *Holding time* **638** (holding time after falling short of the switch-off threshold) are relevant. In the case of a quick stop, the drive is stopped via emergency stop ramps.

The emergency stop ramps are set via parameters *Emergency Stop Clockwise* **424** and *Emergency Stop Anticlockwise* **425**.



If the frequency/speed reaches the value zero during the switch-off time, the drive continues to be supplied with current until the switch-off time has elapsed. This ensures that the drive is at a standstill when the state changes.

The quick stop behavior is only relevant for configurations without Motion Control (parameter *Configuration* **30** ≠ x40).

12.3.2 Behavior in the case of transition 5 (disable operation)

The behavior in transition 5 from "Operation enabled" to "Switched On" can be configured via parameter *State transition 5* **392**. .

Parameters		Settings		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
392	State transition 5	0	2	2

Operation mode	Function
0 - Coast to stop	Immediate transition from "Operation enabled" to "Switched On", drive coasts to a standstill
1 - DC brake	Activation of DC brake, at the end of DC deceleration, there is the change from "Operation enabled" to "Switched On"
2 - Ramp	Transition with normal ramp, when the drive has come to a standstill, there is the change from "Operation enabled" to "Switched On"

Setting 1 "DC brake" is only possible with applications with U/f characteristic control (e.g. configuration 110). Other configurations do not support this operation mode.

If the frequency inverter is operated with a configuration which does not support the operation mode Direct Current Brake (e.g. configuration 210, field-oriented control), value "1" cannot be used.

In this case, the operation mode is not offered in the selection menus of the control unit KP500 and the control software VPlus.

By default, *State-transition 5* **392** is set to operation mode "2 - Ramp". For configurations with torque control, the default value is "0 - coasting".

If the configuration is changed, the value set for *State-transition 5* **392** is also changed, if necessary.

The behavior in transition 5 is only relevant for configurations without Motion Control (parameter *Configuration* **30** ≠ x40).

If *State-transition 5* **392** was triggered with "1 - DC brake", a new control word will only be accepted after completion of the transition process. The change of state from "Operation enabled" to "Started" is done after the *Braking time* **632**. **632** parameterized for the DC brake has elapsed.

If parameter *State-transition 5* **392** = "2 - Ramp" is set, the control word can be set to "Operation enabled" again, while the drive is decelerating. In this way, the drive accelerates to its set reference value again and remains in the state "Operation enabled".

The change of state from "Operation enabled" to "Switched On" is done after the value has dropped below the set switch-off threshold and the set holding time has elapsed (equivalent to the behavior in the case of a quick stop). In this context, parameters *Switch-off threshold stop function* **637** (percentage of parameter *Maximum Frequency* **419**) and *Holding time* **638** (Holding time after passing of threshold) are relevant.

12.3.3 Reference value/actual value

In PZD2, the master sends its reference value to the frequency inverter in its output data set and receives information about the actual value in its input data set.

The use of the reference/actual value channel depends on the set configuration (control method). The actual value is generated according to the control method used.

The reference value and actual value refer to parameter *Rated frequency* **375** OR *Profibus/PROFINET Reference* **390**.

The distinction is made based on the setting of parameter *Profibus/PROFINET reference* **390**. If *Profibus/PROFINET reference* **390** = `0`, the values are obtained from *Rated frequency* **375**. If *Profibus/PROFINET reference* **390** ≠ `0`, *Profibus/PROFINET reference* **390** is used. Both parameters are data set switchable.

Parameters		Settings		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
375	Rated frequency	10.00 Hz	599.00 Hz	50.00 Hz
390	Profibus/PROFINET reference	0.00 Hz	599.00 Hz	0.00 Hz

The reference and actual value are transmitted in standardized form. Standardization is effected through the variable used as the reference variable (*Rated frequency* **375 OR** *Profibus/PROFINET reference* **390**).

Standardization			
Reference value	**Binary**	**Decimal**	**Hexadecimal**
+ 100 %	+ 2^{14}	16384	0x4000
- 100 %	- 2^{14}	49152	0xC000

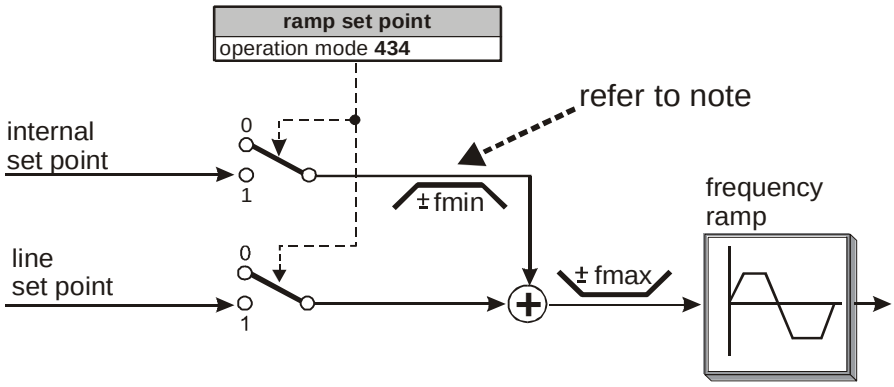
Value range = ±200 % = +32768 through -32768 = 0x7FFF through 0x8000

Example: In Parameter *Profibus/PROFINET reference* **390**, the rated frequency of `60.00 Hz` is set. The required reference frequency is `30.00 Hz`. Since this is 50 % of the reference value, `8192` (`0x2000`) must be transmitted as the reference value.

With the reference variable *Profibus/PROFINET reference* **390**, a machine can be operated in the field weakening range above its reference frequency.

Example: Parameter *Rated frequency* **375** is set to 50.00 Hz. With the setting of parameter *Profibus/PROFINET reference* **390** to 100.00 Hz, the value range ±200 Hz is possible.

The reference value for the frequency inverter from PZD2 is supplied via the reference line value. This reference value is combined in the input of the ramp function with the internal reference frequency from the reference frequency channel. For information on the reference frequency channel, refer to the frequency inverter Operating Instructions.



The internal reference value from the reference frequency channel and the reference line value can be fed to the ramp individually or as an added variable. The operation mode of the ramp function is set via the data set switchable parameter *Ramp setpoint* **434**.

Parameters	Settings		
Description	**Min.**	**Max.**	**Factory setting**
Ramp setpoint	1	3	3

Operation mode		Function
1 -	Internal reference frequency	The internal reference frequency is determined from the percentage reference value source or the reference frequency channel.
2 -	Reference line value	The reference value is supplied externally via the communication interface.
3 -	internal + reference line value	Addition (considering the sign) of internal reference frequency and reference line value

The Internal reference frequency can be controlled via the frequency inverter with the control unit KP500 or the control software VPlus, the reference line value is supplied via PZD2.

If *Ramp setpoint* **434** = 2 (reference line value only), this reference line value is limited to f_{min}.

The sign in front of f_{min} with reference value = 0 is derived from the sign in front of the last reference line value which was not 0.

After Mains On, the reference line value is limited to $+f_{min}$.

For *Ramp setpoint* **434** = 3, the sign of total reference value results from the total of internal reference frequency and reference line value.

Actual values		
Parameters	**Contents**	**Format**
Internal reference frequency **228**	Internal reference value from the reference frequency channel	xxx.xx Hz
Reference bus frequency **282**	PROFINET reference line value	xxx.xx Hz
Reference ramp frequency **283**	= sum of internal reference frequency + reference line value	xxx.xx Hz

12.3.4 Sequence example

In configurations without Motion Control (*Configuration* **30** ≠ x40), the PLC must send the correct sequence:

1	Control word =	0x0000	Disable voltage
2	Control word =	0x0006	Shut down
3	Control word =	0x0007	Switch On
4	Control word =	0x000F	Enable operation

OR

1	Control word =	0x0000	Disable voltage
2	Control word =	0x000F	Enable operation

In configurations without Motion Control (*Configuration* **30** ≠ x40), the second (shortened) sequence can be used, because transition 4 is available in these configurations.

12.4 Motion control configurations

WARNING

Dangerous state due to new mode!

If the mode of operation 'modes of operation' is changed during operation (control word = 0xnnnF), a dangerous state may occur in the new mode.

BONFIGLIOLI VECTRON recommends checking the status word before changing the mode of operation (e.g. for status 0xnn33).

Motion Control Definition

For the full function of the Motion Control Interface, you will have to set *Local/Remote* **412** = "1-Control via state machine". In all other operation modes of parameter *Local/Remote* **412**, there are major restrictions. The descriptions in this chapter and of all objects used are based on the setting *Local/Remote* **412** = "1-Control via state machine".

The usage of Positioning for setting *Local/Remote* **412** ≠ 1 is described in the "Positioning" application manual.

The function of the state machine describes the basic operating behavior of the frequency inverter in configurations with position control (*Configuration* **30** = x40). The objects control word and status word described above support the bits marked as operation mode specific.

These bits and bit "Target reached" have different meanings in the different position control operation modes – defined by modes of operation. The following chapters describe the application of the operation mode specific bits in the control word and status word, depending on the different position control operation modes. The preset mode is Modes of operation = 2 – velocity mode.

Basic functions:

The state machine must be set to "operation enabled", before the position command can be issued via the operation mode specific bits of the control word.

Once a *mode of operation* has been set by the PLC, no commands will be accepted for this operation mode until this operation mode is displayed in the *modes of operation display* object.

The bits in the *control word* and *status word* marked as operation mode specific are only supported in configurations with position control (*Configuration* **30** = x40).

Special functions

For certain functions (e.g. "Technology Controller" or "Torque Reference value") the reference percentage channel is required.

Reference percentages are transmitted by PROFINET via OUT-PZD3. The following sources can be set for parameter *Reference percentage source* **476**, for example:

96 -	Absolute value Profibus OUT-PZD 3	PROFINET OUT-PZD3 is the reference value source as an absolute value.
196 -	+/- Profibus OUT-PZD3	PROFINET OUT-PZD3 is the reference value source as a value with sigh.

12.4.1 Velocity mode [rpm]

Velocity mode [rpm] can be selected via modes of operation = 2.

In velocity mode, the operation mode specific of the control word control the ramp generator (RFG – Ramp Function Generator). The block diagram illustrates the function.

Relevant objects:

OUT-PZD1	Control word	IN-PZD1	Status word
OUT-PZD12[r)]	Target velocity [rpm]	IN-PZD12[r)]	Actual Speed [rpm]
OUT-PZD11[r)]	Modes of operation	IN-PZD11[r)]	Modes of operation display
P.418	Minimum frequency	**P.420** (& **P.422**)	Acceleration
P.419	Maximum Frequency	**P.421** (& **P.423**)	Deceleration
		P.424 (& **P.425**)	Emergency stop

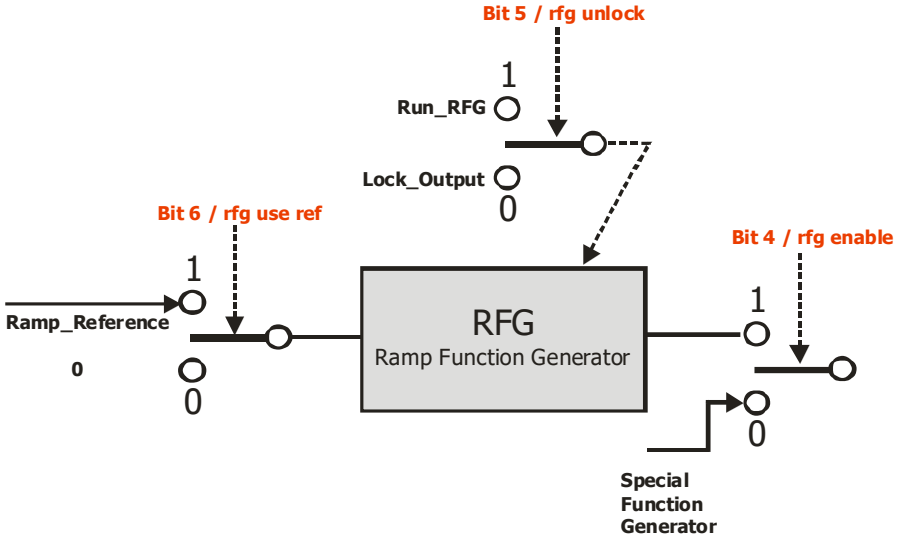
r) permissible only when the recommended settings from 8.3 "Motion Control Mapping for PROFINET" have been made.

The ramp times are specified via parameters **430**…**433**.

Control word	
Bit	
0	Switch on
1	Enable voltage
2	Quick stop (Low active)
3	Enable operation
4	Rfg enable
5	Rfg unlock
6	Rfg use ref
7	Fault reset
8	Halt
9	
10	
11	
12	
13	
14	
15	

Status word	
Bit	
0	Ready to switch on
1	Switched on
2	Operation enabled
3	Fault
4	Voltage enabled
5	Quick stop (Low Active)
6	Switch on disabled
7	Warning
8	
9	Remote
10	Target reached (not used)
11	Internal limit active
12	
13	
14	
15	Warning 2

Block diagram



The special function is evaluated only if **1299** *S. Special Function Generator* ≠ "9-Zero".

If **1299** *S. Special Function Generator* = "9-Zero", the value of the ramp output will always be used.

If special function generator **1299** *S. Special Function Generator* ≠ "`9-Zero`", the reference value from the ramp output will also be used if bit 4 "rfg enable" = `1`, and if bit 4 "rfg enable" = `0`, the reference value from the source specified in **1299** *S. Special Function Generator* will be used.

Control word

Identification	Value	Description
rfg enable **Bit 4**	0	The reference speed comes from a manufacturer-specific special function
	1	The reference speed corresponds to the ramp output
rfg unlock **Bit 5**	0	The last speed will be maintained and used.
	1	The ramp function is active and changes according to the reference value and the ramp.
rfg use ref **Bit 6**	0	Reference value "0" is used.
	1	The setpoint of "vl target Velocity" is used.
Halt **Bit 8**	0	Execute positioning
	1	Stop axis. (The frequency inverter remains enabled in "Operation enabled" state.)

Reference value source

	1299 *S. Special Function Generator* ≠ "9-Zero"	**1299** *S. Special Function Generator* = "9-Zero"
Bit 4 rfg enable = 0	Reference value from special function	Reference value from ramp output
Bit 4 rfg enable = 1	Reference value from ramp output	

Status word

Identification	Value	Description
Target reached Bit 10	0	Stop = 0: Home position (still) not reached.
		Stop = 1: Axis decelerated.
	1	Stop = 0: Home position reached.
		Stop = 1: Axis has speed 0.

Sequence example

In order to start "velocity mode", the correct sequence must be sent by the PLC.

Preparation:

Set *Acceleration (clockwise)* **420** to the required value (factory setting: 5 Hz/s)

Set *Deceleration (clockwise)* **421** to the required value (factory setting: -0.01 Hz/s)

→ -0.01 means that the value set for the acceleration will also be used for deceleration.

	OUT IN	PZD1 Control word Status word	PZD11 r) Modes of operation Mod. Of. Op. Displ.	PZD12 r) Reference actual speed	Remark
1		0x0000 0x0050		arbitrary any	Disable voltage Switch On Disabled
2			0x0002 0x0002	any any	(Velocity mode)
3		0x0006 0x0031	0x0002 0x0002	any any	Shutdown Ready to switch on
4		0x0007 0x0033	0x0002 0x0002	any any	Switch On Switched On
5		0x000F 0xnn37	0x0002 0x0002	0xABCD	Enable operation, no change of previous status if already enabled. Operation enabled
6a		0x007F 0xnn37	0x0002 0x0002	0xABCD	Starts "Velocity mode" with reference value from OUT-PZD12r) 0xABCD. Operation enabled
6b		0x006F 0xnn37	0x0002 0x0002	0xABCD	**1299** *S. Special Function Generator*: = "9-Zero" Starts "Velocity mode" with reference value from OUT-PZD12r) 0xABCD. **1299** *S. Special Function Generator*: ≠ "9-Zero" Starts with reference value with source from **1299** *S. Special Function Generator.* Operation enabled
6c		0x003F 0xnn37	0x0002 0x0002	0xABCD	Starts "Velocity mode" with reference value "0" Operation enabled
6d		0x002F 0xnn37	0x0002 0x0002	0xABCD	**1299** *S. Special Function Generator*: = "9-Zero" Starts "Velocity mode" with reference value "0" **1299** *S. Special Function Generator*: ≠ "9-Zero" Starts with reference value with source from **1299** *S. Special Function Generator* Operation enabled
6e		0x005F 0xnn37	0x0002 0x0002	0xABCD	Starts "Velocity mode" at current speed – current ramps will be canceled. Operation enabled
6f		0x004F 0xnn37	0x0002 0x0002	0xABCD	**1299** *S. Special Function Generator*: = "9-Zero" Starts "Velocity mode" at current speed – current ramps will be canceled. **1299** *S. Special Function Generator*: ≠ "9-Zero" Starts with reference value from source from **1299** *S. Special Function Generator* Operation enabled
7		0x01xx 0xnn37	0x0002 0x0002	0xABCD	HALT: Drive is decelerated at ramp *Velocity deceleration*. Operation enabled

r) permissible only when the recommended settings from "Motion Control Mapping for PROFINET" have been made

WARNING

Dangerous state due to new mode!

If the mode of operation 'modes of operation' is changed during operation (control word = 0xnnnF), a dangerous state may occur in the new mode.

- BONFIGLIOLI VECTRON recommends checking the status word before changing the mode of operation (e.g. for status 0xnn33).

Once the ANG has correctly processed the sequence of the first four control words and responded with the corresponding status word, the ANG is ready for operation (dark table area).

In state "operation enabled" (0xnnnF), the state of the Motion Control can be changed (white table area).

With control word transition from 0xnnnF to 0x0007, "Velocity mode" will be stopped. Then, the mode can be restarted via 0xnnnF.

As long as 0x0007 is active, the mode of operation can be edited safely. Once modes of operation has been set to another value, operation can be started with a corresponding sequence.

12.4.2 Profile Velocity mode [u/s]

The profile velocity mode is selected via object *Modes of operation* =**3**.

In profile velocity mode the inverter receives a reference speed in [u/s].

OUT-PZD1	Control word	IN-PZD1	Status word
OUT-PZD11 r)	Modes of operation	IN-PZD11r)	Modes of operation display
OUT-PZD5/6 r)	Profile velocity	**P. 418**	Minimum frequency
OUT-PZD7/8 r)	Profile acceleration	**P. 419**	Maximum Frequency
OUT-PZD9/10 r)	Profile deceleration	**P. 1179**	Emergency stop ramp

r) permissible only when the recommended settings from "Motion Control Mapping for PROFINET" have been made

The Ramp Rise/Fall times are set up via parameters **1176** and **1178**.

In profile velocity mode, the operation mode specific bits of the control word and the status word are used as follows:

Control word	
Bit	
0	Switch on
1	Enable voltage
2	Quick stop (Low active)
3	Enable operation
4	
5	
6	
7	Fault reset
8	Halt
9	
10	
11	
12	
13	
14	
15	

Status word	
Bit	
0	Ready to switch on
1	Switched on
2	Operation enabled
3	Fault
4	Voltage enabled
5	Quick stop (Low Active)
6	Switch on disabled
7	Warning
8	
9	Remote
10	Target reached
11	Internal limit active
12	Velocity
13	Max Slippage
14	
15	Warning 2

The Profile Velocity Mode is used to set the reference speed in user units [u/s]. The reference speed PZD5/6 *Profile Velocity* is taken over in mode "operation enabled" immediately (0xnn37). The acceleration and deceleration ramp are specified by PZD7/8 *Profile acceleration* and PZD9/10 *Profile deceleration*.

Setting Bit 8 "Halt" of the control word delays the drive with ramp PZD9/10 *Profile deceleration* and holds the drive at standstill. Resetting Bit 8 results in an acceleration with ramp PZD7/8 *Profile acceleration* to the actual reference velocity.

Control word

Identification	Value	Description
Halt **Bit 8**	0	Execute Profile Velocity Mode
	1	Halt Axis. (The Frequency inverter remains in state "Operation enabled".)

Status word

Identification	Value	Description
Target reached **Bit 10**	0	The actual velocity does not match the reference velocity.
	1	The actual velocity matches the reference velocity.
		The actual velocity differs at least from the defined time period in **1277** *Velocity Window Time* up to the amount [us]defined in **1276** *Velocity Window*.
Velocity **Bit 12**	0	The Actual Velocity matches the comparison speed.
		The Actual Velocity has exceeded for a defined time (*Threshold Window Time***1279**) a defined Velocity in user units per seconds [u/s] (*Threshold Window***1278**).
	1	The Actual Velocity doesn't match the Comparison Velocity.
Maximum Slippage **Bit 13**	0	The actual Slippage speed is smaller than defined.
		The comparison value of the slippage speed is defined Object *Max Slippage* **1275**.
	1	The actual Slippage speed is bigger than defined.
		The comparison value of the slippage speed is defined *Max Slippage* **1275**.

Via parameter **1276** *Velocity Window* and **1277** *Velocity Window Time* Bit 10 "Target reached" of the status word is set.

Via parameter **1278** *Threshold Window* and **1279** *Threshold Window Time* Bit 12 "Velocity" of the status word is set.

Via parameter **1275** *Max Slippage* a slip monitoring via Bit 13 "Max Slippage" of the status word can be set up.

Example Sequence

To start the Profile Velocity mode, the correct sequence has to be sent from the PLC.

	OUT IN	PZD1 Control word Status word	PZD11 r) Modes of Op. M. Of. Op. Displ.	PZD5/6 r) *) Profile velocity	Remark
1		0x0000 0x0050	any any	any	Disable voltage Switch On Disabled
2		0x0000 0x0050	0x0003 0x0003	any	Profile Velocity mode
3		0x0006 0x0031	0x0003 0x0003	any	Shutdown Ready to switch on
4		0x0007 0x0033	0x0003 0x0003	0x1234 0x5678*)	Switch On Switched On
5		0x0007 ↓ 0x000F 0xnn37	0x0003 0x0003	0x1234 0x5678*)	Enable Operation, no change to previous state if already enabled. The Profile Velocity mode is started with reference PZD5/6r) Profile velocity and Ramp profile PZD7/8r) *Profile acceleration* and PZD9/10r) *Profile deceleration*. Changes to Target Velocity and Ramps are taken over immediately. Operation enabled

*) In addition to the Profile speed PZD5/6, Acceleration PZD7/8 and Deceleration 9/10 must be assigned appropriate values > 0. These PZDs are not shown in the table for reasons of clarity. Generally, it is recommended that all specified PZDs be changed at the same time.

r) permissible only when the recommended settings from "Motion Control Mapping for PROFINET" have been made

WARNING

Dangerous state due to new mode!

If the mode of operation 'modes of operation' is changed during operation (control word = 0xnnnF), a dangerous state may occur in the new mode.

- The manufacturer recommends checking the status word before changing the mode of operation (e.g. for status 0xnn33).

Once the ANG has correctly processed the sequence of the first four control words and responded with the corresponding status word, the ANG is ready for operation (dark table area).

In state "`operation enabled`" (0xnnnF), the state of the Motion Control can be changed (white table area).

With control word transition from 0xnnnF to 0x0007, "*Profile position mode*" will be stopped. Then, the mode can be restarted via 0xnnnF.

As long as 0x0007 is active, the mode of operation can also be changed safely. Once *modes of operation* has been set to another value, operation can be started with a corresponding sequence.

12.4.3 Profile position mode

Profile position mode can be selected via **247** *Modes of operation* = `1`.

In profile position mode, the frequency inverter receives a target position, followed by the command to travel to this target.

Relevant objects:

OUT-PZD1	Control word	IN-PZD1	Status word
OUT-PZD11 r)	Modes of operation	IN-PZD11 r)	Modes of operation display
OUT-PZD3/4 r)	Target position		
OUT-PZD5/6 r)	Profile velocity	**P.418**	Minimum frequency
OUT-PZD7/8 r)	Profile acceleration	**P.419**	Maximum Frequency
OUT-PZD9/10 r)	Profile deceleration	**P.1179**	Emergency stop ramp

r) permissible only when the recommended settings from 8.3 "Motion Control Mapping for PROFINET" have been made

The ramp times are specified via parameters **1176**…**1178**.

In profile position mode, the mode-specific bits of the control word and the status word are used as follows:

Control word	
Bit	
0	Switch on
1	Enable voltage
2	Quick stop (Low active)
3	Enable operation
4	New set-point
5	Change set immediately
6	Abs/rel
7	Fault reset
8	Halt
9	Change on set-point
10	
11	
12	
13	
14	
15	

Status word	
Bit	
0	Ready to switch on
1	Switched on
2	Operation enabled
3	Fault
4	Voltage enabled
5	Quick stop (Low Active)
6	Switch on disabled
7	Warning
8	
9	Remote
10	Target reached
11	Internal limit active
12	Set-point acknowledge
13	Following error
14	
15	Warning 2

Control word

Change on set-point Bit 9	Change set-point immediately Bit 5	New set-point Bit 4	Description
0	0	0 → 1	Positioning operation to be completed (target reached) before the next one is started.
X	1	0 → 1	Next positioning operation to be started immediately.
1	0	0 → 1	Positioning operation to be started with the current speed profile until the current reference value is reached, then, the next positioning operation is to be processed.

Identification	Value	Description
Abs/rel Bit 6	0	The target position is an absolute value.
	1	The target position is a relative value.
Halt Bit 8	0	Execute positioning operation.
	1	Stop axis with *profile deceleration* (if not supported by *profile acceleration*), the frequency inverter will remain in status "`Operation enabled`".

Status word

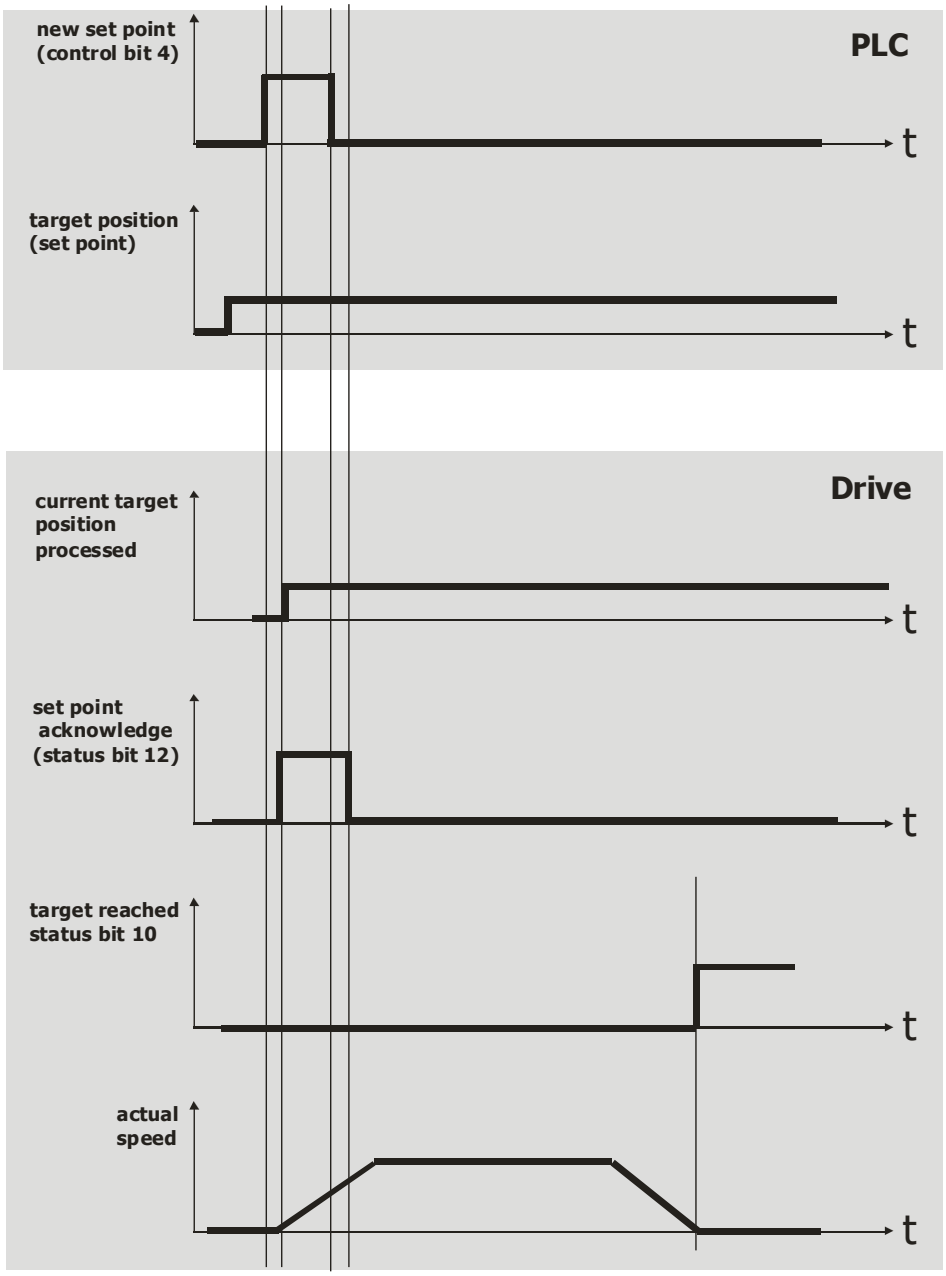
Identification	Value	Description
Target reached Bit 10	0	Stop = 0: *Target position* (still) not reached.
		Stop = 1: Axis decelerated.
	1	Stop = 0: *Target position* reached.
		Stop = 1: Speed of axis is 0.
Set-point acknowledge Bit 12	0	The travel profile calculation has not applied the position value (yet).
	1	The travel profile calculation has applied the position value.
Following error Bit 13	0	No following error.
	1	Following error.

Example: single set-point

– control bit change on set-point = `0`

– control bit change set immediately = 0

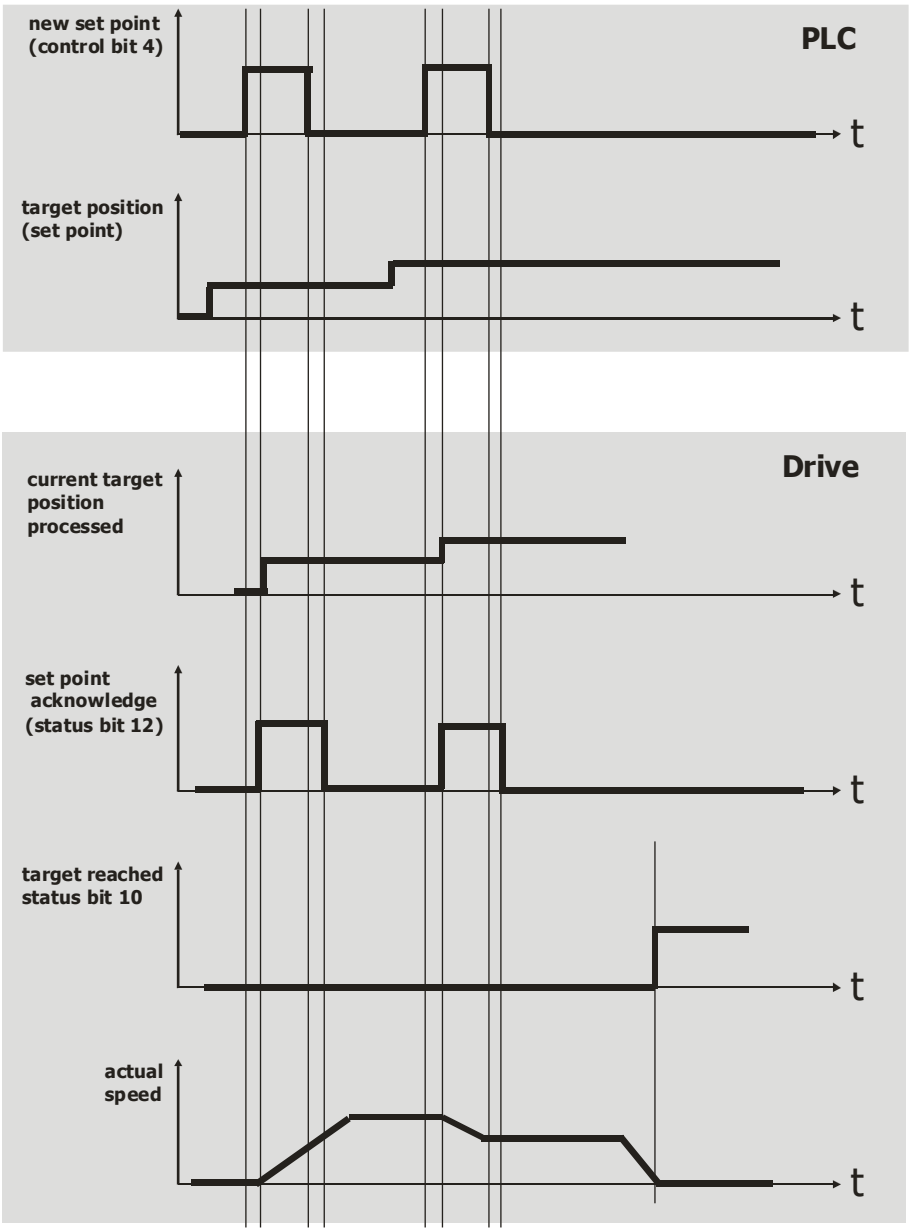
Once a reference value has been transmitted to the drive, the controller signals a permissible value in the control word by a rising signal edge for the bit "New reference value". The drive responds by setting the bit "Reference value confirmed" and starts moving to the new target position. After that, the controller resets the bit "New reference value", and the drive resets the bit "Reference value confirmed". Once the bit "Reference value confirmed" has been reset, the drive is ready for receiving a new target position.



Example: single set-point

– control bit change on set-point = 0
– control bit change set immediately = 1

A new reference value is confirmed by the control bit "New reference value" (rising edge) while a reference value is being processed. The new reference value is processed immediately.



Example: set of set-points

- control bit change on set-point = 0/1
- control bit change set immediately = 0

The travel profile is changed during an active positioning operation.

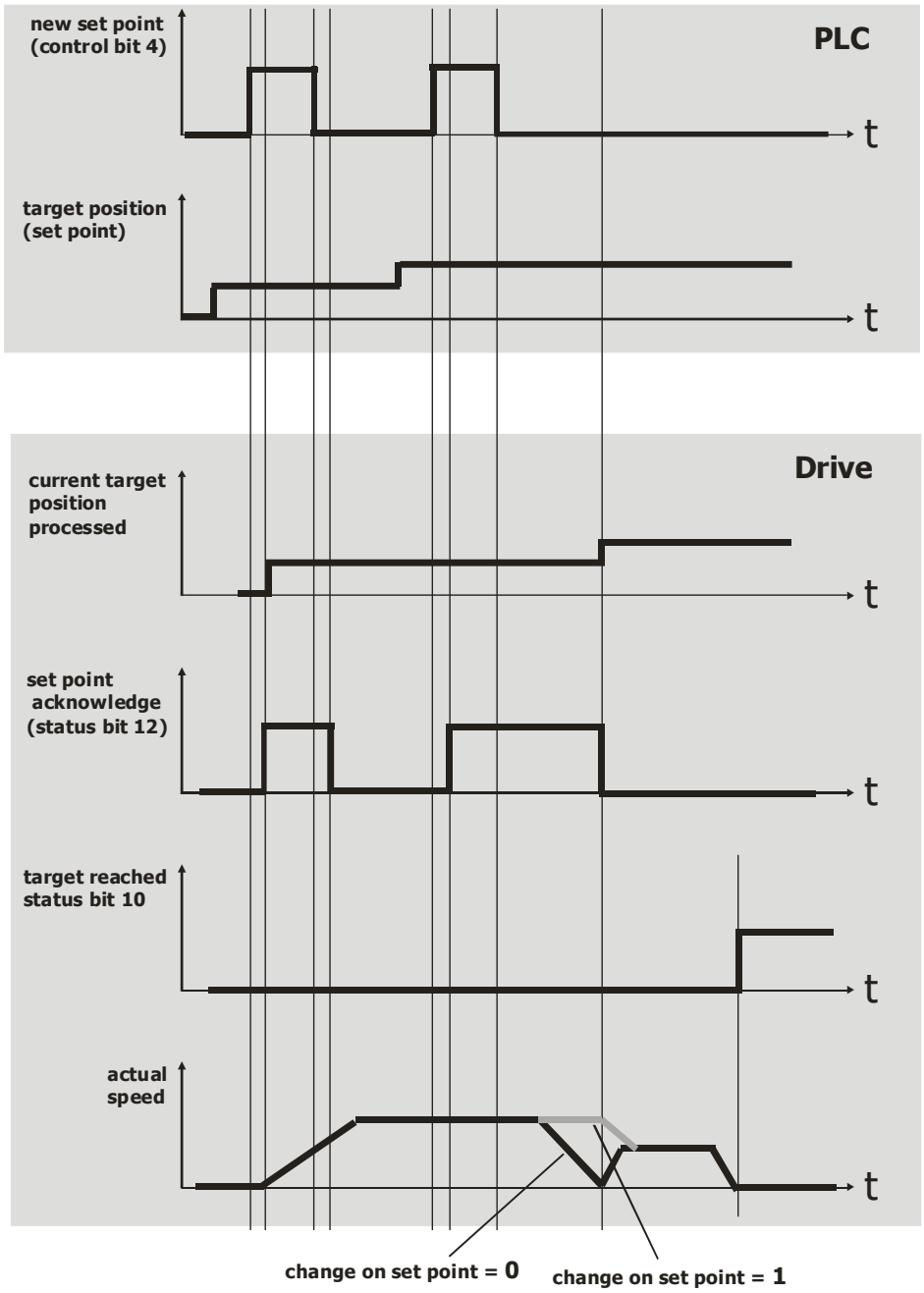
Change on set point = 0

The current target position is approached with a **Stop**. Once the position has been reached, the new reference value is set.

Change on set point = 1

The current target position is approached at the active speed. Once the current target position has been reached, the new reference value is applied without reducing the speed to zero.

The gray line in the segment "Actual speed" shows the speed behaviors when the control bit "Switch at reference value" is set to 1.



Sequence example

In order to start "Profile position mode", the correct sequence must be sent by the PLC.

	OUT IN	PZD1 Control word Status word	PZD11 r) Modes of Op. M. Of. Op. Displ.	PZD3/4 r) *) Target position	Remark
1		0x0000 0x0050	any any	any	Disable voltage Switch On Disabled
2		0x0000 0x0050	0x0001 0x0001	any	Profile position mode
3		0x0006 0x0031	0x0001 0x0001	any	Shutdown Ready to switch on
4		0x0007 0x0033	0x0001 0x0001	0x1234 0x5678*)	Switch On Switched On

5		0x0007 ↓ 0x000F 0xnn37	0x0001 0x0001	0x1234 0x5678*)	Enable operation. Positioning operation is not started. Operation enabled
6a		0x0007 or 0x000F → 0x001F 0xnn37	0x0001 0x0001	0x1234 0x5678*)	Operation enabled, start **absolute** positioning with profile. If a positioning operation is already in process, this operation will be completed. Then, the new profile will be used. Operation enabled
6b		0x0007 or 0x000F → 0x005F 0xnn37	0x0001 0x0001	0x1234 0x5678*)	Operation enabled, start **relative** positioning with profile. If a positioning operation is already in process, this operation will be completed. Then, the new profile will be used. Operation enabled
6C		0x0007 or 0x000F → 0x003F 0xnn37	0x0001 0x0001	0x1234 0x5678*)	Operation enabled, start **absolute** positioning with profile. Running positioning operations will change and apply the new profile Operation enabled
6d		0x0007 or 0x000F → 0x007F 0xnn37	0x0001 0x0001	0x1234 0x5678*)	Operation enabled, start **relative** positioning with profile. Running positioning operations will change and apply the new profile Operation enabled
7		0x01nF 0xnn37	any 0x0001	any	HALT: Drive is decelerated with ramp *Velocity deceleration*. Operation enabled

r) permissible only when the recommended settings from 8.3 Motion Control Mapping for PROFINET have been made

*) In addition to the Target position in PZD3/4, Profile speed PZD5/6, Acceleration PZD7/8 and Deceleration 9/10 must be assigned appropriate values > 0. These PZDs are not shown in the table for reasons of clarity. Generally, it is recommended that all specified PZDs be changed at the same time.

WARNING

Dangerous state due to new mode!

If the mode of operation 'modes of operation' is changed during operation (control word = 0xnnnF), a dangerous state may occur in the new mode.

- • BONFIGLIOLI VECTRON recommends checking the status word before changing the mode of operation (e.g. for status 0xnn33).

Once the ANG has correctly processed the sequence of the first four control words and responded with the corresponding status word, the ANG is ready for operation (dark table area).

In state "`operation enabled`" (0xnnnF), the state of the Motion Control can be changed (white table area).

With control word transition from 0xnnnF to 0x0007, "*Profile position mode*" will be stopped. Then, the mode can be restarted via 0xnnnF.

As long as 0x0007 is active, the mode of operation can also be changed safely. Once *modes of operation* has been set to another value, operation can be started with a corresponding sequence.

In order to start a profile, you don't have to set the control word to 0x0007 first before switching to 0xnnnF.

Once a profile has been processed, a new profile can be started with the bit "New Setpoint" (bit 4) in control word 0xnnnF.

While a profile is being processed, you can start a new profile without stopping by using the bits "Change Setpoint immediately" (bit 5) and "New Setpoint" (bit 4).

12.4.4 Homing mode

Homing mode can be selected via *modes of operation* = 6.

In homing mode, the frequency inverter moves the drive to a reference position. The method used for this movement is defined by parameter *Homing mode* **1130**.

Control word	IN-PZD1	Status word
Modes of operation	IN-PZD11[r)]	Modes of operation display
Homing mode	**P.418**	Minimum frequency
Fast speed / creep speed	**P.419**	Maximum Frequency
Acceleration	**P.1179**	Emergency stop ramp

r) permissible only when the recommended settings from 8.3 "Motion Control Mapping for PROFINET" have been made

The ramp times are specified via parameter **1135**.

In homing, the mode-specific bits of the control word and the status word are used as follows:

Control word	
Bit	
0	Switch on
1	Enable voltage
2	Quick stop (Low active)
3	Enable operation
4	Homing operation start
5	
6	
7	Fault reset
8	Halt
9	
10	
11	
12	
13	
14	
15	

Status word	
Bit	
0	Ready to switch on
1	Switched on
2	Operation enabled
3	Fault
4	Voltage enabled
5	Quick stop (Low Active)
6	Switch on disabled
7	Warning
8	
9	Remote
10	Target reached
11	Internal limit active
12	Homing attained
13	Homing error
14	
15	Warning 2

Control word

Identification	Value	Description
Homing operation start **Bit 4**	0	Homing not active.
	0 → 1	Start homing.
	1	Homing active.
	1 → 0	Stop homing.
Halt **Bit 8**	0	Execute command from bit 4 "Start homing".
	1	Stop axis with acceleration value (as deceleration) for homing. (The frequency inverter remains enabled in "Operation enabled" status.)

Status word

Identification	Value	Description
Target reached Bit 10	0	Stop = 0: Home position (still) not reached.
		Stop = 1: Axis decelerated.
	1	Stop = 0: Home position reached.
		Stop = 1: Axis has speed 0.
Homing attained Bit 12	0	Homing not completed yet.
	1	Homing completed successfully.
Homing error Bit 13	0	No homing error.
	1	Homing error occurred, homing not completed successfully.

For a description of homing operations, refer to Chapter "Homing modes".

Sequence example

In order to start "homing mode", the correct sequence must be sent by the PLC.

Preparation:

Set *Homing mode* **1130** (factory setting: "0 – no homing").

Set *Home Offset* **1131** if available (factory setting: 0).

Set *Fast speed* **1132** (factory setting: 327680 u).

Set *Creep speed* **1133** (factory setting: 163840 u).

Set *Acceleration* **1134** (factory setting: 327680 u/s²).

Set *Ramp time* **1135**, if available (factory setting = 0 ms).

	OUT IN	PZD1 Control word Status word	PZD11 r) Modes of operation Mod. Of. Op. Displ.	Remark
1		0x0000 0x0050		Disable voltage Switch On Disabled
2			0x0006 0x0006	(Homing)
3		0x0006 0x0031	0x0006 0x0006	Shutdown Ready to switch on
4		0x0007 0x0033	0x0006 0x0006	Switch On Switched On
5a		0x000F 0xnn37	0x0006 0x0006	Enable operation. Operation enabled
5b		0x001F 0x1n37	0x0006 0x0006	Enable operation and start homing. Operation enabled and homing attained.

r) permissible only when the recommended settings from 8.3 "Motion Control Mapping for PROFINET" have been made

WARNING

Dangerous state due to new mode!

If the mode of operation 'modes of operation' is changed during operation (control word = 0xnnnF), a dangerous state may occur in the new mode.

BONFIGLIOLI VECTRON recommends checking the status word before changing the mode of operation (e.g. for status 0xnn33).

Once the ANG has correctly processed the sequence of the first four control words and responded with the corresponding status word, the ANG is ready for operation (dark table area).

In state "operation enabled" (0xnnnF), the state of the Motion Control can be changed (white table area).

With control word transition from 0x0007 (or 0x000F) to 0x001F the homing operation is started. Bit "Homing attained" (Bit 12) returns the status in the status word.

As long as 0x0007 is active, the mode of operation can also be changed safely. Once *modes of operation* has been set to another value, operation can be started with a corresponding sequence.

12.4.5 Table travel record mode

Table travel record mode can be selected via *modes of operation* = `0xFF` = `-1`.

Table travel record mode uses pre-defined positions. Each target position is defined by a motion block. Several motion blocks can be defined.

For a description of motion blocks, refer to the "Positioning" application manual.

Relevant objects:

OUT-PZD1	Control word	IN-PZD1	Status word
		IN-PZD5[r)]	Actual position
OUT-PZD11[r)]	Modes of operation	IN-PZD11[r)]	Modes of operation display
P.1106	Error threshold	**P.418**	Minimum frequency
P.1119	Contouring error time	**P.419**	Maximum Frequency
P.1109	Act. contouring error	**P.1179**	Emergency ramp
P.1165	Target window	**P.1246**	Actual Motion Block
P.1166	Target window time	**P.1249**	Motion block to resume

r) permissible only when the recommended settings from"Motion Control Mapping for PROFINET" have been made.

In table travel record mode, the mode-specific bits of the control word and the status word are used as follows:

Control word	
Bit	
0	Switch on
1	Enable voltage
2	Quick stop (Low active)
3	Enable operation
4	Sequence mode
5	
6	Resume
7	Fault reset
8	Halt
9	Start motion block
10	
11	Motion block select 0
12	Motion block select 1
13	Motion block select 2
14	Motion block select 3
15	Motion block select 4

Status word	
Bit	
0	Ready to switch on
1	Switched on
2	Operation enabled
3	Fault
4	Voltage enabled
5	Quick stop (Low Active)
6	Switch on disabled
7	Warning
8	Motion block in progress
9	Remote
10	Target reached
11	Internal limit active
12	In gear
13	Following error
14	
15	Warning 2

Control word

Identification	Value	Description
Sequence mode **Bit 4**	0	Single motion
	1	Automatic sequence
Resume **Bit 6**	0	Start motion block = motion block switching
	1	Start motion block = last active motion block.
Halt **Bit 8**	0	Execute command from bit 4 "Sequence mode"
	1	Stop axis with ramp of current motion block The frequency inverter remains in "Operation enabled" status.
Start motion block **Bit 9**	0	Stop axis with ramp of current motion block
	0 → 1	Execute motion block(s)
Motion block select 0...4 **Bit 11...15**	n	Start motion block = n + 1

Motion block select

Control word															
15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Motion block select						Sta	Stop		Res		Seq				
4	**3**	**2**	**1**	**0**											

Start motion block = motion block select +1

Motion block select					Resulting start motion block
4	3	2	1	0	
0	0	0	0	0	1
0	0	0	1	1	4
1	0	0	0	0	17
1	1	1	1	1	32

Status word

Identification	Value	Description
Motion block in progress **Bit 8**	0	Single motion: Motion block complete
		Automatic sequence: Sequence complete
	1	Single motion/automatic sequence active
Target reached **Bit 10**	0	Halt = 0: Target position not reached yet (only motion blocks with positioning)
		Halt = 1: Axis decelerated
	1	Halt = 0: Target position reached (only motion blocks with positioning)
		Halt = 1: Axis has speed 0
In gear **Bit 12**	0	Electronic gear not coupled
	1	Electronic gear coupled
Following error **Bit 13**	0	No following error
	1	Following error

Basic functions

The control bit "Automatic sequence" defines if a single motion (*Automatic sequence* = 0) or and automatic motion block sequence (*Automatic sequence* = 1) is to be executed.

In both cases, the selection of the required motion block (motion block number of single motion or start motion block number of automatic sequence) is calculated by the motion block switching feature with the rising edge of "*Start motion block"*.

"Motion block is being processed" is set to "1" while a selected motion block or an automatic sequence is being executed. "Motion block is being processed" will remain set to "1" until the motion block sequence is complete. When a single motion block is executed, "Motion block is being processed" will be set to "0" once the single motion block is complete. When an automatic sequence is executed, "Motion block is being processed" will be set to "0" once a motion block with setting 0 for Next motion block (end of motion block), -1 (error stop), -2 (Stop, error) or -3 (emergency stop, error) is reached.

During the automatic processing of motion blocks, the currently processed motion block is indicated by parameter *Actual motion block* **1246**.

If the execution of motion blocks is interrupted by setting "Start motion block" to "0", the drive will stop with the ramp set in the current motion block. The interrupted motion block or automatic motion block sequence can be continued by setting "Resume" and a rising signal edge for "Start motion block". If "Resume" is set to "1" and no valid motion block is available, the motion block selected by the motion block switching function will be used. A valid motion block is indicated by parameter *Motion block to Resume* **1249**. *Motion block to Resume* **1249** reads -1, if no valid motion block is present or if the last motion block or motion block sequence was not interrupted.

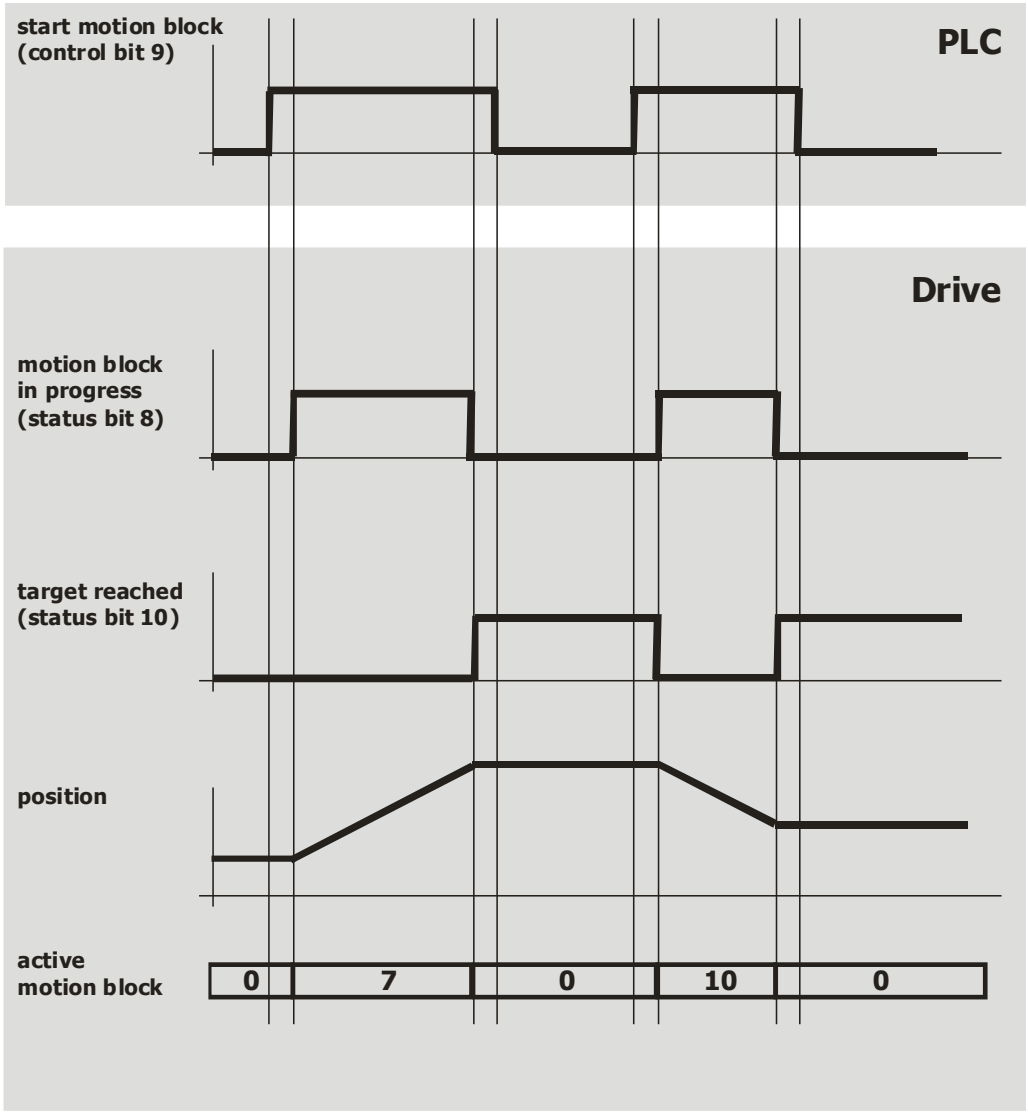
"Target reached" is set if the actual position of motion blocks with absolute or relative positioning reaches the *position window*.

"In Gear" is set when the electronic gear function is used and the electronic gear is coupled (synchronous running).

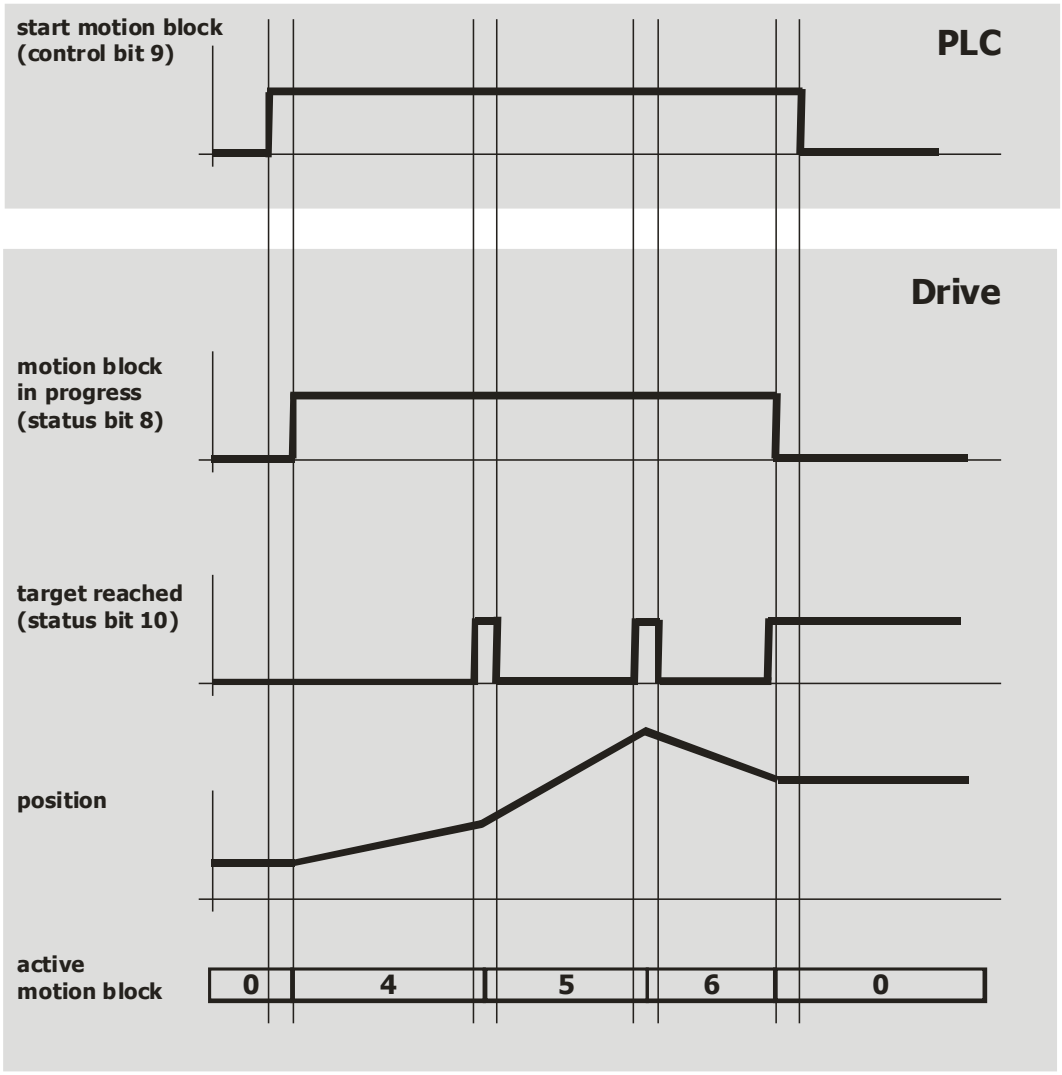
Setting *Halt* to "1" will stop a currently executed motion block. The axis is stopped with the ramp set in the current motion block. "Target reached" is set to "1" when the speed reaches value 0. The drive remains in "Operation enabled" status. To continue the interrupted motion block, reset *Halt* to "0".

Examples:

"single motion block" **sequence mode (control bit 4) = 0**
2 motion blocks 7 + 10



" motion block sequence" sequence mode (control bit 4) = 1
sequence = motion block 4, 5, 6

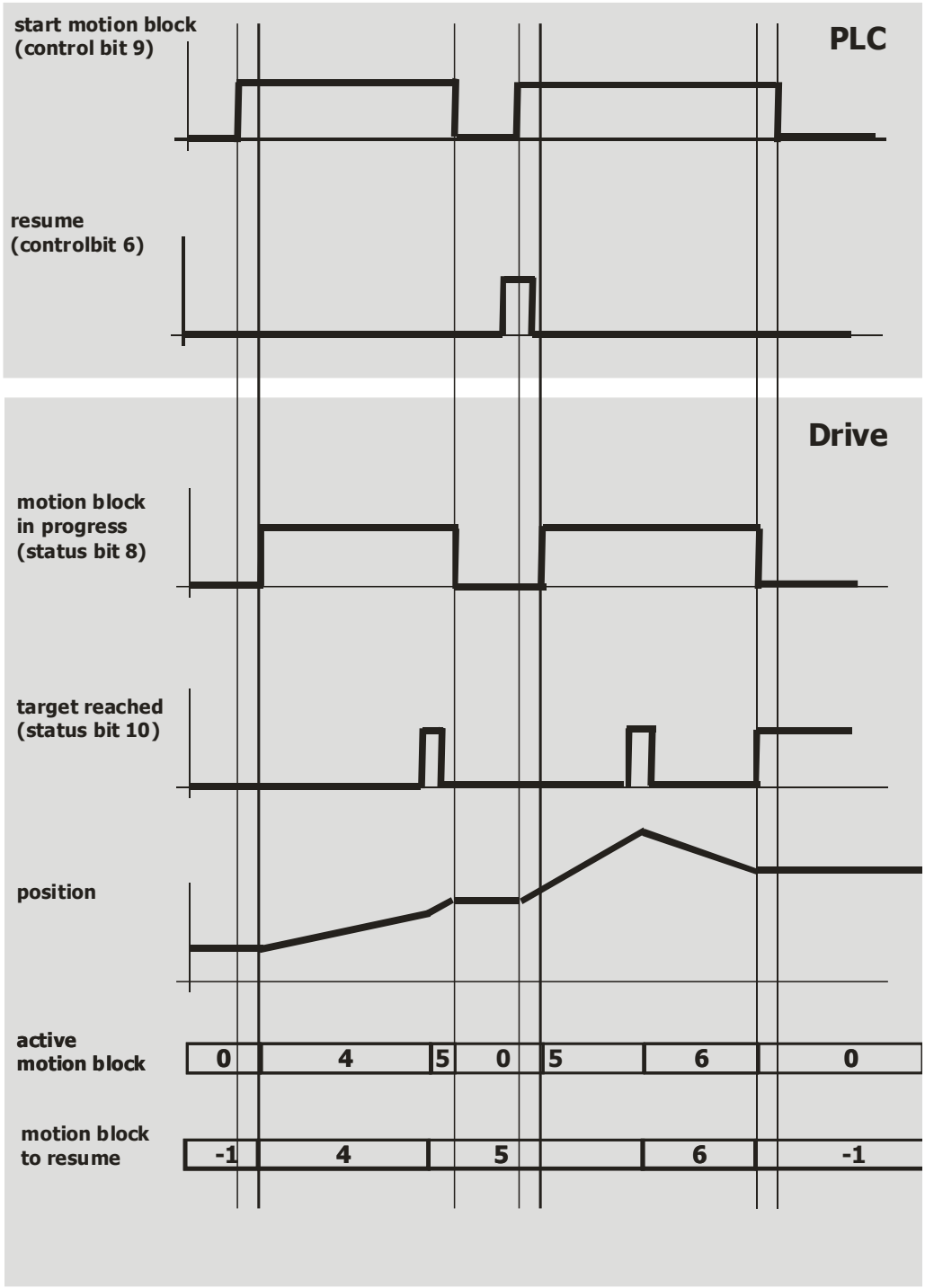


Interrupted motion blocks sequence

Automatic sequence (control bit 4) = 1,

Sequence = Motion block 4, 5, 6

Motion block 5 interrupted



Sequence example

In order to start "Table travel record mode", the correct sequence must be sent by the PLC.

	OUT IN	PZD1 Control word Status word	PZD11 r) Modes of operation Mod. Of. Op. Displ.	Remark
1		0x0000 0x0050	any any	Disable voltage Switch On Disabled
2			0xFFFF (=-1) 0xFFFF (=-1)	(Table travel record mode)
3		0x0006 0x0031	0xFFFF (=-1) 0xFFFF (=-1)	Shutdown Ready to switch on
4		0x0007 0x0033	0xFFFF (=-1) 0xFFFF (=-1)	Switch On Switched On
5a		0x000F 0xnn37	0xFFFF (=-1) 0xFFFF (=-1)	Enable operation Operation enabled
5b		0x020F 0xn337 0xn637	0xFFFF (=-1) 0xFFFF (=-1) 0xFFFF (=-1)	Start motion block 1 as single motion block Operation enabled and Positioning active. Operation enabled and Target reached.
5c		0x0A0F 0xn337 0xn637	0xFFFF (=-1) 0xFFFF (=-1) 0xFFFF (=-1)	Start motion block 2 as single motion block Operation enabled and Positioning active. Operation enabled and Target reached.
5d		0x120F 0xn337 0xn637	0xFFFF (=-1) 0xFFFF (=-1) 0xFFFF (=-1)	Start motion block 3 as single motion block Operation enabled and Positioning active. Operation enabled and Target reached.
5e		0x021F 0xn337 0xn637	0xFFFF (=-1) 0xFFFF (=-1) 0xFFFF (=-1)	Start motion block 1 as sequence motion block Operation enabled and Positioning active. Operation enabled and Target reached.
5f		0x004F 0xn337 0xn637	0xFFFF (=-1) 0xFFFF (=-1) 0xFFFF (=-1)	Resume previous motion block as single motion block Operation enabled and positioning active. Operation enabled and target reached.
5g		0x005F 0xn337 0xn637	0xFFFF (=-1) 0xFFFF (=-1) 0xFFFF (=-1)	Resume previous motion block as sequence motion block Operation enabled and positioning active. Operation enabled and target reached.

r) permissible only when the recommended settings from 8.3 "Motion Control Mapping for PROFINET" have been made

WARNING

Dangerous state due to new mode!

If the mode of operation, 'modes of operation,' is changed during operation (control word = 0xnnnF), a dangerous state may occur in the new mode.

BONFIGLIOLI VECTRON recommends checking the status word before changing the mode of operation (e.g. for status 0xnn33).

Once the ANG has correctly processed the sequence of the first four control words and responded with the corresponding status word, the ANG is ready for operation (dark table area).

In state "operation enabled" (0xnnnF), the state of the Motion Control can be changed (white table area).

Bit 9 "Start motion block" must be active during positioning. If bit 9 is reset to "0", the positioning operation is interrupted.

As long as 0x0007 is active, the mode of operation can also be changed safely. Once *modes of operation* has been set to another value, operation can be started with a corresponding sequence.

12.4.6 Move away from limit switch mode

Move away from limit switch mode can be selected via *modes of operation* = `0xFE` = `-2`.

In *Move away from limit switch* mode, the drive moves back from a triggered limit switch to the permissible travel range.

Relevant objects:

OUT-PZD1	Control word	IN-PZD1	Status word
OUT-PZD11[r)]	Modes of operation	IN-PZD11[r)]	Modes of operation display
P.419	Maximum Frequency	**P.1133**	Creep Speed
P.1179	Emergency Ramp	**P.1134**	Acceleration

r) permissible only when the recommended settings from 8.3 "Motion Control Mapping for PROFINET" have been made

In *Move away from limit switch mode*, the mode-specific bits of the control word and the status word are used as follows:

Control word	
Bit	
0	Switch on
1	Enable voltage
2	Quick stop (Low active)
3	Enable operation
4	Move away from limit switch
5	
6	
7	Fault reset
8	Halt
9	
10	
11	
12	
13	
14	
15	

Status word	
Bit	
0	Ready to switch on
1	Switched on
2	Operation enabled
3	Fault
4	Voltage enabled
5	Quick stop (Low Active)
6	Switch on disabled
7	Warning
8	
9	Remote
10	Target reached
11	Internal limit active
12	
13	
14	
15	Warning 2

NOTICE

"Move away from limit switch mode" will always work with hardware limit switches. In the case of software limit switches, the mode will only work if a software limit switch *Fault reaction* **1144** with error stop was selected. If a setting with warning (e.g. "10-Warning") was selected, the software limit switch will not trigger an error, thus "Move away from limit switch mode" will not clear the software limit switch.

NOTICE

"Move away from limit switch mode" must not be used when one of the following error messages occurs:

- F1444 Pos. limit switch < Neg. limit switch
- F1445 Both limit switches at the same time
- F1446 Wrong limit switch wiring

If one of these errors has occurred, the wiring and parameter settings must be checked first before resuming operation.

Control word

Identification	Value	Description
Move away from limit switch mode **Bit 4**	0	Do not start or stop movement.
	1	Start (or resume) movement from limit switch to travel range.
Halt **Bit 8**	0	Execute command from bit 4 "Move away from limit switch".
	1	Stop axis with ramp of current motion block (The frequency inverter remains enabled in "Operation enabled" status).

Status word

Identification	Value	Description	
Target reached **Bit 10**	0	Halt = 0:	Limit switch still active
		Halt = 1:	Axle decelerated
	1	Halt = 0:	Limit switch cleared
		Halt = 1:	Axle has speed 0

Basic functions

In mode -2 "Move away from limit switch", the drive is cleared from a triggered hardware limit switch or software limit switch. The direction of rotation depends on the active limit switch: If the positive limit switch is active, the drive moves to negative direction and vice versa.

"Move away from limit switch" mode is started in status "Operation enabled" by control word bit 4 "Move away from limit switch". The drive is accelerated with the ramp from parameter *Acceleration* **1134** to the speed set in parameter *Creep speed* **1133**. Once the active limit switch has been cleared, the drive is stopped. Once speed 0 has been reached, status word bit 10 "Target reached" will be set.

When both directions of rotation are blocked, e.g. due to simultaneous triggering of positive and negative limit switch, error message "F1449 Both directions locked". In this case, the function "Move away from limit switch" cannot be used.

NOTICE

In the clearing phase of a hardware limit switch, the hysteresis defined in parameter *Hysteresis* **1149** will be active. After detection of the limit switch edge, the axis will be moved on, at least by the defined hysteresis distance.

Setting *Halt* to "1" will stop the started clearing operation. The axis will be stopped. Status bit "Target reached" is set to "1" when the speed reaches value 0. The drive remains in "Operation enabled" status. By resetting *Halt* to "0", the interrupted clearing operation will be continued, and "Target reached" will be reset to "0".

Sequence example

In order to clear the limit switches, the correct sequence must be sent by the PLC.

	OUT IN	PZD1 Control word Status word	PZD11 r) Modes of operation Mod. Of. Op. Displ.	Remark
1		0x0000 0x0050	any any	Disable voltage Switch On Disabled
2			0xFFFE (=-2) 0xFFFE (=-2)	(Move away from limit switch)
3		0x0006 0x0031	0xFFFE (=-2) 0xFFFE (=-2)	Shutdown Ready to switch on
4		0x0007 0x0033	0xFFFE (=-2) 0xFFFE (=-2)	Switch On Switched On
5		0x000F 0xnn37	0xFFFE (=-2) 0xFFFE (=-2)	Enable Operation. Operation enabled
6a		0x001F 0xn2B7 0xn637	0xFFFE (=-2) 0xFFFE (=-2) 0xFFFE (=-2)	Move away from limit switch mode Operation enabled, limit switch active, clearing active Operation enabled and limit switch cleared (target reached).

r) permissible only when the recommended settings from 8.3 "Motion Control Mapping for PROFINET" have been made

WARNING

Dangerous state due to new mode!

If the mode of operation, modes of operation, is changed during operation (control word = 0xnnnF), a dangerous state may occur in the new mode.

BONFIGLIOLI VECTRON recommends checking the status word before changing the mode of operation (e.g. for status 0xnn33).

Once the ANG has correctly processed the sequence of the first four control words and responded with the corresponding status word, the ANG is ready for operation (dark table area).

In state "operation enabled" (0xnnnF), the state of the Motion Control can be changed (white table area).

Bit 4 "Move away from limit switch" must be active in the clearing phase. If bit 4 is reset to "0", the clearing operation is interrupted.

As long as 0x0007 is active, the mode of operation can also be changed safely. Once *modes of operation* has been set to another value, operation can be started with a corresponding sequence.

12.4.7 Electronic gear: Slave

The mode *Electronic gear: Slave* can be selected via *modes of operation* = 0xFD = -3.

In *Electronic gear slave mode* the drive follows a master drive as a slave drive.

Relevant objects:

OUT-PZD1	Control word	IN-PZD1	Status word
		IN-PZD5[r)]	Actual position
OUT-PZD11[r)]	Modes of operation	IN-PZD11[r)]	Modes of operation display
419	Maximum Frequency	**1179**	Emergency stop ramp
1106	Following error window	**1119**	Following error time
1165	Position window	**1166**	Target window time
1123 & **1124**	Electronic Gear: Gear factor	**1125**, **1126**, **1127**, **1142**	Electronic Gear: Phasing 1 … Electronic Gear: Phasing 4

r) permissible only when the recommended settings from 8.3 "Motion Control Mapping for PROFINET" have been made

In *Electronic gear: Slave* mode, the operation mode specific bits of the control word and the status word are used as follows:

Control word	
Bit	
0	Switch on
1	Enable voltage
2	Quick stop (Low active)
3	Enable operation
4	Start Gearing
5	Start M/S Correction
6	Direct Sync
7	Fault reset
8	Halt
9	Start phasing
10	
11	
12	Phasing switching 0
13	Phasing switching 1
14	
15	

Status word	
Bit	
0	Ready to switch on
1	Switched on
2	Operation enabled
3	Fault
4	Voltage enabled
5	Quick stop (Low Active)
6	Switch on disabled
7	Warning
8	Phasing Done or M/S Correction Done
9	Remote
10	Target reached / In gear
11	Internal limit active
12	M/S Position Correction successful
13	Following error
14	
15	Warning 2

WARNING

Dangerous state due to faulty parameterization

The function Master/Slave Position Correction is only allowed to be used after complete setup of this function.

- Check for parameter setup chapter "Master/Slave Position Correction".

Control word

Identification	Value	Description
Start electronic gear **Bit 4**	0	Stop drive with ramp **1296** *S.Deceleration*.
	1	Start electronic gear with master speed reference value with ramp **1295** *S.Acceleration*.

Start M/S Correction **Bit 5**	0	M/S Correction not started.
	1	Start Master/Slave Position correction. See chapter "Master/Slave Position Correction".
Direct Sync **Bit 6**	0	Direct Synchronisation enabled.
	1	Direct Synchronisation disabled.
Halt **Bit 8**	0	Execute command from bit 4 "Start el. gear".
	1	Stop axis with ramp of current motion block The frequency inverter remains in "Operation enabled" status.
Start Phasing **Bit 9**	0	Phasing disabled / aborted.
	1	Start Phasing with profile defined by Bits 12 & 13.
Phasing select 0...1 **Bit 12...13**	n	Phasing Profile = n + 1

Phasing select

Control word															
15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
		Ph. sw.				Pha	Stop		DS	MS	SG				
		1	**0**												

Phasing profile = Phasing switch over +1

Phasing select		Phasing profile
Bit 13	Bit 12	
0	0	1
0	1	2
1	0	3
1	1	4

Status word

Identification	Value	Description	
Phasing done (or M/S Correction done) **Bit 8**	0	Phasing (or M/S Correction) in process or not started yet.	
	1	Phasing (or M/S Correction) done.	
Target reached/ gear in **Bit 10**	0	Halt = 0:	Electronic gear (still) not in gear
		Halt = 1:	Axis decelerated.
	1	Halt = 0:	Electronic gear in gear.
		Halt = 1	Axis has speed 0.
M/S Position Correction successful **Bit 12**	0	M/S Correction is running or wasn't started yet.	
	1	M/S Correction finished. See chapter "Master/Slave Position Correction".	
Following error **Bit 13**	0	No following error.	
	1	Following error.	

Basic functions

Mode "-3 Electronic gear: Slave" implements a mode for a slave drive in the electronic gear to a master drive. The master of the electronic gear must be connected to the slave via signal cables or System Bus (recommended). The master input is selected in the Slave via parameter *Master position source* **1122**.

Master Position Source **1122**		Function
0 -	Off	No source selected.
1 -	Encoder 1	The current speed and position of the master drive is taken over from encoder input 1.
2 -	Encoder 2 / Resolver	The current speed and position of the master drive is taken over from encoder input 2 or resolver.

11 -	RxPDO1.Long1 extrapolated	The current position of the master drive is taken over by the process data channel RxPDO1.Long1 of the system bus. Additionally, the data received are extrapolated, even for slow settings of TxPDO Time of the master. Depending on the application, select a setting of the corresponding TxPDO.Long of the master: – "606 – Internal act. Position (16/16)", mechanical position of master drive. Value will not change abruptly when a homing operation of the master drive is completed. – "607 – Act. Position (16/16)", mechanical position of master drive. Value will jump when the master drive carries out a homing operation. – "620 – motion profile gen.: internal reference position", reference position of master drive; advantage: Improved controller properties. Value will not change abruptly when a homing operation of the master drive is completed. – "627 - Motion profile gen.: reference position", reference position of master drive; advantage: Improved controller properties. Value will jump when the master drive carries out a homing operation. Settings 607 and 627 are only to be used in exceptional situations. In most applications, source 606 or 620 is the better setting.

In setting "11 - RxPDO1.Long1 extrapolated" of parameter *Master position source* 1122, the *Operation mode* 1180 of the system bus synchronization must be set to 1 or 10 to ensure reliable functional operation.

Operation mode **1180**	
0 -	Off [1]
1 -	RxPDO1 [2]
2 -	RxPDO2 [3]
3 -	RxPDO3 [3]
10 -	SYNC

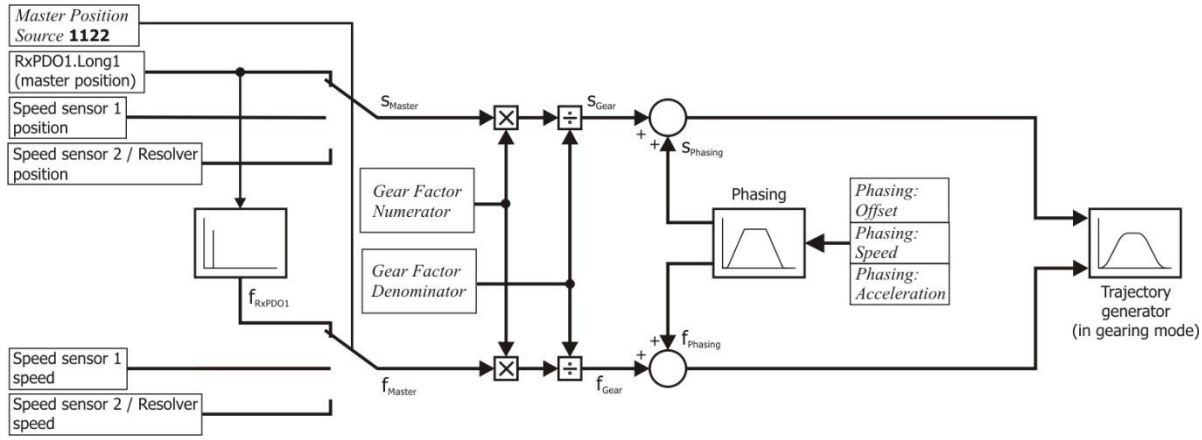
[1] If the error message "F1453 Systembus-Synchronization not activated" is displayed when the slave drive is started, operation mode 1, 2, 3 or 10 must be selected.
[2] Synchronization of processing with data message or cyclic sending of SYNC message.
[3] Not recommended for el. gear because no extrapolation carried out.

Synchronization between several drives must be performed at high updating rates in order to guarantee optimum results. In the transmitter of the TxPDO object, set a low value for the time (e.g. *TxPDO1 Time* **931**). If you use the SYNC function of Systembus, set parameter *SYNC time* **919** to a lower value.

Note that, due to these settings, the bus load of the Systembus must provide for sufficient reserves for proper operation.

Systembus is described in the manuals of the expansion modules with Systembus interface.

Block diagram: electronic gear and phasing function



The master position and speed are multiplied by the *gear factor*. When phasing is started, the phasing profile is added to the master speed until the phasing offset is reached.

Start electronic gear and phasing function

The electronic gear is started by control word bit 4 "Start electronic gear". The drive accelerates as specified in *Acceleration* **1295**. Once the slave speed is coupled into the master, status word bit 10 "Target reached/In Gear" is set. The conditions for "In Gear" status are set via parameters *In Gear'-Threshold* **1168** and *In Gear'-Time* **1169**.

"Target reached/In Gear" is set when the electronic gear function is used and electronic gear synchronous running is reached.

Setting *Halt* "1" will stop a currently executed movement. The axis is stopped with the ramp **1296** *S.Deceleration*. "Target reached" is set to "0" to start the deceleration and to "1" when the speed reaches value 0. The drive remains in "Operation – enabled" status. To continue the interrupted movement, reset *Halt* to "0". Bit "Target reached" is set to "0" to start the acceleration and to "1" when the conditions for "Gear in" of parameters *In Gear'-Threshold* **1168** and *In Gear'-Time* **1169** are reached.

Phasing

With the phasing function, the slave position is offset from the master position received by the value of *Phasing: Offset* **1125**.

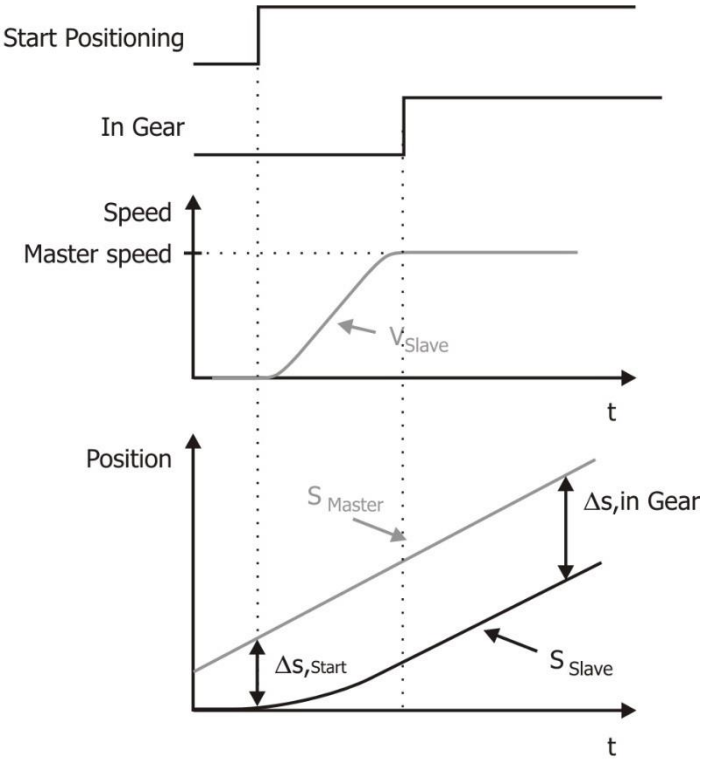
Function without direct synchronization

("Standard Synchronization")

The drive accelerates the master speed with the ramps parameterized in the motion block. As soon as the master speed is reached for the first time, the drive is synchronized with the master drive. The slave is engaged at the current position and operates at a synchronous angle to the master. In the case of a relative positioning operation, this engaging position is used as the start position.

The acceleration and deceleration for synchronizations follow an S-curve.

The relative position change due to acceleration is not compensated.

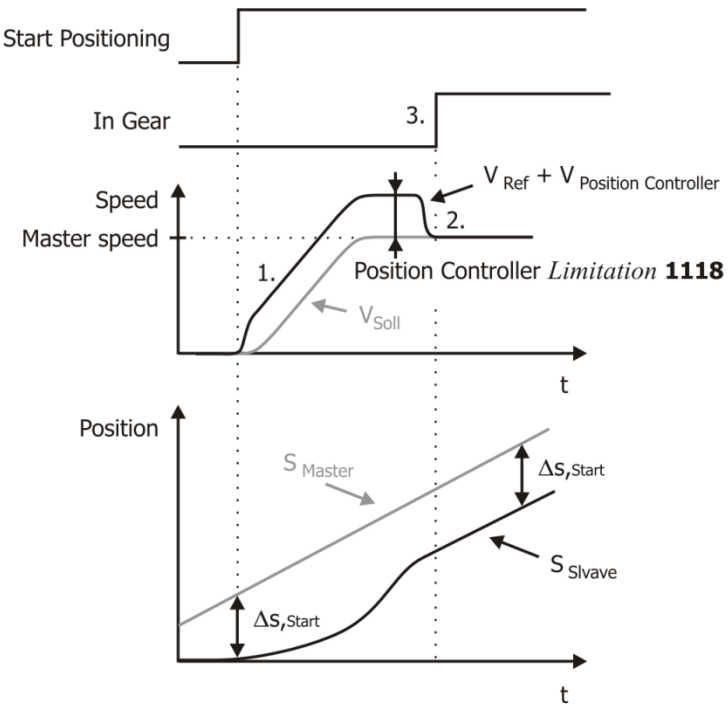


Function with direct synchronization

The drive accelerates the master speed with the ramps parameterized in the motion block. When the motion block is started, the drive is synchronized with the master drive directly. The master position is processed directly by the position controller.

The acceleration and deceleration for synchronizations follow an S-curve.

The relative position change due to acceleration is compensated by the position controller.



Master/Slave Position Correction

NOTICE

When using this functionality master drive and slave drive have to use the same mechanical characteristics (i.e. gear transmission ratios) and use the same reference system.

The Master/Slave Position Correction offers as part of the Electronic Gear the possibility to synchronize the absolute Position of the Slave to the absolute Position of the master.

This function is helpful in example in applications, in which drives often work independently from each other and have to work together for certain activities. In example this could be the case in crane applications, where normal loads are operated intently from each other and which are switched together for heavy loads. To speed up the switching together process, the Master/Slave Position correction can be used to synchronize the absolute position of the Slave with the absolute position of the Master.

Additionally by using an Offset a relative reference can be set up in the target position.

Preparations Master drive

The Master drive must be set up as follows:

TxPDO2 Identifier **927 =** `640` (or a different unused Identifier)

TxPDO2 Function **932** = `1 - controlled by time` or `2 - controlled by SYNC`

TxPDO2.Long1 **964** = `743 - Act. Position` [User Units]

Additionally the following parameters must be set according to the electronic gear: *TxPDO1.Long1* **954** corresponding to the description of *Master Position Source* **1122**

TxPDO1 Identifier **925 =** `384` (or a different unused Identifier)

TxPDO1 Function **930** = `1 - controlled by time` or `2 - controlled by SYNC`

Preparations Slave drive

The Slave drive must be set up as follows:

RxPDO2 Function **926 =** `640` (or the Identifier defined in the Master drive)

Additionally the following parameters must be set according to the electronic gear:

RxPDO1 Function **924 =** `384` (or the Identifier defined in the Master drive)

Source Master position **1122** = `11 - RxPDO1.Long`

The function Master/Slave Position Correction expects the Target Position [u] always in RxPD2.Long. When using this function RxPDO2.Long1 and also RxPDO2.Word1, RxPDO2.Word2, RxPDO2.Boolean1 and RxPDO2.Boolean2 are not allowed to be used for any other purpose.

Starting of Master/Slave Position Correction in Slave drive

To start the Master/Slave Position correction at first Bit 4 and then Bit 5 have to be set in the Control word. Bit 5 is only allowed to be set when Bit 10 In Gear is shown in the Status word.

By setting Bit 5 in the Control word the Slave drive is started to position to the Master position + Offset.

The acceleration is done with Parameter *Acceleration* **1134**. The used velocity can be set up via Parameter *Fast Speed* **1132**.

As long as the Master/Slave Position correction is executed, Bit 12 is deactivated in the Status word. When the Master/Slave Position correction is finished successfully Bit 12 is set.

During the Correction sequence the Status word bit 8 "Master/Slave Position correction" is set to "Low". As soon as the Master/Slave Position correction is finished or cancelled, the Bit is set to "High". After first switch-on (or after a device reset) the "Phasing Done" bit is also "Low".

Since Bit 8 is also used for Phasing, always the last started function is signaled by this bit.

Offset Reference

The Offset for the M/S Synchronization can be set via *M/S Synchronization offset* **1284**.

Parameters		Settings		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
1284	M/S Synchronisationsoffset	-2147483647 u	2147483647 u	0 u

Application limitations

The function can be used in most of all applications without any limitations. In applications with very long travelling distances the following must be checked:

- The position difference to be compensated must not be greater than 2^{15}-1 motor revolutions.
- The position difference to be compensated must not be greater than 2^{31}-1 user units.

Depending on the used reference system it can vary, which limit is decisive. Always the smaller limit must be complied with.

A motor with a reference speed of 6000 rpm would have to travel for around 5.5 minutes into one direction to exceed this limit.

Sequence example

In order to start "Electronic Gear: Slave mode", the correct sequence must be sent by the PLC.

	OUT IN	PZD1 Control word Status word	PZD11 r) Modes of Operation Mod. Of. Op. Displ.	Remark
1		0x0000 0x0050	any any	Disable voltage Switch On Disabled
2			0xFFFD (=-3) 0xFFFD (=-3)	(Electronic Gear: Slave mode)
3		0x0006 0x0031	0xFFFD (=-3) 0xFFFE (=-3)	Shutdown Ready to switch on
4		0x0007 0x0033	0xFFFD (=-3) 0xFFFE (=-3)	Switch On Switched On
5		0x000F 0xnn37	0xFFFD (=-3) 0xFFFE (=-3)	Operation enabled, reference speed "0" Operation enabled
6a		0x001F 0xn327 0xn337 0xn727 0xn737	0xFFFD (=-3) 0xFFFD (=-3) 0xFFFD (=-3) 0xFFFD (=-3) 0xFFFD (=-3)	Start electronic gear without direct synchronization Operation enabled, Slave not coupled (yet), Phasing not finished. Operation enabled, Slave not coupled (yet), Phasing finished. Operation enabled, Slave coupled, Phasing not (yet) finished. Operation enabled, Slave coupled, Phasing finished.
6b		0x005F See 6a	0xFFFD (=-3) 0xFFFD (=-3)	Start Electronic Gear with Direct Synchronisation See 6a
7a		0x021F See 6a	0xFFFD (=-3) 0xFFFD (=-3)	Start Electronic Gear **without** Direct Synchronisation and Phasing Profile 1 See 6a
7b		0x121F See 6a	0xFFFD (=-3) 0xFFFD (=-3)	Start Electronic Gear without Direct Synchronisation and Phasing Profile 2 See 6a

7c		0x221F See 6a	0xFFFD (=-3) 0xFFFD (=-3)	Start Electronic Gear without Direct Synchronisation and Phasing Profile 3 See 6a
7d		0x321F See 6a	0xFFFD (=-3) 0xFFFD (=-3)	Start Electronic Gear without Direct Synchronisation and Phasing Profile 4 See 6a
8a		0x025F See 6a	0xFFFD (=-3) 0xFFFD (=-3)	Start Electronic Gear **with** Direct Synchronisation and Phasing Profile 1 See 6a
8b		0x125F See 6a	0xFFFD (=-3) 0xFFFD (=-3)	Start Electronic Gear **with** Direct Synchronisation and Phasing Profile 2 See 6a
8c		0x225F See 6a	0xFFFD (=-3) 0xFFFD (=-3)	Start Electronic Gear **with** Direct Synchronisation and Phasing Profile 3 See 6a
8d		0x225F See 6a	0xFFFD (=-3) 0xFFFD (=-3)	Start Electronic Gear **with** Direct Synchronisation and Phasing Profile 4 See 6a
9		0x001F 0x003F 0xnn37 0x1n37	0xFFFD (=-3) 0xFFFD (=-3)	Enable Operation, the Slave drive synchronizes to the Master position. Operation enabled M/S Position Correction finished.

r) permissible only when the recommended settings from 8.3 "Motion Control Mapping for PROFINET" have been made

WARNING

Dangerous state due to new mode!

If the mode of operation, modes of operation, is changed during operation (control word = 0xnnnF), a dangerous state may occur in the new mode.

BONFIGLIOLI VECTRON recommends checking the status word before changing the mode of operation (e.g. for status 0xnn33).

Once the ANG has correctly processed the sequence of the first four control words and responded with the corresponding status word, the ANG is ready for operation (dark table area).

In state "operation enabled" (0xnnnF), the state of the Motion Control can be changed (white table area).

Bit 4 "Start electronic gear" must be active during the movement. If bit 4 is reset to "0", the movement is interrupted.

As long as 0x0007 is active, the mode of operation can also be changed safely. Once *modes of operation* has been set to another value, operation can be started with a corresponding sequence.

Bit 5 "Start Position Correction" is only allowed to be used when the Slave is in gear (Status word Bit 10).

Bit 5 "Start Position Correction" should be used for optimum results when the master drive doesn't move.

When Bit 5 of the Control word is reset to "0" the movement is interrupted.

13 Analog input/Analog output MF4

The function of terminal X410B.4 is configured by *Operation mode X410B.4* **502**.

Operation mode **X410B.4**		Function
1 -	Voltage input 0…10 V	Unipolar Voltage input DC 0…10 V.
2 -	Current input 0…20 mA	Unipolar Current input DC 0…20 mA.
3 -	Digital input	Usage as digital input
4 -	Voltage input -10…10 V	Bipolar Voltage input DC -10…10 V.
5 -	Voltage output 0…10 V	Unipolar Voltage output DC 0…10 V.
11 -	Motor PTC	Evaluation of a Motor PTC. Also consider *Therm.Contact* **204** and *Motortemp. Operation Mode* **570**.
12 -	Motor KTY	Evaluation of a Motor KTY. Also consider *Therm.Contact* **204** and *Motortemp. Operation Mode* **570**.
13 -	Motor PT1000	Evaluation of a Motor PT1000. Also consider *Therm.Contact* **204** und *Motortemp. Betriebsart* **570**.

13.1 Analog input MF4IA

The terminal X410B.4 can be used as voltage input or current input.

13.1.1 General

The analog input of the EM-AUT module can optionally be configured as a voltage or a current input. Parameterization of the input signal is done by the definition of a linear characteristic and assignment as a

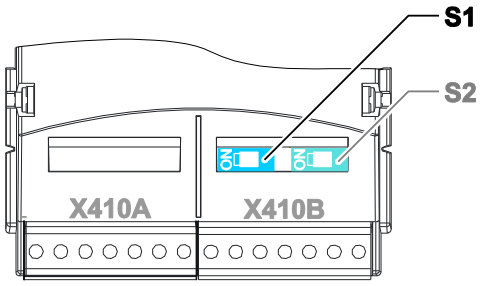
- reference value source
  (can be selected via the parameter *Reference frequency source* **475**),
- reference percentage source
  (can be selected via the parameter *Reference percentage source* **476**),
- actual percentage source
  (can be selected via the parameter *Actual percentage source* **478**, in configuration x11) or
- limit value source
  (can be selected via the parameter *Limit Source* **734**…**737**).

The terminal X410B.4 is assigned as function in the selection tables with MF4 (MF4ID for digital input, MF4IA for analog input, MF4OA for analog output).

13.1.2 Configuration voltage/current input

The terminal X410B.4 can be used optionally as analog input, analog output, PTC, KTY, PT1000 or digital input.

Analog input/ Analog output MF4: Switch **S1** enables a switchover of the operation mode for an analog current signal of 0… 20 mA between "Input" and "Output". The selection of current input and voltage input is done via the selection of the operation mode in the software.



Operation mode – switch S1		Function
OFF -	Operation mode "input"	OFF (to the right) – MF4IA is configured an an input. The operation modes "analog", "digital", "voltage" or "current" are configured within the software.
ON -	Operation mode "output"	ON (to the left) – MF4IA is configured as a voltage output.

13.1.3 Characteristic

The mapping of the analog input signals onto a frequency or percentage reference value is possible for various demands. The parameterization is to be done via two points of the linear characteristic of the reference channel.

The characteristic point 1, with the coordinates X1 and Y1, and the characteristic point 2, with the coordinates X2 and Y2, are to be set in the four data sets.

The characteristic points X1 and X2 are stated as percentages, as the analog input can be switched as a current or voltage input via switch S1.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
564	Characteristic point X1	-100.00 %	100.00 %	-98.00 %
565	Characteristic point Y1	-100.00 %	100.00 %	-100.00 %
566	Characteristic point X2	-100.00 %	100.00 %	98.00 %
567	Characteristic point Y2	-100.00 %	100.00 %	100.00 %

The coordinates of the characteristic points are related as a percentage to the analog signal, with 10 V or 20 mA, and the parameter *Maximum Frequency* **419** or parameter *Maximum reference percentage* **519**. The change of direction of rotation can be done via the digital inputs and/or by selecting the characteristic points.

The definition of the analog input characteristic can be calculated via the two-point form of the straight-line equation. The speed Y of the drive mechanism is controlled according to the analog control signal X.

$$Y = \frac{Y2 - Y1}{X2 - X1} \cdot (X - X1) + Y1$$

NOTICE

Monitoring of the analog input signal via the parameter *Error/Warning Behavior* **563** demands a check of the characteristic parameters. Sensible use is only possible if the *Characteristic point X1* **564** is in the positive range.

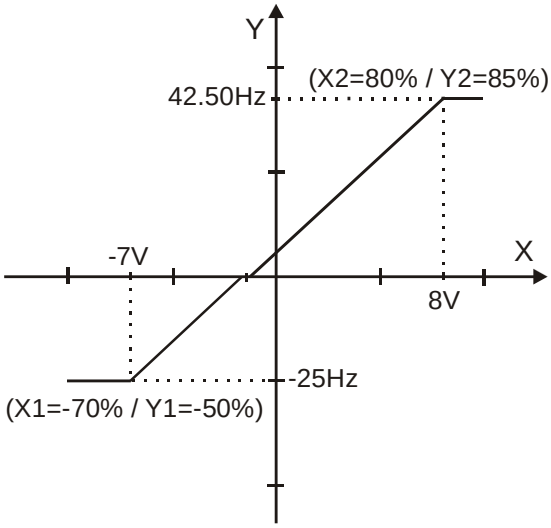
13.1.3.1 Examples

The analog input signal is mapped onto a reference value as a function of the characteristic. The following examples show the operation modes for an analog voltage signal. The parameter *Minimum Frequency* **418** is set to the value 0.00 Hz. The characteristic point 100% for the Y-axis corresponds to the parameter *Maximum Frequency* **419** of 50.00 Hz in the examples.

The various operation modes change the input characteristic as a function of the parameterized characteristic points. In the following examples, the areas of the coordinate system from which a characteristic point is displaced are marked.

Operation mode "4 – Voltage input -10...10 V"

In operation mode "4 – voltage input", the characteristic of the analog input can be freely set by stating two characteristic points.



Characteristic point 1:

X1 = -70.00% · 10 V = -7.00 V

Y1 = -50.00% · 50.00 Hz = -25.00 Hz

Characteristic point 2:

X2 = 80.00% · 10 V = 8.00 V

Y2 = 85.00% · 50.00 Hz = 42.50 Hz

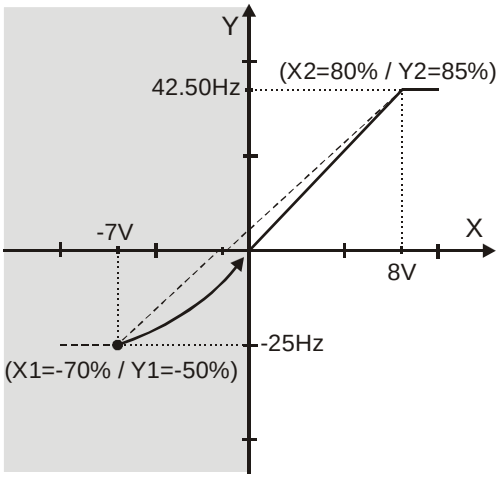
Tolerance band:

ΔX = 2.00% · 10 V = 0.20 V

The change of direction of rotation is done in the example at an analog input signal of -1.44 V, with a tolerance band of ±0.20 V.

Operation mode "1 – Voltage input 0...10 V"

In operation mode "1 – Voltage input", the characteristic points are displaced to the origin of the characteristics with a negative value for the X-axis.



Characteristic point 1:

X1 = -70.00% · 10 V = -7.00 V

Y1 = -50,00 % · 50.00 Hz = -25.00 Hz

Characteristic point 2:

X2 = 80.00% · 10 V = 8.00 V

Y2 = 85.00% · 50.00 Hz = 42.50 Hz

Tolerance band:

ΔX = 2.00% · 10 V = 0.20 V

The characteristic point 1 has been displaced to the origin. The parameter *Tolerance band* **560** is not taken into account in this example, as no change of sign of the reference frequency value takes place.

13.1.4 Scaling

The analog input signal is mapped to the freely configurable characteristic. The maximum admissible setting range of the drive mechanism is to be set according to the configuration selected via the frequency limits or the percentage value limits. In the parameterization of a bipolar characteristic, the minimum and maximum limit for both directions of rotation are taken over. The percentage values of the characteristic points are relative to the maximum limits selected.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
418	Minimum Frequency	0.00 Hz	599.00 Hz	3.50 Hz
419	Maximum Frequency	0.00 Hz	599.00 Hz	50.00 Hz

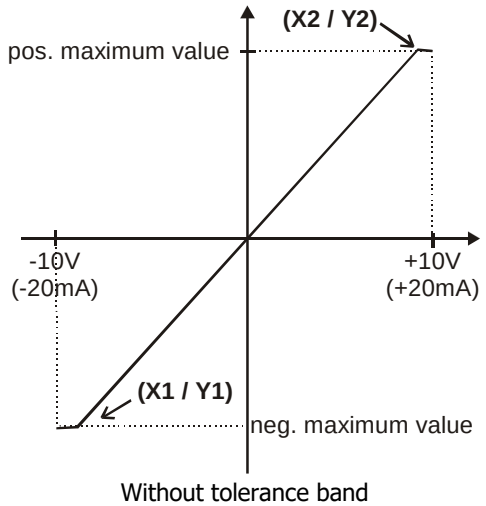
The controls use the maximum value of the output frequency, which is calculated from the parameter *maximum frequency* **419** and the compensated slip of the drive mechanism. The frequency limits define the speed range of the drive mechanism and the reference percentage values supplement the scaling of the input characteristic according to the configured functions.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
518	Minimum reference percentage	0.00 %	300.00 %	0.00 %
519	Maximum reference percentage	0.00 %	300.00 %	100.00 %

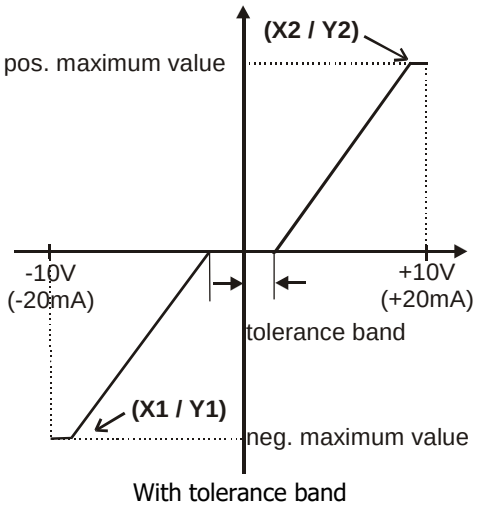
13.1.5 Tolerance band and hysteresis

The analog input characteristic with change of sign of the reference value can be adapted by the parameter *Tolerance band* **560** of the application. The tolerance band to be defined extends the zero crossing of the speed relative to the analog control signal. The percentage parameter value is relative to the maximum current or voltage signal.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
560	Tolerance band	0.00 %	25.00 %	2.00 %

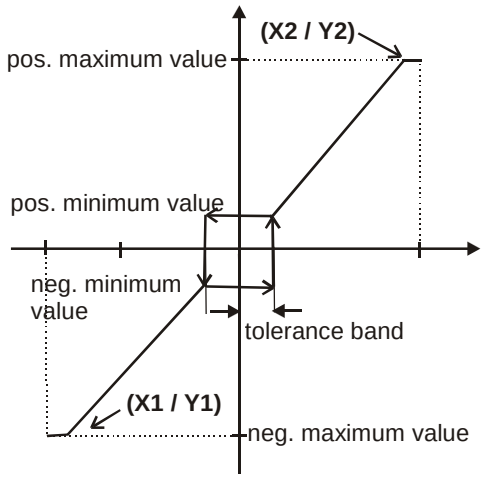


Without tolerance band



With tolerance band

The *Minimum Frequency* **418** or the *Minimum reference percentage* **518** set in the factory extends the parameterized tolerance band to the hysteresis.



With tolerance band and minimum value

For example, the output variable resulting from the positive input signals is kept at the positive minimum value until the input signal is below the value for the tolerance band in a negative direction. After that proceed on the set characteristic.

13.1.6 Error and warning behavior

The monitoring of the analog input signal necessary according to the application is to be configured via the parameter *Error/Warning behavior* **563**.

Operation mode		Function
0 -	Off	The input signal is not monitored.
1 -	Warning < 1 V / 2 mA	If the input signal is less than 1 V or 2 mA, there is a warning message.
2 -	Shutdown < 1V / 2 mA	If the input signal is less than 1 V or 2 mA, there is a warning message; the drive mechanism is decelerated according to stopping behavior 2.
3 -	Fault switch-off < 1 V / 2 mA	If the input signal is less than 1 V or 2 mA, there is a warning and fault message and the drive mechanism stops freely.

The monitoring of the analog input signal is active independent of the release of the frequency inverter according to the operation mode selected.

In operation mode **2**, the drive mechanism is decelerated independent of the stopping behavior set (Parameter *Operation mode* **630**) according to stopping behavior 2 (shutdown and stop). If the set holding time has expired, there is a fault message. A repeat start of the drive mechanism is possible by switching the start signal on and off if the fault has been cleared.

Operation mode **3** defines the free stoppage of the drive mechanism, independent of the stopping behavior selected, which is stipulated with the parameter *Operation Mode* **630**.

NOTICE

Monitoring of the analog input signal via the parameter *Error/Warning Behavior* **563** demands a check of the characteristic parameters.

13.1.7 Filter time constant

The time constant of the filter for the reference analog value can be set via the parameter *Filter time constant* **561**.

The time constant states the time for which the input signal is averaged by means of a low pass filter, e.g. in order to eliminate fault effects.

The setting range is a range of values between 0 ms and 5000 ms in 15 steps.

Operation mode		Function
0 -	Time constant 0 ms	Filter deactivated – analog reference value is forwarded unfiltered
2 -	Time constant 2 ms	Filter activated – averaging of the input signal via the set value of the filter time constants
4 -	Time constant 4 ms	
8 -	Time constant 8 ms	
16 -	Time constant 16 ms	
32 -	Time constant 32 ms	
64 -	Time constant 64 ms	
128 -	Time constant 128 ms	
256 -	Time constant 256 ms	
512 -	Time constant 512 ms	
1000 -	Time constant 1000 ms	
2000 -	Time constant 2000 ms	
3000 -	Time constant 3000 ms	
4000 -	Time constant 4000 ms	
5000 -	Time constant 5000 ms	

13.2 Analog output MF4OA

The terminal X410B.4 can be used as voltage output if the switch S1 is ON (see chapter 14.1.2).

NOTICE

The MF4OA output used as analog output (terminal X410B.4) cannot permanently withstand short circuits and external voltages. External voltages can damage the module. Avoid short circuits and external voltages.

13.2.1 General

The analog output is a voltage output with the range of 0..10 V. The parameterisation is done by the selection of the operation mode and a linear characteristic with the consideration of an offset and amplification.

To use terminal X410B.4 as Analog output *Operation mode X410B.4* **502** has to be set up.

Operation mode **502**	Function
5 – Voltage Output 0 – 10 V	Voltage signal (MFO2A), 0 V ... 10 V

13.2.2 Function for analog output MFO2A

The selected configuration determines which actual values can be selected for parameter *Analog operation* **584** of analog output 2.

Operation mode **584**		Function
0 -	Off	Analog operation MFO1 is switched off.
1 -	Abs. Fs	Abs. value of the Stator Frequency 0.00 Hz ... *Maximum frequency* **419**.
2 -	Abs. Fs betw. fmin/fmax	Abs. value of the Stator Frequency *Minimum frequency* **418**...*Maximum frequency* **419**.
3 -	Abs. Speed Sensor 1	Abs. value of speed sensor signal 1, 0.00 Hz ... *Maximum frequency* **419**.
4 -	Abs. Speed Sensor 2	Abs. value of speed sensor signal 2, 0.00 Hz ... *Maximum frequency* **419**.
5 -	Abs. Speed Sensor 3	Abs. value of speed sensor signal 3, 0.00 Hz ... *Maximum frequency* **419**.
7 -	Abs. Actual Frequency	Abs. value of act. frequency, 0.00 Hz ... *Maximum frequency* **419**.
10 -	Abs. Ref. Percentage	Abs. value of ref. percentage, 0.00 % ... *Maximum Reference Percentage* **519**.
11 -	Abs. Ref. Percent. betw. %min / %max	Abs. value of ref. percentage betw. %min / %max *Minimu Reference Percentage* **518**... *Maximum Reference Percentage* **519**.
20 -	Abs. Iactive	Abs. value of current effective current I_{Active}, 0.0 A ... FU rated current.
21 -	Abs. Isd	Abs. value of flux-forming current component, 0.0 A ... FU rated current.
22 -	Abs. Isq	Abs. value of torque-forming current component, 0.0 A ... FU rated current.
30 -	Abs. Pactive	Abs. value of current active power P_{Active}, 0.0 kW ... *Rated mech. power* **376**.
31 -	Abs. M	Abs. value of calculated torque M, 0.0 Nm ... Rated torque.
32 -	Abs. Inside Temperature	Abs. value of measured inside temperature, 0 °C ... 100 °C
33 -	Abs. Heat Sink Temperature	Abs. value of measured heat sink temperature, 0 °C ... 100 °C
40 -	Abs. Analog Input MF1IA	Abs. signal value on analog input 1, 0.0 V ... 10.0 V or -10 V .. 10 V.
41 -	Abs. Analog Input EM-MF1IA	Abs. signal value on analog input 1 of EM, 0.0 V ... 10.0 V or -10 V .. 10 V.
50 -	Abs. I	Abs. current value of measured output currents, 0.0 A ... FU rated current.
51 -	DC –Link Voltage	DC link voltage du, 0.0 V ... 1000.0 V.
52 -	V	Output voltage U, 0.0 V ... 1000.0 V.
53 -	Volume Flow	Abs. value of calculated volume flow 0.0 m^3/h ... *Nominal volumetric flow* **397**.
54 -	Pressure	Abs. value of calculated pressure 0.0 kPa ... *Reference pressure* **398**.
61 -	Abs. Val. FT-Output percentage 1	Abs. value of FT-Output percentage 1, 0.00 % ... 327.67%.
62 -	Abs. Val. FT-Output percentage 2	Abs. value of FT-Output percentage 2, 0.00 % ... 327.67%.
101 to 162		Operation modes in analog operation with signs.

13.2.3 Zero adjustment and amplification

With the parameters *Offset* **585** (zero adjustment) and *Amplification* **586** the voltage of the output signal at 0% and 100% of the reference signals can be set.

The zero adjustment with the parameter *Offset* **585** is done specific to the application as a percentage of the final value of the analog output (10 V).

Via the parameter *Amplification* **586** the amplification can be set as a percentage of the final value of the analog output (10 V).

In the factory setting, the zero point has been set at 0% Offset, i.e. minimum value of the reference signal equal to 0 V output signal. The factory setting amplification equal to 100% means that the output signal is 10 V when the reference value is reached.

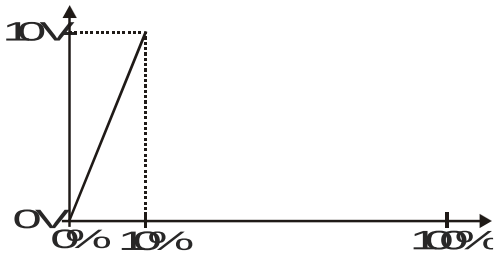
Parameter		Setting		
Nº.	**Description**	**Min.**	**Max.**	**Fact. Sett.**
585	Offset	-100.00%	100.00%	0.00%
586	Amplification	5.0%	1000.0%	100.0%

13.2.3.1 Examples

The actual value parameter is mapped to the analog output signal as a function of the selected parameters *Offset* **585** and *Amplification* **586**. The following examples show the application-specific adaptation for an analog voltage signal.

Example 1:

Parameter		Setting
Nº.	**Description**	**Example**
585	Offset	0.00 %
586	Amplification	1000.0 %

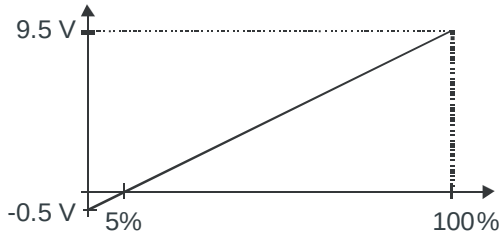


The setting of the parameter *Offset* **585** to 0.00% and the parameter *Amplification* **586** to 1000.0% means that the output signal:

- is 0 V at 0% of the reference signal,
- is 10 V at 10% of the reference signal

Example 2:

Parameter		Setting
Nº.	**Description**	**Example**
585	Offset	0.00 %
586	Amplification	1000.0 %



The setting of the parameter *Offset* **585** to -5,00% and the parameter *Amplification* **586** to 100.0% means that the output signal:

- is -0.5 V at 0% of the reference signal,
- is 9.5 V at 100% of the reference signal.

13.3 Operation mode MF4ID Digital input

The terminal X410B.4 can be used according to parameter *Operation mode X410B.4* **502** as digital input.

13.4 Operation mode Motor temperature monitoring

The terminal X410B.4 can be used for motor temperature monitoring.

The characteristics according to parameter *Operation mode X410B.4* **502** are available. Also consider *Therm. Contact* **204** and *Motor Temp. Operation Mode* **570**.

14 Parameter List

The parameter list is structured according to the menu branches of the control unit. For better overview, the parameters are marked with pictograms:

- The parameter is available in the four data sets.
- ☑ The parameter value is set by the SETUP routine.
- ⊗ This parameter cannot be written when the frequency inverter is in operation.

14.1 Actual values

No.	Description	Unit	Indication range	Chapter
Actual values of frequency inverter				
228	Internal reference frequency	Hz	-1000.00 ... 1000.00	9.3.3
249	Active dataset	-	1 ... 4	9
250	Digital inputs	-	0 ... 255	9.1
260	Current error	-	0 ... 0xFFFF	555H 1.5
270	Warnings	-	0 ... 0xFFFF	1.3
274	Warning application	-	0 ... 0xFFFF	11.4
282	Reference bus frequency	Hz	-1000.00 ... 1000.00	9.3.3
283	Reference ramp frequency	Hz	-1000.00 ... 1000.00	9.3.3
Actual values of Motion Control Interface (MCI)				
1108	Actual Position	u	-2147483647 ... 2147483647	8.2.4
1109	Act. Contouring Error	u	-2147483647 ... 2147483647	8.2.4
1267	Abs. encoder raw data	-	String	
1273	Warning Dig. Encoder	-	Word	
1274	Warning Dig. Encoder	-	Selection	

The Parameter *Warning Dig. Encoder* **1273** is provided for read-out via a PLC. The Parameter *Warning Dig. Encoder* **1274** is provided for read-out via VPlus and Keypad KP500.

Parameters *Current error* **260,** *Warnings* **270** and *Application warnings* **274** are only accessible via the communication channel of objects PPO1 and PPO2. They cannot be addressed via the VPlus control software or the KP500 control unit.

14.2 Parameters

	No.	Description	Unit	Setting range	Chapter
	PROFINET				
	Rated motor values				
▤	371	Rated current	Hz		10.3.3
▤	373	No. of pole pairs	-	1 ... 24	11.2.1
▤	375	Rated frequency	Hz	10.00 ... 1000.00	12.3.3
	PROFIBUS/PROFINET				
	388	Bus Error Behaviour	-	0 ... 5	7.4
▤	390	Profibus/PROFINET reference	Hz	0.00 ... 599.00	12.3.3
	Bus control				
	392	Transition 5	-	0 ... 5	12.3.2
▤	412	Local/Remote	-	0 ... 44	12
	Data set switching				
	414	Data set selection	-	0 ... 4	12
	Frequency ramps				
▤	420	Acceleration (Clockwise)	Hz/s	0.00 ... 9999.99	

No.	Description	Unit	Setting range	Chapter
421	Deceleration (Clockwise)	Hz/s	0.01 ... 9999.99	11.1, 11.2.10, 12.3, 12.4.1
422	Acceleration Anticlockwise	Hz/s	-0.01 ... 9999.99	
423	Deceleration Anticlockwise	Hz/s	-0.01 ... 9999.99	
424	Emergency Stop Clockwise	Hz/s	0.01 ... 9999.99	
425	Emergency Stop Anticlockwise	Hz/s	0.01 ... 9999.99	
430	Ramp Rise Time Clockwise	ms	0 ... 2000	11.2.10, 12.3, 12.4.1
431	Ramp Fall Time Clockwise	ms	0 ... 2000	
432	Ramp Rise Time Anticlockwise	ms	0 ... 2000	
433	Ramp Fall Time Anticlockwise	ms	0 ... 2000	
434	Reference Ramp	-	1 ... 3	12.3.3
	Digital outputs			
549	Max. Control deviation	%	0.01 ... 20.00	12.1, 12.2
	Stopping behavior			
637	Switch-off threshold	%	0.0 ... 100.0	12.3.1, 12.3.2
638	Holding time	s	0.0 ... 200.0	
	Motion Control Interface: Reference system			
1115	Feed constant		1 ... 2147483647	6.4.5
1116	Gear: Shaft revolutions		1 ... 65535	
1117	Gear: Motor revolutions		1 ... 65535	
	Electronic gear			
1122	Master position source	-	Selection	12.4.7
	Motion Control Interface: Homing			
1130	Homing mode		0 ... 35	11.2.11
1131	Home offset		-2147483647 ... 2147483647	
1132	Fast speed		1 ... 2147483647	
1133	Creep speed		1 ... 2147483647	
1134	Acceleration		1 ... 2147483647	
1135	Ramp time		0 ... 2000	
	Motion Control Interface: Limit switch fault reaction			
1143	Fault Reaction		0 ... 3, 10	11.3
	Motion Control Interface: Fixed speed values			
1170	Fixed speed 1	u/s	-2147483647 ... 2147483647	11.2.8

No.	Description	Unit	Setting range	Chapter
	Motion Control Interface: Profile position mode			
1175	Acceleration	u/s^2	1 ... 2147483647	11.2.8
1176	Ramp time Accel.	ms	0 ... 2000	
1177	Deceleration	u/s^2	1 ... 2147483647	
1178	Ramp time Decel.	ms	0 ... 2000	
1179	Emergency stop ramp	u/s^2	1 ... 2147483647	
	Systembus			
1180	Operation mode	-	Selection	12.4.7
	Motion Control Interface: Velocity Mode			
1275	Max Slippage	u/s	0 ... 2147483647	12.4.2
1276	Velocity Window	u/s	0 ... 65535	
1277	Velocity Window Time	ms	0 ... 65535	
1277	Threshold Window	u/s	0 ... 65535	
1279	Threshold Window Time	ms	0 ... 65535	
	Master/Slave Position Correction			
1284	M/S Synchronisation offset	u	-2147483647 ... 2147483647	12.4.7
	Motion Control Interface: Mapping			
1285	S. Target velocity pv [u/s]	-	Selection	11.4
1292	S. Modes of Operation	-	Selection	11.2.9
1293	S. Target Position	-	Selection	11.2.9

No.	Description	Unit	Setting range	Chapter
1294	S. Profile Velocity	-	Selection	
1295	S. Acceleration	-	Selection	
1296	S. Deceleration	-	Selection	
1297	S. Target Velocity vl [rpm]	-	Selection	
1299	S. Special Function Generator	-	Selection	12.4.1
PROFIBUS/PROFINET				
1300 . . . 1324	In-PZD 3 Boolean all In-PZD parameters In-PZD 11/12 Long	- -		10.3.3, 11.2.9
Motion Control Override				
1454	Override Modes Of Operation	-	Selection	11.5
1455	Override Target Position	-	-2^{31}-1…2^{31}-1 u	
1456	Override Profile Velocity	-	-1…2^{31}-1 u/s	
1457	Override Profile Acceleration	-	-1…2^{31}-1 u/s²	
1458	Override Profile Deceleration	-	-1…2^{31}-1 u/s²	
1459	Override Target velocity vl [rpm]	-	-32768…32767 rpm	
1460	Override Target velocity pv [u/s]	-	-2^{31}-1…2^{31}-1 u/s	

Parameter *Data set selection* **414** is only accessible via the communication channel of objects PPO1 and PPO2. It cannot be addressed via the VPlus control software or the KP500 control unit.

For information about positioning and use of the Motion Control Interface, refer to the application manual "Positioning".

15 Appendix

15.1 Control Word overview

The tables on this page provide an overview of the functions of the **control word** bits.

Bit	*Standard (No Positioning)*	*Positioning without MCI*	*MCI: Velocity Mode*	*MCI: Profile Velocity Mode*	*MCI: Profile Position Mode*
0	Switch On	Switch On	Switch On	Switch On	Switch On
1	Enable Voltage	Enable Voltage	Enable Voltage	Enable Voltage	Enable Voltage
2	Quick Stop (low active)	Quick Stop (low active)	Quick Stop (low active)	Quick Stop (low active)	Quick Stop (low active)
3	Enable Operation	Enable Operation	Enable Operation	Enable Operation	Enable Operation
4			Rfg enable		New setpoint
5			Rfg unlock		Change set immediately
6			Rfg use ref		Abs/rel
7	Fault reset	Fault reset	Fault reset	Fault reset	Fault reset
8	Halt	Halt	Halt	Halt	Halt
9					Change on setpoint
10					
11					
12					
13					
14					
15					

Bit	*MCI: Homing Mode*	*MCI: Table travel record Mode*	*MCI: Move away from Limit Sw.*	*MCI: Electronic Gear: Slave*
0	Switch On	Switch On	Switch On	Switch On
1	Enable Voltage	Enable Voltage	Enable Voltage	Enable Voltage
2	Quick Stop (low active)	Quick Stop (low active)	Quick Stop (low active)	Quick Stop (low active)
3	Enable Operation	Enable Operation	Enable Operation	Enable Operation
4	Homing operat.start	Sequence mode	Move away from LS	Start Gearing
5				
6		Resume		Direct Sync
7	Fault reset	Fault reset	Fault reset	Fault reset
8	Halt	Halt	Halt	Halt
9		Start motion block		Start Phasing
10				
11		Motion Block Select 0		
12		Motion Block Select 1		Phasing Profile Sel. 1
13		Motion Block Select 2		Phasing Profile Sel. 2
14		Motion Block Select 3		
15		Motion Block Select 4		

15.2 Status Word overview

The tables on this page list in an overview the functionality of the **Status Word** bits.

Bit	*Standard (No Positioning)*	*Positioning without MCI*	*MCI: Velocity Mode*	*MCI: Profile Velocity Mode*	*MCI: Profile Position Mode*
0	Ready to Switch On	Ready to Switch On	Ready to Switch On	Ready to Switch On	Ready to Switch On
1	Switched On	Switched On	Switched On	Switched On	Switched On
2	Operation enabled	Operation enabled	Operation enabled	Operation enabled	Operation enabled
3	Fault	Fault	Fault	Fault	Fault
4	Voltage enabled	Voltage enabled	Voltage enabled	Voltage enabled	Voltage enabled
5	Quick Stop (low active)	Quick Stop (low active)	Quick Stop (low active)	Quick Stop (low active)	Quick Stop (low active)
6	Switch On Disabled	Switch On Disabled	Switch On Disabled	Switch On Disabled	Switch On Disabled
7	Warning	Warning	Warning	Warning	Warning
8		Homing done			
9	Remote	Remote	Remote	Remote	Remote
10	Target reached	Target reached	Target reached	Target reached	Target reached
11	Internal limit active	Internal limit active	Internal limit active	Internal limit active	Internal limit active
12				Speed	Set-point acknowl.
13				Max slippage error	Following error
14		Target Pos. reached			
15	Warning 2	Warning 2	Warning 2	Warning 2	Warning 2

Bit	*MCI: Homing Mode*	*MCI: Table travel record Mode*	*MCI: Move away from Limit Sw.*	*MCI: Electronic Gear: Slave*
0	Ready to Switch On	Ready to Switch On	Ready to Switch On	Ready to Switch On
1	Switched On	Switched On	Switched On	Switched On
2	Operation enabled	Operation enabled	Operation enabled	Operation enabled
3	Fault	Fault	Fault	Fault
4	Voltage enabled	Voltage enabled	Voltage enabled	Voltage enabled
5	Quick Stop (low active)	Quick Stop (low active)	Quick Stop (low active)	Quick Stop (low active)
6	Switch On Disabled	Switch On Disabled	Switch On Disabled	Switch On Disabled
7	Warning	Warning	Warning	Warning
8		Motion Block in Progress		Phasing Done
9	Remote	Remote	Remote	Remote
10	Target reached	Target reached	Target reached	Target reached
11	Internal limit active	Internal limit active	Internal limit active	Internal limit active
12	Homing attained	In gear		
13	Homing error	Following error		Following error
14				
15	Warning 2	Warning 2	Warning 2	Warning 2

15.3 Warning messages

The different control methods and the hardware of the frequency inverter include functions for continuous monitoring of the application. In addition to the messages documented in the frequency inverter Operating Instructions, further warning messages are activated by the PROFINET communication module. The bit-coded warning reports are issued via parameter *Warnings* **270** according to the following pattern: Parameter *Warnings* **270** is provided for read-out via a PLC, Parameter *Warnings* **269** provides the information, including a brief description in VPlus and the KP500 control unit.

Warning messages		
Bit no.	**Warning code**	**Description**
0	0x0001	Warning Ixt
1	0x0002	Warning short-time Ixt
2	0x0004	Warning long-time Ixt
3	0x0008	Warning heat sink temperature Tk
4	0x0010	Warning inside temperature Ti
5	0x0020	Warning Limit
6	0x0040	Warning Init
7	0x0080	Motor temperature warning
8	0x0100	Warning mains failure
9	0x0200	Warning motor circuit breaker
10	0x0400	Warning Fmax
11	0x0800	Warning analog input MFI1A
12	0x1000	Warning analog input A2
13	0x2000	Warning Systembus
14	0x4000	Warning Udc
15	0x8000	Warning Application warning status **273**

The meanings of the individual warnings are described in detail in the frequency inverter Operating Instructions.

15.4 Application warning messages

When the highest bit of the warning message is set, an "Application warning message" is present. The application warning messages are bit-encoded as per the following pattern via parameter *Application warnings* **274**. Parameter *Application warnings* **273** indicates the warnings as plain text in the control panel and the VPLus PC control software.

Use parameter *Application warnings* **274** in order to read the warning messages via Field Bus.

Application warning messages			
Bit no.	**Warning code**	**Description**	
0	0x0001	BELT	- V-belt
1	0x0002	SW-LIM CW	– SW limit switch clockwise
2	0x0004	SW-LIM CCW	– SW limit switch anticlockwise
3	0x0008	HW-LIM CW	– HW limit switch clockwise
4	0x0010	HW-LIM CCW	– HW limit switch anticlockwise
5	0x0020	CONT	– contouring error
6	0x0040	ENC	– Warning Absolute encoder
7	0x0080	User 1	– User Warning 1
8	0x0100	User 2	– User Warning 2
9	0x0200	(reserved)	
10	0x0400	(reserved)	
11	0x0800	(reserved)	
12	0x1000	(reserved)	
13	0x2000	(reserved)	
14	0x4000	(reserved)	
15	0x8000	(reserved)	

For details on the warnings, refer to the frequency inverter Operating Instructions and the "Positioning" application manual.

The Warning Bit 6 "Absolute encoder" can be read out via Parameter **1274** in VPlus or **1273** via field bus. The Absolute encoder warnings are described in detail in the Extension manual EM-ABS-01.

15.5 Error messages

The error code stored following a fault comprises the error group FXX (high-byte, hexadecimal) and the code YY (low-byte, hexadecimal).

Communication error			
	Key		**Meaning**
Motion Control Interface	F04	04	Control Deviation Position Controller
	F14	42	Pos. SW Limit Switch
		43	Neg. SW Limit Switch
		44	Pos. SW Limit Sw. < Neg. SW Limit Sw.
		45	Pos. and Neg. HW-Lim Switch Simultaneously
		46	Limit Switch Incorrect Wired
		47	Pos. HW Limit Switch
		48	Neg. HW Limit Switch
		51	Switch: Pos. Dir. Blocked
		52	Switch: Neg. Dir. Blocked
		53	System bus-Synchronization not activated
		60	Pos. HW Limit Sw.: Non-permissible signal source
		61	Pos. HW Limit Sw.: Input deactivated by PWM /FF input
		62	Pos. HW Limit Sw.: Input deactivated of index controller
		63	Pos. HW Limit Sw.: wrong mode for MFI1
		64	Pos. HW Limit Sw.: Input deactivated by encoder 1
		65	Pos. HW Limit Sw.: Input deactivated by encoder 2
		66	Pos. HW Limit Sw.: wrong mode for EM-S1IOD
		70	Neg. HW Limit Sw.: Non-permissible signal source
		71	Neg. HW Limit Sw.: Input deactivated by PWM /FF input
		72	Neg. HW Limit Sw.: Input deactivated of index controller
		73	Neg. HW Limit Sw.: wrong mode for MFI1
		74	Neg. HW Limit Sw.: Input deactivated by encoder 1
		75	Neg. HW Limit Sw.: Input deactivated by encoder 2
		76	Neg. HW Limit Sw.: wrong mode for EM-S1IOD
	F15	xx	User-Defined Error in Motion Block xx ($1 \leq xx \leq 32$)
		70	No Homing Done
		71	Homing Encoder-Mode without Z-Impulse
		72	Both Directions Locked
		73	No Touch Probe Signal Detected
		74	M/S Position Correction: Master Position source not set. Check chapter 11.4.7.1 "Master/Slave Position Correction".
PROFINET	F27	14	Communication loss to PLC*
		50	PNIO Configuration Error (wrong configuration of cyclic data objects PZD)

* This message is only displayed if *Bus Error Behaviour* **388** ≠ 0.

The current error can be read via parameter *Current error* **260**.

Parameter *Current error* **259** indicates the current error as plain text in the control panel and the VPlus PC control software.

In addition to the error messages mentioned, there are other error messages specified in the Operating Instructions. The errors of the Motion Control Interface (F14xx, F15xx) are described in detail in the "Positioning" application manual.

15.6 Homing modes

For parameter *Homing Mode* **1130** the following settings are available:

Homing Mode 1130		Function
0 -	No Homing Done	**Factory setting.** No homing; the current position value is not changed. The current position value is the value saved upon last disconnection of power supply.
1 -	Neg. Limit switch & zero impulse	Homing to negative HW limit switch with detection of encoder ref. signal
2 -	Pos. limit switch & zero impulse	Homing to positive HW limit switch with detection of encoder ref. signal
3 -	Pos. Home-Sw.: Ref.-Signal left of Edge	Homing to positive home switch with detection of encoder ref. signal Ref. position is the first encoder ref. signal to the left of the edge of the home switch signal.
4 -	Pos. Home-Sw.: Ref.-Signal right of Edge	Homing to positive home switch with detection of encoder ref. signal Ref. position is the first encoder ref. signal to the right of the edge of the home switch signal.
5 -	Neg. Home-Sw.: Ref.-Signal right of Edge	Homing to negative home switch with detection of encoder ref. signal Ref. position is the first encoder ref. signal to the right of the edge of the home switch signal.
6 -	Neg. Home-Sw.: Ref.-Signal left of Edge	Homing to negative home switch with detection of encoder ref. signal Ref. position is the first encoder ref. signal to the left of the edge of the home switch signal.
7 -	Pos. Limit Sw., zero pulse to the left of left home switch edge	Homing to home switch with detection of encoder ref. signal Homing direction positive (clockwise). Reversal of direction of rotation when positive HW limit switch is reached. Ref. position is the first encoder ref. signal to the left or right of the left or right edge of the home switch signal.
8 -	Pos. Limit Sw., zero pulse to the right of left home switch edge	
9 -	Pos. Limit Sw., zero pulse to the left of right home switch edge	
10 -	Pos. Limit Sw., zero pulse to the right of right home switch edge	
11 -	Neg. Limit Sw., zero pulse to the right of right home switch edge	Homing to home switch with detection of encoder ref. signal Homing direction negative (anticlockwise). Reversal of direction of rotation when negative HW limit switch is reached. Ref. position is the first encoder ref. signal to the left or right of the left or right edge of the home switch signal.
12 -	Neg. Limit Sw., zero pulse to the left of right home switch edge	
13 -	Neg. Limit Sw., zero pulse to the right of left home switch edge	
14 -	Neg. Limit Sw., zero pulse to the left of left home switch edge	
17...30: like 1 … 14, but without encoder ref. signal		
17 -	Neg. Limit Switch	Moving to negative HW limit switch.
18 -	Pos. Limit Switch	Moving to positive HW limit switch.
19 -	Pos. Home-Sw., to the left of edge	Moving to positive home switch. Home position is to the left of the edge of the home switch signal.
20 -	Pos. Home-Sw., to the right of edge	Moving to positive home switch. Home position is to the right of the edge of the home switch signal.
21 -	Neg. Home-Sw., to the right of edge	Moving to negative home switch. Home position is to the right of the edge of the home switch signal.
22 -	Neg. Home-Sw., to the left of edge	Moving to negative home switch. Home position is to the left of the edge of the home switch signal.
23 -	Pos. Limit Sw., to the left of left home switch edge	Moving to home switch. Homing direction positive (clockwise). Reversal of direction of rotation when positive HW limit switch is reached. Ref. position is to the left or right of the left or right edge of the home switch signal.
24 -	Pos. Limit Sw., to the right of left home switch edge	
25 -	Pos. Limit Sw., to the left of right home switch edge	
26 -	Pos. Limit Sw., to the right of right home switch edge	
27 -	Neg. Limit Sw., to the right of right home switch edge	

Homing Mode 1130		Function
28 -	Neg. Limit Sw., to the left of right home switch edge	Moving to home switch. Homing direction negative (anticlockwise). Reversal of direction of rotation when negative HW limit switch is reached. Ref. position is to the left or right of the left or right edge of the home switch signal.
29 -	Neg. Limit Sw., to the right of left home switch edge	
30 -	Neg. Limit Sw., to the left of left home switch edge	
33 -	zero impulse to the left of act. pos.	Ref. position is the first encoder ref. signal in negative (operation mode 33) or positive (operation mode 34) direction.
34 -	zero impulse to the right of act. pos.	
35 -	Current position	Current position is ref. position. Home offset (Parameter *Home offset* **1131**) is taken over as actual position value.

For detailed descriptions of the homing modes, refer to the "Positioning" application manual.

15.7 Conversions

The speeds/frequencies can be converted to other speed formats using the formulas in this chapter:

Frequency [Hz] into	speed [1/min]	See Chapter 11.7.2
	Speed into user units per second [u/s]	See Chapter 11.7.4
Speed [1/min] in	Frequency [Hz]	See Chapter 11.7.1
	Speed into user units per second [u/s]	See Chapter 11.7.6
Speed into user units per second [u/s] into	Speed [1/min]	See Chapter 11.7.5
	Frequency [Hz]	See Chapter 11.7.3

15.7.1 Speed [1/min] into frequency [Hz]

$$f\ [\text{Hz}] = \frac{n\left[\text{min}^{-1}\right] \times No.of\ pole\ pairs\ \ (P.373)}{60}$$

15.7.2 Frequency [Hz] into speed [1/min]

$$n[rpm] = \frac{f\ [\text{Hz}] \times 60}{No.of\ pole\ pairs\ (P.373)}$$

15.7.3 Speed in user units per second [u/s] into frequency [Hz]

$$f\ [\text{Hz}] = v\ [\frac{\text{u}}{\text{s}}] \times \frac{No.of\ pole\ pairs\ (P.373)}{Feed\ Constant\ (P.1115)} \times \frac{Gear\ Box: Motor\ Shaft\ Revolutions\ (P.1117)}{Gear\ Box: Driving\ Shaft\ Revolutions (P.1116)}$$

15.7.4 Frequency [Hz] into speed in user units per second [u/s]

$$v\ [\frac{\text{u}}{\text{s}}] = f\ [\text{Hz}] \times \frac{Feed\ Constant\ (P.1115)}{No.of\ pole\ pairs\ (P.373)} \times \frac{Gear\ Box: Driving\ Shaft\ Revolutions (P.1116)}{Gear\ Box: Motor\ Shaft\ Revolutions\ (P.1117)}$$

15.7.5 Speed in user units pro second [u/s] into speed [1/min]

$$n\ [\text{rpm}] = v\ [\frac{\text{u}}{\text{s}}] \times \frac{60}{Feed\ Constant\ (P.1115)} \times \frac{Gear\ Box: Motor\ Shaft\ Revolutions\ (P.1117)}{Gear\ Box: Driving\ Shaft\ Revolutions\ (P.1116)}$$

15.7.6 Speed [1/min] into speed in user units per second [u/s]

$$v\ [\frac{\text{u}}{\text{s}}] = n\ [rpm] \times \frac{Feed\ constant\ (P.1115)}{60} \times \frac{Gear\ Box: Driving\ Shaft\ Revolutions\ (P.1116)}{Gear\ Box: Motor\ Shaft\ Revolutions\ (P.1117)}$$

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