Bonfiglioli
Vectron

ACTIVE CUBE

Modbus/TCP
Communication module CM-Modbus/TCP
Frequency inverter 230 V / 400 V

Bonfiglioli
power, control and green solutions

CONTENTS

1 General Information about the Documentation

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

The present manual was created in the German language. The German manual is the original version. Other language versions are translations.

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 software of the frequency inverter.

User manual

The user manual documents the complete functionality of the frequency inverter. The parameters required for special purposes, for adjustment to the application and the numerous additional functions are described in detail.

Separate user manuals are supplied for optional components for the frequency inverter. These manuals complement the operating instructions and the “Quick Start Guide” for the frequency inverter.

Application manual

The application manual complements the documentation to ensure goal-directed installation and commissioning of the frequency inverter. Information on various topics in connection with the use of the frequency inverter is described in context with the specific application.

Installation instructions

The installation manual describes the installation and use of devices, complementing the “Quick Start Guide” and the user manual.

1.1 This document

This document describes the communication via the Modbus/TCP protocol with frequency inverters of the *ACTIVE* Cube series of devices. Thanks to the modular hardware and software structure, the frequency inverters can be customized to meet to customer's specific requirements, including applications requiring high functionality and dynamism.

⚠ WARNING

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.

1.2 Warranty and liability

BONFIGLIOLI VECTRON GmbH would like to point out that the contents of this user manual do not form part of any previous or existing agreement, assurance or legal relationship. 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 notice. The manufacturer shall not be liable for any damage, injuries or costs which may be caused for the aforementioned reasons.

Furthermore, BONFIGLIOLI VECTRON GmbH excludes any warranty/liability claims for any personal and/or material damage if such damage is due to 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 frequency 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.

1.3 Obligation

This user manual must be read before commissioning and complied with. 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 user manual and, in particular, the safety instructions in order to prevent personal and material losses.

1.4 Copyright

In accordance with applicable law against unfair competition, this user manual is a certificate. Any copyrights relating to it shall remain with

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This user manual 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.

Any non-compliance will constitute an offense against the copyright law dated 09 September 1965, the law against unfair competition and the Civil Code and may result in claims for damages. All rights relating to patent, utility model or design registration reserved.

1.5 Storage

The documentation form an integral part of the frequency inverter. It must be stored such that it is accessible to operating staff at all times. If the frequency inverter is sold on to other users, then this user manual 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 that have 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 that are 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 have their qualification verified.

Expert

The term Expert covers qualified and trained staff that have special technical know-how and experience relating to the 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.

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 2006/95/EEC and DIN EN 61800-5-1. CE-labeling is based on these standards. Responsibility for compliance with the EMC Directive 2004/108/EC 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 at all times.

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 plant operator shall bear the sole risk.

2.3.1 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 hazards 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 user manual

2.6.1 Hazard classes

The following hazard identifications and symbols are used 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.

NOTE

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

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

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 Discharge (can damage components and assemblies)

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	italic, Font Times New Roman	Representation of parameter names
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 user manual, the operator should issue separate internal operating instructions for the frequency inverter. The user manual of the frequency inverter must be included in the user manual 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 qualified technical staff. The staff must not be under the influence of any drugs. Note the minimum age required by law. Define the staff's responsibility in connection with 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 user manual 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 this user manual, 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.

2.10 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 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 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 this at your own risk.

2.10.3 Transport and Storage

- The frequency inverters must be transported and stored in an appropriate way. During transport and storage the devices must remain in their original packaging.
- The units may only be stored in dry rooms which are protected against dust and moisture and are exposed to small temperature deviations only. The requirements of DIN EN 60721-3-1 for storage, DIN EN 60721-3-2 for transport and labeling on the packaging must be met.
- The duration of storage without connection to the permissible nominal voltage may not exceed one year.

2.10.4 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 a 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.

2.10.5 Electrical connections

- The five safety rules must be complied with.
- Never touch live terminals. The DC link may have dangerous voltage levels even up to three 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.

2.10.5.1 The five safety rules

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

1. Isolate
2. Take appropriate measures to prevent re-connection
3. Check isolation
4. Earth and short-circuit
5. Cover or shield neighboring live parts.

2.10.6 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, never open the machine/plant
- Do not connect/disconnect any components/equipment during operation.
- 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 brake 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. Wait for at least 3 minutes after shutdown before starting electrical or mechanical work on the frequency inverter. Even after this waiting time, make sure that the equipment is deenergized 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 frequency inverters must not have access to the frequency inverter. Do not bypass nor decommission any protective facilities.
- 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 Auto-Start 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 safety directives (e.g. Working Machines Act or Accident Prevention Directives).

2.10.7 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. Repairs on the frequency inverters may only be carried out by the manufacturer or persons authorized by the manufacturer. 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.

2.10.8 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.

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

3 Introduction

The present document describes the Modbus/TCP protocol for the CM-Modbus/TCP and CM-Modbus/TCP-2P (switch function integrated) communication modules. After connecting Modbus/TCP to the PLC, you can use an additional logic connection from CM-Modbus/TCP to the VPlus software running on a terminal connected via an Ethernet network.

For Modbus/TCP connection, the frequency inverter must be equipped with the CM-Modbus/TCP or CM-Modbus/TCP-2P communication module.

The CM-Modus/TCP and CM-Modbus/TCP-2P communication modules are separate components and must be attached to the frequency inverter. This is described in chapter 5.1 “Assembly”.

Modbus/TCP communication (as described in this manual) requires software version 5.3.0 or higher.

This manual only describes the CM-Modbus/TCP and CM-Modbus/TCP-2P communication modules. This manual is not to be understood as providing general/basic information on Ethernet interfaces or frequency inverters.
General/basic knowledge of the methods and function of Modbus/TCP interfaces and Modbus/TCP protocol are a prerequisite for understanding and implementing the instructions provided by this document.

In some chapters of these instructions, setting and display options via the PC software VPlus are described as an alternative to the control unit. In this case, VPlus can use
- CM-Modbus/TCP or CM-Modbus/TCP-2P module **or**
- the serial interface

for communication with the frequency inverter.

The module enables using Modbus/TCP and VPlus via the VABus/TCP protocol at the same time.

⚠ WARNING

With CM-Modbus/TCP or CM-Modbus/TCP-2P, controllers can access **all** parameters of the frequency inverter.

Changing parameters the function of which is unknown can result in malfunction of the frequency inverter and dangerous situations in the plant.

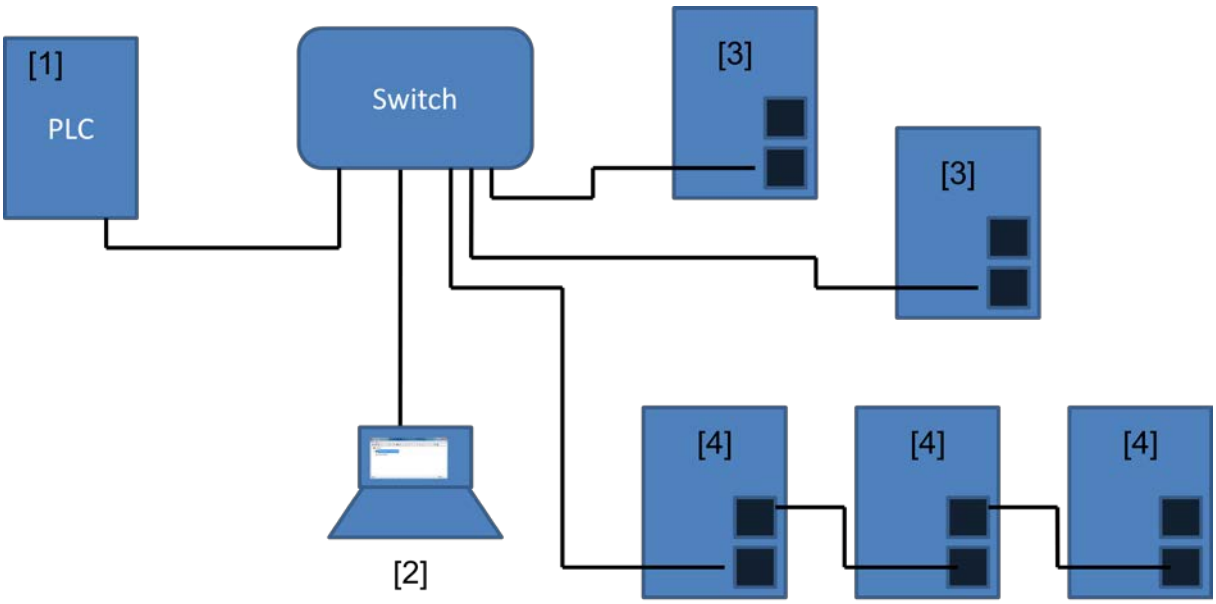
Module variants:

There are two Modbus/TCP variants.

CM-Modbus/TCP provides a physical interface for communication via Modbus/TCP. A star-type network topology can be used. An external switch is the star point.

CM-Modbus/TCP-2P provides two physical interfaces for communication via Modbus/TCP. The following network topologies are possible:

- Star-type (like in CM-Modbus/TCP)
- Line



[1] PLC
[2] PC for commissioning or diagnosis (connected temporarily or permanently)
[3] ACU with CM-Modbus/TCP or CM-Modbus/TCP-2P (2nd port not connected)
[4] ACU with CM-Modbus/TCP-2P

3.1 Supported configurations

ACTIVE Cube frequency inverters support various types of control and reference point input

- Standard (without positioning functions)
- Positioning via contacts (or remote contacts)
- Positioning via Motion Control Interface (MCI) via Field Bus

A configuration with position control is selected when parameter *Configuration* **30** = x40 (e.g. 240) is set. In order to use the full functionality of the Motion Control Interfaces, parameter *Local/Remote* **412** = "1-Control via statemachine" must be set additionally.

The operating behavior of the frequency inverter varies in the configuration groups, considering *control word/status word* and *modes of operation*.

Standard:

Required settings: *Configuration* **30** ≠ x40
Local/Remote **412** = (remote) contacts

➔ Control (start, stop, frequency changeover, etc.) is typically performed through
- Digital contacts.
- Remote contacts via field bus.

➔ Reference values depend on the selected configuration. Typical:
- Reference speed/reference frequency:
  - Analog input.
  - Fixed values from parameters.
  - *Override Target Velocity vl [rpm]* **1459** (target speed).
- Reference percentage for technology controller or torque control
  - Analog input.
  - Fixed values from parameters.

See Chapter 11.3 "Configurations without Motion Control" for control without positioning functions.

Positioning via contacts (or remote contacts)

Required settings: *Configuration* **30** = x40
Local/Remote **412** = (remote) contacts

➔ Control (start, stop, target position changeover, etc.) is typically performed through
- Digital contacts.
- Remote contacts via field bus.

➔ Reference values depend on the selected configuration. Typical:
- Reference speed/ reference frequency.
- Reference target position.

Also refer to application manual "Positioning".

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

In Modbus/TCP communication, MCI is not available. You can use Motion Control Override (MCO) instead.

Required settings: *Configuration* **30** = x40
Local/Remote **412** = 1 – Statemachine

➔ Control (start, stop, change of mode, etc.) is performed via *Control word* **410**.

➔ Reference values result from the selected *Override Modes Of Operation* **1454**.

Typical:
- Speed reference via *Override Target Velocity vl [rpm]* **1459** (target speed).
- Target position via *Override Target Position* **1455**.

For information on how to use the Motion Control Interface, refer to Chapters 10 "Motion Control Interface (MCI) / Motion Control Override (MCO)" and 11.4 "Motion control configurations".

3.2 Initialization time

When the frequency inverter is turned on, the communication 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).

4 First commissioning

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

- Installation of module — Chapter 5.1
- Selection of device control *Local/Remote* **412** — Chapter 11
- Commissioning of device functions via PLC
  - Motion Control Override — Chapter 10.1
  - Fault Reaction — Chapter 6.3
    - Fault reset — Chapter 7.3
- Setting reference values:
  - Reference speed in speed-controlled configuration x10, x11, x15, x16, x30, x60 — Chapter 11.3
  - Reference in position configuration x40 — Chapter 10 and 11.4
    - Velocity Mode — Chapter 11.4.1
    - Profile Velocity Mode — Chapter 11.4.2
    - Profile Position Mode — Chapter 11.4.3
    - Homing Mode — Chapter 11.4.4
    - Table Travel record Mode — Chapter 11.4.5
    - Mode change — Chapter 10
- Diagnosis: — Chapter 14 and 13.1

5 Assembly / disassembly of communication module

5.1 Assembly

The CM-Modbus/TCP and CM-Modbus/TCP-2P communication modules are pre-assembled in a case and are ready for installation. In addition, a PE-spring is supplied for PE-connection (shield).

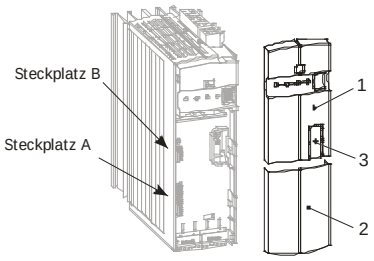
⚠ CAUTION

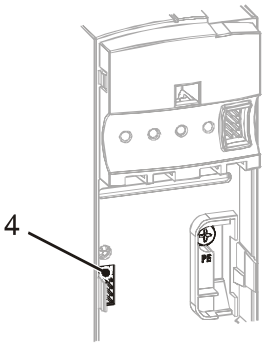
Danger of destruction of frequency inverter and / or communication module

- Before installation of the communication module, the frequency inverter must be disconnected from power supply. Installation is not permissible while the unit is energized.
- Do not touch the PCB visible on the back of the module, otherwise components may be damaged.

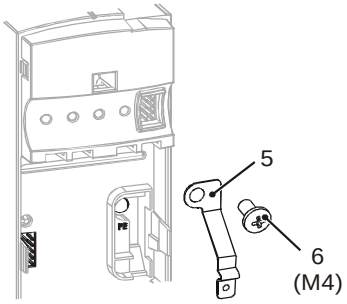
Work steps:

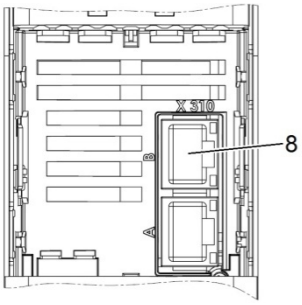
- Disconnect the frequency inverter from mains voltage and protect it against being energized unintentionally.
- Remove covers **(1)** and **(2)** of the frequency inverter. Slot B **(4)** for the communication module is now accessible.





- Mount the supplied PE spring **(5)** using the M4 screw **(6)** in the unit. The spring must be aligned centrally.
- Insert the communication module in slot B **(4)** until it engages audibly.
- Fix the communication module and PE spring **(5)** using the M2-screw provided at the module.

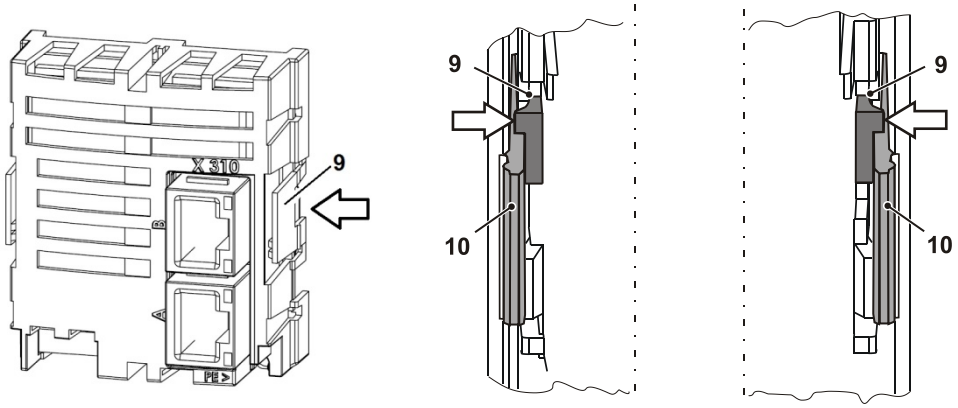




- In the upper cover **(1)**, break out the pre-punched cutout **(3)** for the plug X310 **(8)**.
- Mount the two covers **(1)** and **(2)**.

5.2 Disassembly

- Disconnect the frequency inverter from power supply and protect it against being energized unintentionally.
- Remove covers **(1)** and **(2)** of the frequency inverter, see Chapter 5.1 “Assembly”.

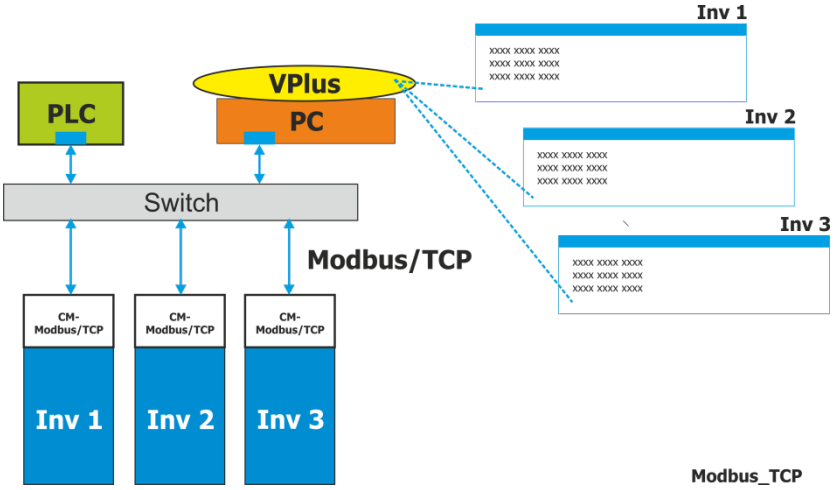


- Loosen the M2 screw at the communication module.
- Unplug the communication module from Slot B **(4)** by unlocking the locking hooks **(9)** on the right and left side of the module from the case of the frequency inverter using a small screwdriver.
- The locking hooks **(9)** are located at the place where the locking hooks **(10)** for the upper cover **(1)** project from the case of the frequency inverter.
  - To do this, insert the screwdriver in the gap between the case of the module and the frequency inverter carefully and push the locking hook inwards in the direction of the arrow **(⇦)**. As soon as the right side is unlocked, pull out the module a bit on the right side and hold it.
  - Hold the module on the right side while unlocking the locking hook on the left side in the same way **(⇨)**.
  - Pull the module out of the slot by gently pulling on the right and left side alternately.
- Disassemble the PE spring **(5)**, see Chapter 5.1 “Assembly”.
- Mount the two covers **(1)** and **(2)**, see Chapter 5.1 “Assembly”.

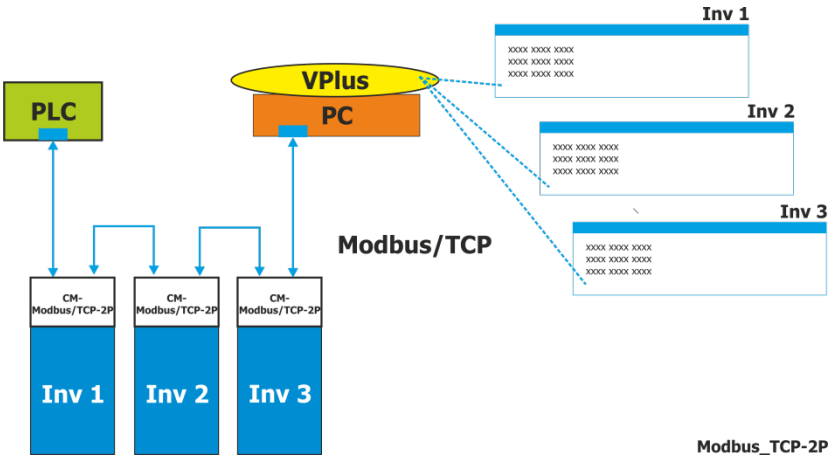
6 Modbus/TCP interface

The frequency inverter can be controlled by a PLC or another master device via an Ethernet interfaces using the Modbus/TCP protocol.

When a Modbus/TCP or Modbus/TCP-2P communication module is used, you can also access the frequency inverter using the VPlus software via Ethernet. VPlus can be used in parallel with a PLC with Modbus/TCP communication.



Modbus_TCP



Modbus_TCP-2P

This document does not provide basic information about Ethernet interfaces. Basic knowledge of the Modbus/TCP protocol and Ethernet interfaces is required.

In some sections, setting and display options via the PC software VPlus are described as an alternative to the control unit. In this case, VPlus communicates with the frequency inverter via a serial interface or a direct Ethernet connection.

⚠ WARNING

With Modbus/TCP communication, controllers can access **all** parameters of the frequency inverter.

Changing parameters the function of which is unknown can result in malfunction of the frequency inverter and dangerous situations in the plant.

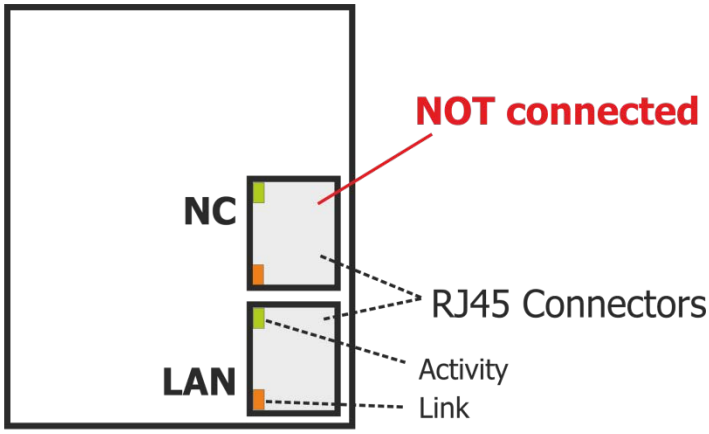
⚠ CAUTION

When values are to be written cyclically at a high repetition rate, no entries shall be made in the EEPROM, as this only allows a limited number of write cycles (approx. 1 million cycles). If the number of permissible write cycles is exceeded, the EEPROM will be damaged. See chapter 8.1 “Handling of datasets / cyclic writing of parameters”.

6.1 Communication modules

CM-Modbus/TCP

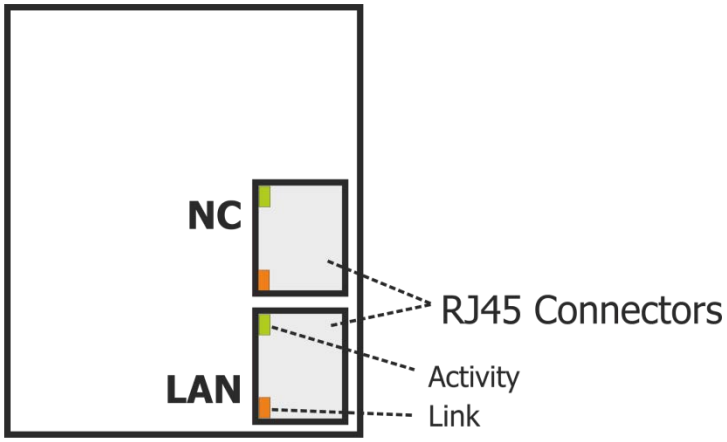
The CM-Modbus/TCP communication module features an active RJ45 port.



CM-Modbus/TCP

CM-Modbus/TCP-2P

The CM-Modbus/TCP-2P communication module features two active RJ45 ports with integrated switching function. This enables easy linking (daisy chain) of frequency inverters which are connected to a PLC.



CM-Modbus/TCP-2P

6.1.1 Installation instructions

The Modbus/TCP module is connected to the PLC or other devices using standard CAT cables and RJ45 connectors:

Ethernet standard: IEEE 802.3, 100Base-TX (fast Ethernet)

Cable type: S/FTP (cable with braided shield, (ISO/IEC 11801 or EN 50173, Straight Through or Cross Over)

6.2 Setup

By default, the parameters of the CM-Modbus/TCP and CM-Modbus/TCP-2P communication modules are set up as follows:

Parameters		Settings
No.	**Description**	**Factory setting**
388	*Bus Error Behaviour*	1
1432	*IP-Address*	172.22.1.25
1433	*Netmask*	255.255.255.0
1434	*Gateway*	0.0.0.0
1435	*DNS Server*	0.0.0.0
1436	*DHCP Option*	0
1437	*IP Command*	-
1440	*Email Function*	0
1441	*Email Text (Body)*	-
1439	*Modbus/TCP Timeout*	0

The parameter settings must be adapted to the actual application.

6.2.1 TCP/IP configuration

For the configuration of the IP address, Netmask, etc., refer to the CM-VABus/TCP user manual. For details refer to the CM-VABus/TCP user manual, Chapter “TCP/IP configuration”.

6.2.2 TCP/IP address & Subnet settings

For proper identification, each frequency inverter is assigned a TCP/IP address which must be unique in the system.

6.2.2.1 Network without DHCP server:

The address is set via parameter *IP-Address* **1432**. In addition, the subnet mask-*Netmask* **1433** must be entered properly for the local network.

Parameters		Settings		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
1432	IP Address	0.0.0.0	255.255.255.255	172.22.1.25
1433	Netmask	0.0.0.0	255.255.255.255	255.255.255.0

6.2.2.2 Network with DHCP server:

When a DHCP server is used, manual network configuration is not required. Set *DHCP Option* **1436** to “1-Enabled” if you wish to use the DHCP function.

DHCP Option 1436	Function
0 - Disabled	Module must be configured manually, no DHCP server is used. (**Factory setting**).
1 - Enabled	The settings are made by a DHCP server.

6.2.3 Modbus/TCP Timeout settings

The communication can be monitored: If communication fails, no data or faulty data will be transmitted. The Modbus/TCP Timeout feature will identify this state.

The timeout feature monitors communication for the time defined by parameter *Modbus/TCP Timeout* **1439**. The set value represents the time in milliseconds where correct data transfer must take place.

If no data is transferred correctly within this time, the frequency inverter will signal the fault **F2735 Modbus/TCP Timeout**.

Parameters		Settings		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
1439	Modbus/TCP Timeout	0 ms	60000 ms	0 ms

When the parameter is set to 0 (factory setting), the monitoring function is off.

6.3 Operating behavior in the case of a communication error

The operating behavior in the case of errors in Modbus/TCP communication can be parameterized. The required behavior can be set via parameter *Bus Error Behaviour* **388**.

Bus Error Behaviour 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**.

For evaluation of settings 2...5, parameter *Local/Remote* **412** must be set to value "1 - Control via statemachine".

7 Protocol

The Modbus/TCP communication protocol is a Client/Server based protocol. Modbus/TCP communication will always be initialized by the client (e.g. PLC). The server nodes (frequency inverters) do not communicate with one another.

Modbus/TCP communication will be established by the client via the TCP/IP-Port #502 on the side of the Modbus/TCP server.

CM-Modbus/TCP and CM-Modbus/TCP-2P only support

- Port #502 for establishing Modbus/TCP connection
- one request per transaction only (NumberMaxOfServerTransaction = 1)

7.1 Telegram structure

A Modbus/TCP telegram comprises the following fields:

MBAP	Function code	Data (Modbus RTU data contents)

MBAP Modbus Application Header

Field	Length	Description	Client	Server (inverter)
Transaction ID (transaction identifier)	2 bytes	Identification of Modbus request/response transaction	Initialized by client	Written back by the server from the request received
Protocol ID (protocol identifier)	2 bytes	0 = Modbus protocol	Initialized by client	Written back by the server from the request received
Length	2 bytes	Number of subsequent bytes (including ID of data unit)	Initialized by client (request)	Initialized by server (response)
ID of data unit (unit identifier)	1 byte	Identification of serially connected Remote Slave	Initialized by client (request)	Initialized by server (response)

- The data unit identifier will not be processed by the server.
- The function code and data field structure are the same in Modbus/TCP and Modbus-RTU.
- Modbus/TCP uses byte sequence Big-Endian (Motorola format).

The **function code** tells the server/frequency inverter which action is to be performed. The function code is followed by a data field containing the parameters of the request (or the response parameters in the case of the response by the frequency inverter).

If there are no errors while a request is received via Modbus/TCP, the data field will contain the required data. If an error occurs, the field contains an exception condition code to tell the master that the request was not processed successfully. For information on how to handle exception conditions and the exception condition codes, refer to Chapter 7.2.9 “Exception condition codes”.

7.2 Supported function codes

The Modbus definitions for writing and reading of data are not directly compatible with parameter access by a frequency inverter (irrespective of the manufacturer of the frequency inverter). Modbus is designed for reading bits and captures data in a different way. Data access is limited to a bit width of 16.

In order to meet the requirements of Modbus, data access is defined in the frequency inverters by the following function codes.

16-bit values:

- Function code 3, read ONE data width of 16 bits (reading of hold register)
- Function code 6, write ONE data width of 16 bits (writing of single register)
- Function code 16, read ONE data width of 16 bits (writing of multiple registers)

32-bit values:

For access to 32-bit data, frequency inverters use the following adapted function codes:

- Function code 3, read TWO data widths of 16 bits (=32 bits) (reading of hold register)
- Function code 16, write TWO data widths of 16 bits (=32 bits) (writing of multiple registers)
- Function code 100, read ONE bit width 32
- Function code 101, write ONE bit width 32

The Modbus specification does not describe handling of 32-bit values. The implemented handlings and function codes are quite common and frequently used. These functions enable data access to 32-bit “Long” variables in the frequency inverter.

In all data fields containing more than one byte, the highest-value byte will be transferred firs (Big-Endian, Motorola Format).

7.2.1 Function code 3, reading 16-bit or 32-bit parameters

This function code is used for reading 16-bit or 32-bit values from the frequency inverter.

Request Read 16-bit parameter:

Function code	1 byte	0x03
Start address (dataset / para. no.)	2 bytes	0x0000 – 0x963F
Number of registers	2 bytes	0x0001

Response Read 16-bit parameter:

Function code	1 byte	0x03
Number of bytes	1 byte	0x02
Register value (parameter value)	2 bytes	0 – 0xFFFF

Request Read 32-bit parameter:

Function code	1 byte	0x03
Start address (dataset / para. no.)	2 bytes	0x0000 – 0x963F
Number of registers	2 bytes	0x0002

Response Read 32-bit parameter:

Function code	1 byte	0x03
Number of bytes	1 byte	0x04
Register value (parameter value)	4 bytes	0 – 0xFFFFFFFF

Exception condition response:

Error code	1 byte	0x83
Exception condition code	1 byte	2, 3 or 4

Start address
This field is used for saving the parameter number and dataset number. The parameter number is in the range between 0 and 1599 and is saved in the 12 least significant bits. The dataset number is in the range between 0 and 9 and is saved in the 4 most significant bits.

Example:
Parameter **372** (hex. 0x174), dataset 2 (hex. 0x2) is saved as hex. 0x2174.

	Start address															
	Data set				Parameter number											
Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	For the above example:															
Hex.	0	0	1	0	0	0	0	1	0	1	1	1	0	1	0	0
Bin.	2				1				7				4			

Number of registers
This field is used for saving the number of parameters to be written. The value must always be 1, since only one parameter can be written at a time.

Number of bytes
This field is set to

- 2 for 16-bit parameters
- 4 for 32-bit parameters

Register value
This field contains the 16-bit or 32-bit parameter value.

Parameter values with decimal places are transferred without decimal point. Depending on the number of decimal places, the values are multiplied by 10, 100 or 1000.

Example:
A current value of 10.3 A is transferred. The actually transferred numerical value is 103, i.e. 0x67 in the hexadecimal system.

Exception condition code
The following exception condition codes are possible:

2	INVALID DATA ADDRESS	• Value of register number field is not 1 • Parameter unknown
3	INVALID DATA VALUE	• Number of bytes in data field too small or too high
4	SLAVE DEVICE ERROR	• Error when reading parameters

For a description of the exception condition codes, refer to Chapter 7.2.9 “Exception condition codes”.

Example Telegrams:

	16 Bit	32 Bit
Modbus RTU	see chapter 9.1.1	see chapter 9.2.1

7.2.2 Function code 6, write 16-bit parameter

This function code is used for writing integer or unsigned integer values into the frequency inverter.

Request Write 16-bit parameter:

MBAP header	7 bytes	
Address	1 byte	1 – 0xF7 (=247)
Function code	1 byte	0x06
Start address (dataset / para. no.)	2 bytes	0x0000 – 0x963F
Register value (parameter value)	2 bytes	0 – 0xFFFF

Response:

MBAP header		
Address	1 byte	1 – 0xF7 (=247)
Function code	1 byte	0x06
Start address (dataset / para. no.)	2 bytes	0x0000 – 0x963F
Register value (parameter value)	2 bytes	0 – 0xFFFF

Exception condition response:

MBAP header		
Address	1 byte	1 – 0xF7 (=247)
Error code	1 byte	0x86
Exception condition code	1 byte	2, 3 or 4

Start address
This field is used for saving the parameter number and dataset number. The parameter number is in the range between 0 and 1599 and is saved in the 12 least significant bits. The dataset number is in the range between 0 and 9 and is saved in the 4 most significant bits.

Example:
Parameter **372** (hex. 0x174), dataset 2 (hex. 0x2) is saved as hex. 0x2174.

	Start address															
	Data set				Parameter number											
Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	For the above example:															
Hex.	0	0	1	0	0	0	0	1	0	1	1	1	0	1	0	0
Bin.	2				1				7				4			

Register value
This field is used for saving the 16-bit parameter value.

Parameter values with decimal places are transferred without decimal point. Depending on the number of decimal places, the values are multiplied by 10, 100 or 1000.

Example:
A current value of 10.3 A is to be transferred. The actually transferred numerical value is 103, i.e. 0x67 in the hexadecimal system.

Exception condition code
The following exception condition codes are possible:

2	INVALID DATA ADDRESS	• Parameter unknown
3	INVALID DATA VALUE	• Number of bytes in data field too small or too high
4	SLAVE DEVICE ERROR	• Error when writing parameters

For a description of the exception condition codes, refer to Chapter 7.2.9 “Exception condition codes”.

For an example of a Modbus RTU telegram, refer to Chapter 9.1.2.

7.2.3 Function code 16, write 16-bit parameter

Function code 16 can be used for writing 16-bit values into the frequency inverter.

Request Write 16-bit parameter:

MBAP header	7 bytes	
Address	1 byte	1 – 0xF7 (=247)
Function code	1 byte	0x10
Start address (dataset / para. no.)	2 bytes	0x0000 – 0x963F
Number of registers	2 bytes	0x0001
Number of bytes	1 byte	0x02
Register value (parameter value)	2 bytes	0 – 0xFFFF

Response:

MBAP header		
Address	1 byte	1 – 0xF7 (=247)
Function code	1 byte	0x10
Start address (dataset / para. no.)	2 bytes	0x0000 – 0x963F
Number of registers	2 bytes	0x0001

Exception condition response:

MBAP header		
Address	1 byte	1 – 0xF7 (=247)
Error code	1 byte	0x90
Exception condition code	1 byte	2, 3 or 4

Start address
This field is used for saving the parameter number and dataset number. The parameter number is in the range between 0 and 1599 and is saved in the 12 least significant bits. The dataset number is in the range between 0 and 9 and is saved in the 4 most significant bits.

Example:

Parameter **372** (hex. 0x174), dataset 2 (hex. 0x2) is saved as hex. 0x2174.

	Start address															
	Data set				Parameter number											
Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	For the above example:															
Hex.	0	0	1	0	0	0	0	1	0	1	1	1	0	1	0	0
Bin.	2				1				7				4			

Register value
This field is used for saving the 16-bit parameter value.

Parameter values with decimal places are transferred without decimal point. Depending on the number of decimal places, the values are multiplied by 10, 100 or 1000.

Example:
A current value of 10.3 A is to be transferred. The actually transferred numerical value is 103, i.e. 0x67 in the hexadecimal system.

Exception condition code
The following exception condition codes are possible:

2	INVALID DATA ADDRESS	• Parameter unknown
3	INVALID DATA VALUE	• Number of bytes in data field too small or too high
4	SLAVE DEVICE ERROR	• Error when writing parameters

For a description of the exception condition codes, refer to Chapter 7.2.9 “Exception condition codes”.

For an example of a Modbus RTU telegram, refer to Chapter 9.1.3.

7.2.4 Function code 16, write 32-bit parameter

Function code 16 can be used for writing 32-bit values into the frequency inverter.

Request Write 32-bit parameter:

MBAP header		
Address	1 byte	1 – 0xF7 (=247)
Function code	1 byte	0x10
Start address (dataset / para. no.)	2 bytes	0x0000 – 0x963F
Number of registers	2 bytes	0x0002
Number of bytes	1 byte	0x04
Register value (parameter value)	2 bytes	0 – 0xFFFF FFFF

Response:

MBAP header		
Address	1 byte	1 – 0xF7 (=247)
Function code	1 byte	0x10
Start address (dataset / para. no.)	2 bytes	0x0000 – 0x963F
Number of registers	2 bytes	0x0002

Exception condition response:

MBAP header		
Address	1 byte	1 – 0xF7 (=247)
Error code	1 byte	0x90
Exception condition code	1 byte	2, 3 or 4

Start address
This field is used for saving the parameter number and dataset number. The parameter number is in the range between 0 and 1599 and is saved in the 12 least significant bits. The dataset number is in the range between 0 and 9 and is saved in the 4 most significant bits.

Example:

Parameter **372** (hex. 0x174), dataset 2 (hex. 0x2) is saved as hex. 0x2174.

	Start address															
	Data set				Parameter number											
Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	For the above example:															
Hex.	0	0	1	0	0	0	0	1	0	1	1	1	0	1	0	0
Bin.	2				1				7				4			

Register value
This field is used for saving the 32-bit parameter value.

Parameter values with decimal places are transferred without decimal point. Depending on the number of decimal places, the values are multiplied by 10, 100 or 1000.

Example:
A frequency value of 123.45 Hz is to be transferred. The actually transferred numerical value is 12345, i.e. 0x3039 in the hexadecimal system.

Exception condition code
The following exception condition codes are possible:

2	INVALID DATA ADDRESS	• Parameter unknown
3	INVALID DATA VALUE	• Number of bytes in data field too small or too high
4	SLAVE DEVICE ERROR	• Error when writing parameters

For a description of the exception condition codes, refer to Chapter 7.2.9 “Exception condition codes”.

For an example of a Modbus RTU telegram, refer to Chapter 9.2.2.

7.2.5 Function code 100 (=0x64), read 32-bit parameter

Request:

MBAP header		
Address	1 byte	1 – 0xF7 (=247)
Function code	1 byte	0x64
Start address (dataset / para. no.)	2 bytes	0x0000 – 0x963F

Response:

MBAP header		
Address	1 byte	1 – 0xF7 (=247)
Function code	1 byte	0x64
Register value (parameter value)	4 bytes	0 – 0x FFFF FFFF

Exception condition response:

MBAP header		
Address	1 byte	1 – 0xF7 (=247)
Error code	1 byte	0xE4
Exception condition code	1 byte	2, 3 or 4

Start address
This field is used for saving the parameter number and dataset number. The parameter number is in the range between 0 and 1599 and is saved in the 12 least significant bits. The dataset number is in the range between 0 and 9 and is saved in the 4 most significant bits.

Example:
Parameter 372 (hex. 0x174), dataset 2 (hex. 0x2) is saved as hex. 0x2174.

	Start address															
	Data set				Parameter number											
Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	For the above example:															
Hex.	0	0	1	0	0	0	0	1	0	1	1	1	0	1	0	0
Bin.	2				1				7				4			

Number of registers
This field is used for saving the 32-bit parameter values.

Parameter values with decimal places are transferred without decimal point. Depending on the number of decimal places, the values are multiplied by 10, 100 or 1000.

Example:
A frequency value of 100.25 Hz is to be transferred. The actually transferred numerical value is 10025, i.e. 0x2729in the hexadecimal system.

Exception condition code
The following exception condition codes are possible:

2	INVALID DATA ADDRESS	• Parameter unknown
3	INVALID DATA VALUE	• Number of bytes in data field too small or too high
4	SLAVE DEVICE ERROR	• Error when reading parameters

For a description of the exception condition codes, refer to Chapter 7.2.9 “Exception condition codes”.

For an example of a Modbus RTU telegram, refer to Chapter 9.2.3.

7.2.6 Function code 101 (=0x65), write 32-bit parameter

Request:

MBAP header		
Address	1 byte	1 – 0xF7 (=247)
Function code	1 byte	0x65
Start address (dataset / para. no.)	2 bytes	0x0000 – 0x963F
Register value (parameter value)	4 bytes	0 – 0xFFFF FFFF

Response:

MBAP header		
Address	1 byte	1 – 0xF7 (=247)
Function code	1 byte	0x65
Start address (dataset / para. no.)	2 bytes	0x0000 – 0x963F
Register value (parameter value)	4 bytes	0 – 0xFFFF FFFF

Exception condition response:

MBAP header		
Address	1 byte	1 – 0xF7 (=247)
Error code	1 byte	0xE5
Exception condition code	1 byte	2, 3 or 4

Start address
This field is used for saving the parameter number and dataset number. The parameter number is in the range between 0 and 1599 and is saved in the 12 least significant bits. The dataset number is in the range between 0 and 9 and is saved in the 4 most significant bits.

Example:
Parameter **372** (hex. 0x174), dataset 2 (hex. 0x2) is saved as hex. 0x2174.

	Start address															
	Data set				Parameter number											
Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	For the above example:															
Hex.	0	0	1	0	0	0	0	1	0	1	1	1	0	1	0	0
Bin.	2				1				7				4			

Register value
This field is used for saving the 32-bit parameter value.

Parameter values with decimal places are transferred without decimal point. Depending on the number of decimal places, the values are multiplied by 10, 100 or 1000.

Example: Frequency value
A frequency value of 100.25 Hz is to be transferred. The actually transferred numerical value is 10025, i.e. 0x2729in the hexadecimal system.

Exception condition code
The following exception condition codes are possible:

2	INVALID DATA ADDRESS	• Parameter unknown
3	INVALID DATA VALUE	• Number of bytes in data field too small or too high
4	SLAVE DEVICE ERROR	• Error when reading parameters

For a description of the exception condition codes, refer to Chapter 7.2.9 “Exception condition codes”.

For an example of a Modbus RTU telegram, refer to Chapter 9.2.4.

7.2.7 Function code 8, diagnosis

This function code is used for accessing the Modbus diagnosis counter of the frequency inverter. Each counter can be accessed via a sub-function code and a counter number. Each counter can be deleted by entering the hexadecimal sub-function code 0x0A.

The following sub-function codes are supported.

Sub-function	Name	Description
0x0A	Delete all counters	Resets all counters to 0
0x0B	Return number of bus messages	Number of valid messages received (including all addresses)
0x0C	Return number of bus transfer errors	Number of messages with CRC or parity/block check/data loss errors
0x0D	Return number of bus exceptions	Number of exception responses sent
0x0E	Return number of slave messages	Number of messages received (including slave address)
0x0F	Return number of “Slave – no response” messages	Number of broadcast messages received
0x10	Return number of slave NAK (negative receipt acknowledgment)	Not used, return value will always be 0
0x11	Return number of “Slave busy” messages	Not used, return value will always be 0
0x12	Return number of bus character data loss error	Number of messages with data loss errors

Request (sub-function 0x0A, Delete all counters):

MBAP Header		
Address	1 byte	1 – 0xF7 (=247)
Function code	1 byte	0x08
Sub-function	2 bytes	0x000A
Data	2 bytes	0x0000

Response:

MBAP Header		
Address	1 byte	1 – 0xF7 (=247)
Function code	1 byte	0x08
Sub-function	2 bytes	0x000A
Data	2 bytes	0x0000

Exception condition response:

MBAP Header		
Address	1 byte	1 – 0xF7 (=247)
Error code	1 byte	0x88
Exception condition code	1 byte	1, 3 or 4

Data

This field will always be 0x0000.

Exception condition code

1	INVALID FUNCTION CODE	• Sub-function is not supported
3	INVALID DATA VALUE	• Number of bytes in data field too small or too high • "Data field" not 0x0000
4	SLAVE DEVICE ERROR	• Error while executing the function.

For a description of the exception condition codes, refer to Chapter 7.2.9 "Exception condition codes".

Request (sub-function 0x0B – 0x12, return counter value):

Address	1 byte	1 – 0xF7 (=247)
Function code	1 byte	0x08
Sub-function	2 bytes	0x000B – 0x0012
Data	2 bytes	0x0000

Response:

Address	1 byte	1 – 0xF7 (=247)
Function code	1 byte	0x08
Sub-function	2 bytes	0x000B – 0x0012
Data (counter value)	2 bytes	0 – 0xFFFF

Exception condition response:

Address	1 byte	1 – 0xF7 (=247)
Error code	1 byte	0x88
Exception condition code	1 byte	1, 3 or 4

Data
In the request, this field will always be set to 0x0000, in the response, it will show the current counter value.

Exception condition code
The following exception condition codes are possible:

1	INVALID FUNCTION CODE	• Sub-function is not supported
3	INVALID DATA VALUE	• Number of bytes in data field too small or too high • "Data field" not 0x0000
4	SLAVE DEVICE ERROR	• Error when reading diagnosis counter

For a description of the exception condition codes, refer to Chapter 7.2.9 "Exception condition codes".

7.2.8 Exception condition responses

The master device expects a normal response when it sends a request to the frequency inverter. A request by the master can result in one of four reactions:

- If the frequency inverter receives the request without any transmission errors, it can process it and send a normal response.
- If the frequency inverter does not receive the request due to a transmission error, it will not send a response. The master will check the conditions for time monitoring of the request.
- If the frequency inverter receives the request and identifies a transmission error (parity, LCR, CRC, ...), it will not send a response. The master will check the conditions for time monitoring of the request.
- If the frequency inverter receives the request without any transmission error, but cannot process it, e.g. because an unknown parameter is to the read, it will send an exception response containing information about the type of error.

The exception condition response contains two fields which are different from normal responses:

Function code field:
In a normal response, the frequency inverter will return the function code of the original request. All function codes have 0 as the most significant bit (MSB); their values are less than the hexadecimal value of 0x80. In an exception condition response, the frequency inverter will set the most significant bit of the function code to 1. This will increase the hexadecimal value of the function code in an exception condition response by 0x80 compared to the value of a normal response. With the most significant bit in the function code set to the new value, the master can identify the exception response and analyze the exception condition code in the data field.

Data field:
In a normal response, the frequency inverter will send data or statistical values in the data field (requested information) . In an exception condition response, the frequency inverter will send an exception condition code in the data field. This code indicates the cause of the exception condition.

The exception condition codes generated by the frequency inverter are listed in Chapter 7.2.9 “Exception condition codes”.

7.2.9 Exception condition codes

The frequency inverter generates the following exception condition codes:

Code	Modbus name	Reason of generation by frequency inverter
1	INVALID FUNCTION	• Function code unknown • Sub-function code unknown (diagnosis function)
2	INVALID DATA ADDRESS	• Wrong number of registers (must always be 0x01) • Unknown parameter or data type of parameter unknown
3	INVALID DATA VALUE	• Block check error • Number of bytes in too small or too high • Certain fields not set to typical values
4	SLAVE DEVICE ERROR	• Unsuccessful reading or writing of parameters The cause of the error can be analyzed by reading parameter *VABusSST Error Register* **11**.

VABusSST Error Register **11**	
Error number	**Meaning**
0	No error
1	Non-permissible parameter value.
2	Non-permissible dataset
3	Parameter not readable (write-only)
4	Parameter not writable (read-only)
5	EEPROM read error
6	EEPROM write error
7	EEPROM checksum error
8	Parameter cannot be written while the drive is running
9	Values of data sets are different
10	Wrong parameter type
11	Unknown parameter
12	Checksum error in received telegram
13	Syntax error in received telegram
14	Data type of parameter does not match the number of bytes in the telegram
15	Unknown error

When parameter *VABusSST Error Register* **11** is read, it is deleted automatically at the same time.

7.2.10 Modbus/TCP mode of transmission

The usable contents of Modbus/TCP is basically structured like Modbus RTU.

7.2.10.1 Modbus RTU message telegram

Modbus messages are added by a sending device into a telegram which has a defined start and end point. The TCP/IP frame enables receiving devices to identify the beginning and end of the message. Incomplete messages must be detected and result in an error.

Modbus RTU messages

Address	Function	Data
8 bits	8 bits	N x 8 bits

The whole message telegram must be transmitted as a coherent flow of characters.

7.3 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** = Statemachine:
  Set bit 7 of control word *Control word* **410**= 0x8000.
- 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 acknowledgment* **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 Parameter access

8.1 Handling of datasets / cyclic writing of parameters

The parameter values are accessed based on the parameter number and the required dataset. There are parameters the values of which are present once (dataset 0) as well as parameters the values of which are present four times (dataset 1...4). These are used for dataset switching.

If parameters which are present four times in the datasets are set to Dataset = 0, the four datasets are set to the same transmitted 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. If this is not the case, an error will be signaled.

NOTE

The values are entered automatically in the EEPROM of the controller. When values are to be written cyclically, no entries shall be made in the EEPROM, as this only allows a limited number of write cycles (approx. 1 million cycles). When the number of permissible write cycles is exceeded, the EEPROM will be destroyed.

In order to avoid this, data which is written cyclically can be entered in the RAM exclusively without a writing cycle on the EEPROM. Such data will be lost in the case of a power failure and have to be written again after Power off/on.
This mechanism is started when the target dataset is increased by five when specifying the dataset.

Writing on virtual dataset in RAM

Parameters	EEPROM	RAM
Dataset 0	0	5
Dataset 1	1	6
Dataset 2	2	7
Dataset 3	3	8
Dataset 4	4	9

8.2 Handling of index parameters / cyclic writing

Index parameters are used for various ACU 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
		Write EEPROM and 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.

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). When this number is exceeded, the EEPROM will be destroyed.

- Values which are written cyclically at a high repetition rate should be written to the RAM and not the EEPROM.

In the RAM, the data is not protected against loss of power. Once power supply is disrupted, the data must be written again.

8.2.1 Example: Writing of index parameters

Typically, index parameters are written regularly during commissioning or in simple positioning applications.

Writing of Parameter *Target position/distance* **1202** (Type double word), in Index 1 in RAM (→ Index 34 for write access) with parameter value 30000.

Index = 1200 + 0x2000 = 0x24B0, Wert (int) = 34 = 0x0022
Index = 1202 + 0x2000 = 0x24B2, Wert (long) = 30000 = 0x0000 7530

If various parameters of an index are to be edited, it will be sufficient to set index access via parameter **1200** once at the beginning.

8.2.2 Example: Reading of index parameters

In order to read an index parameter, you will have to set the indexing parameter to the relevant index first, then you can read the parameter.

Reading of Parameter *Target position/distance* **1202** (type long), in Index 1 with parameter value 123000.
Index = 1201 + 0x2000 = 0x24B1, Wert (int) = 1 = 0x0001
Index = 1202 + 0x2000 = 0x24B2, Wert (long) = 123000 = 0x0001 E078

If various parameters of an index are to be read, it will be sufficient to set index access via **1201** once at the beginning.

9 Example messages Modbus/TCP

This chapter describes some examples of telegrams for Modbus/TCP.

9.1 16-bit access

9.1.1 Function code 3, read 16-bit parameter

Example 1:
Reading of parameter *Rated speed* **372** (0x0174) in data set 2 from the frequency inverter with address 1.

Request: Master ➔ frequency inverter

Field:	MBAP						Unit ID	Func.	DSet/ParNo.		Number of registers	
	Transaction ID		Protocol ID		Length							
Hex	nn	nn	nn	nn	00	06	01	03	21	74	00	01

Response: Frequency inverter ➔ Master

Field:	MBAP						Unit ID	Func.	No. Bytes	Par.value	
	Transaction ID		Protocol ID		Length						
Hex	nn	nn	nn	nn	nn	nn	01	03	02	05	6E

The sent hexadecimal value is 0x056E = Decimal 1390. Parameter *Rated speed* **372** has no decimal places. Thus, the rated speed is 1390 min^{-1}.

Example 2:
Reading of parameters *Rated speed* **372** (0x0174) in dataset 0 of frequency inverter with address set to 1 and number of registers set to 2 (non-permissible value).

Request: Master ➔ frequency inverter

Field:	MBAP						Unit ID	Func.	DSet/ParNo.		Number of registers	
	Transaction ID		Protocol ID		Length							
Hex	nn	nn	nn	nn	00	06	01	03	01	74	00	02

Error response: Frequency inverter ➔ Master

Field:	MBAP						Unit ID	Func.	Excep.
	Transaction ID		Protocol ID		Length				
Hex	nn	nn	nn	nn	00	03	01	83	04

The sent exception condition code is the hexadecimal value 0x04 = ERROR SLAVE DEVICE.

9.1.2 Function code 6, write 16-bit parameter

Example 1:
Writing of parameter *Rated Mech. Power* **376** (0x0178) in dataset 4 of frequency inverter with address 3.

The rated mechanical power is to be set to 1.5 kW. Parameter *Rated Mech. Power* **376** has one decimal place. Thus the value to be sent is 15 = 0x000F.

Request: Master ➔ frequency inverter

Field:	MBAP						Unit ID	Func.	DSet/ParNo.		Par.value	
	Transaction ID		Protocol ID		Length							
Hex	nn	nn	nn	nn	00	06	01	06	41	78	00	0F

Response: Frequency inverter ➔ Master

Field:	MBAP						Unit ID	Func.	DSet/ParNo.		Par.value	
	Transaction ID		Protocol ID		Length							
Hex	nn	nn	nn	nn	00	06	01	06	41	78	00	0F

The response is the reflected signal of the request message.

Example 2:
Writing of non-permissible value 0 in parameter *Rated Mech. Power* **376** (0x0178) in dataset 2 of frequency inverter with address 3.

Request: Master ➔ frequency inverter

Field:	MBAP						Unit ID	Func.	DSet/ParNo.		Par.value	
	Transaction ID		Protocol ID		Length							
Hex	nn	nn	nn	nn	00	06	03	06	21	78	00	00

Error response: Frequency inverter ➔ Master

Field:	MBAP						Unit ID	Func.	Excep.
	Transaction ID		Protocol ID		Length				
Hex	nn	nn	nn	nn	00	03	03	86	04

The sent exception condition code is the hexadecimal value 0x04 = Error SLAVE device.

9.1.3 Function code 16, write 16-bit parameter

Example 1:
Writing of parameter *Rated Mech. Power* **376** (0x0178) in dataset 4 of frequency inverter with address 1.

The rated mechanical power is to be set to 1.5 kW. Parameter *Rated Mech. Power* **376** has one decimal place. Thus the value to be sent is 15 = 0x000F.

Request: Master ➔ frequency inverter

Field :	MBAP						Unit ID	Func.	DSet/ ParNo.		No. registers		No. Byte	Par. value	
	Transaction ID		Protocol ID		Length										
	nn	nn	nn	nn	00	09	01	10	41	78	00	01	02	00	0F

Response: Frequency inverter ➔ Master

Field :	MBAP						Unit ID	Func.	DSet/ Par.No.		No. registers	
	Transaction ID		Protocol ID		Length							
	nn	nn	nn	nn	00	09	01	10	41	78	00	01

The response contains the number of written registers

Example 2:
Writing of non-permissible value 0 in parameter *Rated Mech. Power* **376** 0x0178) in dataset 2 of frequency inverter with address 3.

Request: Master ➔ frequency inverter

Field :	MBAP						Unit ID	Func.	DSet/ ParNo.		No. registers		No. Byte	Par. value	
	Transaction ID		Protocol ID		Length										
	nn	nn	nn	nn	00	09	03	10	41	78	00	01	02	00	00

Error response: Frequency inverter ➔ Master

Field:	MBAP						Unit ID	Func.	Excep.
	Transaction ID		Protocol ID		Length				
Hex	nn	nn	nn	nn	00	03	03	90	04

The sent exception condition code is the hexadecimal value 0x04 = ERROR SLAVE DEVICE.

9.2 32-bit access

9.2.1 Function code 3, read 32-bit parameter

Example 1:
Reading of parameter *Fixed Frequency 2* **481** (0x01E1) in dataset 1 of frequency inverter with address 1.

Request: Master ➔ frequency inverter

Field:	MBAP						Unit ID	Func.	DSet/ ParNo.		No. registers	
	Transaction ID		Protocol ID		Length							
	nn	nn	nn	nn	00	06	01	03	11	E1	00	02

Response: Frequency inverter ➔ Master

Field:	MBAP						Addi.	Func.	No. Bytes	Par.value			
	Transaction ID		Protocol ID		Length								
Hex	nn	nn	nn	nn	00	07	01	03	04	00	00	03	E8

The sent hexadecimal value is 0x03E8 = Decimal 1000. Parameter *Fixed Frequency 2* **481** has two decimal places. Thus, the frequency is 10.00 Hz.

Example 2:
Reading of parameters *Fixed Frequency 2* **481** (0x01E1) in dataset 0 of frequency inverter with address set to 1 and number of registers set to 1 (non-permissible value).

Request: Master ➔ frequency inverter

Field:	MBAP						Unit ID	Func.	DSet/ Par.No.		No. registers	
	Transaction ID		Protocol ID		Length							
	nn	nn	nn	nn	00	06	01	03	01	E0	00	01

Error response: Frequency inverter ➔ Master

Field:	MBAP						Unit ID	Func.	Excep.
	Transaction ID		Protocol ID		Length				
Hex	nn	nn	nn	nn	00	03	01	83	04

The sent exception condition code is the hexadecimal value 0x04 = ERROR SLAVE DEVICE.

9.2.2 Function code 16, write 32-bit parameter

Example 1:
Writing of parameter *Fixed Frequency 3* **482** (0x01E2) in dataset 9 (= RAM for dataset 4) of frequency inverter with address 1.

The fixed frequency is to be set to 44.50 Hz. Parameter *Fixed Frequency 3* **482** has two decimal places. Thus the value to be sent is 4450 = 0x00001162.

Request: Master ➔ frequency inverter

Field:	MBAP						Unit ID	Func.	DSet/ Par.No.		No. registers		No. Byte	Par. value			
	Transaction ID		Protocol ID		Length												
Hex	nn	nn	nn	nn	00	0B	01	10	91	E2	00	02	04	00	00	11	62

Response: Frequency inverter ➔ Master

Field:	MBAP						Unit ID	Func.	DSet/ Par.No.		No. registers	
	Transaction ID		Protocol ID		Length							
Hex	nn	nn	nn	nn	00	0B	01	10	91	E2	00	02

The response contains the number of written registers

Example 2:
Writing of parameter *Fixed Frequency 3* **482** (0x01E2) in dataset 9 (= RAM for dataset 4) of frequency inverter with address 1.

The frequency is to be set to 2000.00 Hz (non-permissible value). Parameter *Fixed Frequency 3* **482** has two decimal places. Thus the value to be sent is 20000 = 0x00030D40.

Request: Master ➔ frequency inverter

Field:	MBAP						Unit ID	Func.	DSet/ Par.No.		No. registers		No. Byte	Par. value			
	Transaction ID		Protocol ID		Length												
Hex	nn	nn	nn	nn	00	0B	01	10	91	E2	00	02	04	00	03	0D	40

Error response: Frequency inverter ➔ Master

Field:	MBAP						Unit ID	Func.	Excep.
	Transaction ID		Protocol ID		Length				
Hex	nn	nn	nn	nn	00	03	01	90	04

The sent exception condition code is the hexadecimal value 0x04 = ERROR SLAVE DEVICE.

9.2.3 Function code 100 (=0x64), read 32-bit parameter

Example 1:
Reading of parameter *Fixed Frequency 2* **481** in dataset 0 of frequency inverter with address 1.

Request: Master ➔ frequency inverter

Field:	MBAP						Unit ID	Func.	DSet/ Par.No.	
	Transaction ID		Protocol ID		Length					
Hex	nn	nn	nn	nn	00	04	01	64	01	E1

Response: Frequency inverter ➔ Master

Field:	MBAP						Unit ID	Func.	Par. value			
	Transaction ID		Protocol ID		Length							
Hex	nn	nn	nn	nn	00	06	01	64	00	00	03	E8

The sent hexadecimal value is 0x000003E8 = 1000. Parameter *Fixed Frequency 2* **481** has two decimal places. Thus, Fixed Frequency 2 = 10.00 Hz.

Example 2:
Reading of unknown parameter **1600** (0x0640) in dataset 2 of frequency inverter with address 1.

Request: Master ➔ frequency inverter

Field:	MBAP						Unit ID	Func.	DSet/ Par.No.	
	Transaction ID		Protocol ID		Length					
Hex	nn	nn	nn	nn	00	04	01	64	26	40

Error response: Frequency inverter ➔ Master

Field:	MBAP						Unit ID	Func.	Excep.
	Transaction ID		Protocol ID		Length				
Hex	nn	nn	nn	nn	00	03	01	E4	04

The exception condition code is the hexadecimal value 0x04 = ERROR SLAVE DEVICE.

9.2.4 Function code 101 (=0x65), write 32-bit parameter

Example 1:
Writing of parameter *Rated Frequency* **375** (0x0177) in dataset 2 of frequency inverter with address 1.

The Rated Frequency is to be set to 10.00 Hz. Parameter *Rated Frequency* **375** has two decimal places. Thus the value to be sent is 1000 = 0x03E8.

Request: Master ➔ frequency inverter

Field:	MBAP						Unit ID	Func.	DSet/ Par.No.		Par. value			
	Transaction ID		Protocol ID		Length									
Hex	nn	nn	nn	nn	00	08	01	65	21	77	00	00	03	E8

Response: Frequency inverter ➔ Master

Field:	MBAP						Unit ID	Func.	DSet/ Par.No.		Par. value			
	Transaction ID		Protocol ID		Length									
Hex	nn	nn	nn	nn	00	08	01	65	21	77	00	00	03	E8

The response is the reflected signal of the request message.

Example 2:
Writing of non-permissible value 9.00 Hz in parameter *Rated Frequency* **375** in dataset 2 of frequency inverter with address 1.

Parameter *Rated Frequency* **375** has 2 decimal places. Thus the value to be sent is 900 = 0x0384.

Request: Master ➔ frequency inverter

Field:	MBAP						Unit ID	Func.	DSet/ Par.No.		Par. value			
	Transaction ID		Protocol ID		Length									
Hex	nn	nn	nn	nn	00	08	01	65	21	77	00	00	03	84

Error response: Frequency inverter ➔ Master

Field:	MBAP						Unit ID	Func.	Excep.
	Transaction ID		Protocol ID		Length				
Hex	nn	nn	nn	nn	00	03	01	E5	04

The sent exception condition code is the hexadecimal value 0x04 = ERROR SLAVE DEVICE.

9.2.5 Function code 8, diagnosis

Example 1a:
Deleting of all diagnosis counters (sub-function 0x0A) in frequency inverter with address 1.

Request: Master ➔ frequency inverter

Field:	MBAP						Unit ID	Func.	Sub-function		Data	
	Transaction ID		Protocol ID		Length							
Hex	nn	nn	nn	nn	00	06	01	08	00	0A	00	00

Response: Frequency inverter ➔ Master

Field:	MBAP						Unit ID	Func.	Sub-function		Data	
	Transaction ID		Protocol ID		Length							
Hex	nn	nn	nn	nn	00	06	01	08	00	0A	00	00

The response is the reflected signal of the request message. All counters are set to zero.

Example 1b:
With all counters set to zero, reading of diagnosis counter 4 “Slave Messages Counter” (sub-function 0x0E) of frequency inverter with address 1.

Request: Master ➔ frequency inverter

Field:	MBAP						Unit ID	Func.	Sub-function		Data	
	Transaction ID		Protocol ID		Length							
Hex	nn	nn	nn	nn	00	06	01	08	00	0E	00	00

Response: Frequency inverter ➔ Master

Field:	MBAP						Unit ID	Func.	Sub-function		Data	
	Transaction ID		Protocol ID		Length							
Hex	nn	nn	nn	nn	00	06	01	08	00	0E	00	01

Counter value is 1 because this is the first message received after resetting of all counters to zero.

Example 2:
Reading of unknown diagnosis counter 8 (sub-function 0x13) of frequency inverter with address 1.

Request: Master ➔ frequency inverter

Field:	MBAP						Unit ID	Func.	Sub-function		Data	
	Transaction ID		Protocol ID		Length							
Hex	nn	nn	nn	nn	00	06	01	08	00	13	00	00

Error response: Frequency inverter ➔ Master

Field:	MBAP						Unit ID	Func.	Excep.
	Transaction ID		Protocol ID		Length				
Hex	nn	nn	nn	nn	00	03	01	88	01

The sent exception condition code is the hexadecimal value 0x01 = INVALID FUNCTION CODE.

10 Motion Control Interface (MCI) / Motion Control Override (MCO)

The Motion Control Interface (MCI) is a defined interface of the ACU device for positioning control via Field Bus. Typically, this interface is used by field bus systems such as CANopen®. 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.

In the case of Modbus/TCP communication, MCI cannot be used directly. Instead, positioning is performed via MCO (Motion Control Override), see Chapter 10.1 “Motion Control Override”.

The Motion Control Interface uses parameter *Override Modes Of Operation* **1454** 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
- 7 – Interpolated mode (not available when MCO is used)
- 8 – Cyclic sync position mode (not available when MCO is used)
- 9 – Cyclic sync velocity mode (not available when MCO is used)

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 mode of operation can be switched in any operating state.

It is recommended that running movements be stopped by the PLC first, then, switch the mode of operation using *Override Modes Of Operation* **1454** and restart in the new mode.

In order to use the Motion Control Interface, *Local/Remote* **412** = “1 - Control via statemachine” must be set. In configurations without positioning control (*Configuration* **30** ≠ x40), only velocity mode is available.

For a description of the positioning parameters, please refer to the “Application manual - Positioning”.

10.1 Motion Control Override

The Motion Control Override feature can be used for specifying a travel profile via serial communication (VABus or Modbus as well as VABus/TCP or Modbus/TCP). This enables testing a travel profile in the VPlus user software for Windows when the controller has not been programmed completely yet. 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	-2^{31}-1...2^{31}-1 u		-1 u
1456	Override Profile Velocity	-1...2^{31}-1 u/s		-1 u/s
1457	Override Acceleration	-1...2^{31}-1 u/s²		-1 u/s²
1458	Override Deceleration	-1...2^{31}-1 u/s²		-1 u/s²
1459	Override Target Velocity vl [rpm]	-32768...32767 rpm		-1 rpm
1460	Override Target Velocity pv [u/s]	-2^{31}-1...2^{31}-1 u/s		-1 u/s

Based on the default settings of the Motion Control Interface (parameters **P.1292**... **P.1297**), the override parameters and CANopen® objects are used as follows:

1454 *Override Modes Of Operation*	**or**	0x6060 Modes of Operation
1455 *Override Target Position*	**or**	0x607A Target Position
1456 *Override Profile Velocity*	**or**	0x6081 Profile Velocity
1457 *Override Acceleration*	**or**	0x6083 Profile Acceleration
1458 *Override Deceleration*	**or**	0x6084 Profile Deceleration
1459 *Override Target Velocity vl [rpm]*	**or**	0x6042 Target Velocity
1460 *Override Target Velocity pv [u/s]*	**or**	0x60FF Target Velocity

With the default settings "-1" in parameters **P.1455**... **P.1460** and "0" in parameter *Override Modes Of Operation* **1454** the values of the Motion Control from the links of parameters **P.1292**... **P.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.

Target position "-1 u" cannot be approached because *Override Target Position* **1455** = *-1* deactivates the override feature.

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.
The following tables show the available modes of Operation using the Motion Control Override.

Mode	Homing	Velocity Mode	Profile Velocity Mode
1454 *Override Modes Of Operation*	**6**	**2**	**3**
Target position			
Speed	**1132** & **1133** *Fast speed / Creep speed*	**1459** *Override Target Velocity vl [rpm]*	**1460** *Override Target Velocity pv [u/s]*
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*	**1457** *Override Acceleration*
Deceleration	**1134** *Acceleration*	**421** *Deceleration (clockwise)* **423** *Deceleration anticlockwise*	**1458** *Override Deceleration*
Emergency stop [2)] Quick Stop	**1179** *Emergency stop ramp*	**424** *Emergency stop clockwise* **425** *Emergency stop anticlockwise*	**1179** *Emergency stop ramp*
Homing Method	**1130** *Homing type*		

1) 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.
2) Emergency stop or Deceleration is used depending on the stopping behavior *Mode of operation* **630** or the behavior in the case of communication errors *Bus Error Behaviour* **388**.

Mode	Profile Positioning mode
1454 *Override Modes Of Operation*	1
Target position	**1455** *Override Target Position*
Speed	**1456** *Override Profile Velocity*
Limitation[3)]	**418** *Minimum frequency* **419** *Maximum Frequency*
Acceleration	**1456** *Override Acceleration*
Deceleration	**1458** *Override Deceleration*
Emergency stop [4)] Quick Stop	**1179** *Emergency stop ramp*

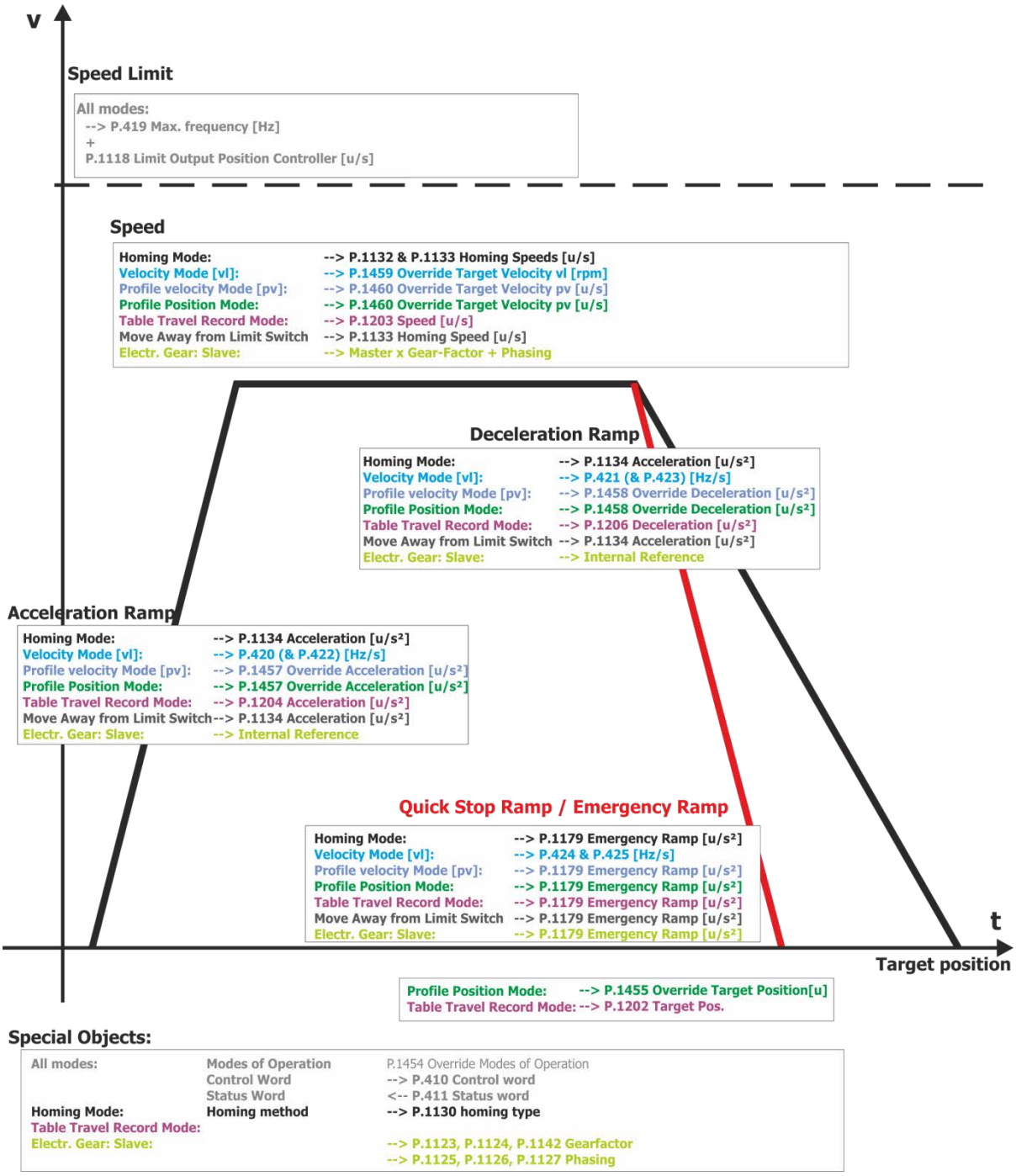
1) The limitation results from *Minimum frequency* **418** and *Maximum Frequency* **419**. Through *Limitation* **1118** of the position controller in Configuration x40, an increase above the Maximum Frequency can occur, because the output of the position controller is added to the Maximum Frequency.
2) Emergency stop or Deceleration is used depending on the stopping behavior *Mode of operation* **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
1454 *Override Modes Of Operation*	**255**	**254**	**253**
Target position	**1202** *Target position*		
Speed	**1203** *Speed*	**1132** *Fast speed* **1133** *Creep speed*	**1460** *Override Target Velocity pv [u/s]*
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*	**1457** *Override Acceleration*
Deceleration	**1205** *Deceleration*	**1134** *Acceleration*	**1458** *Override Deceleration*
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 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.

2) Emergency stop or Deceleration is used depending on the stopping behavior *Mode of operation* **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.

10.2 Functions of Motion Control Interface (MCI)

Via the Motion Control Interface, numerous positioning functions can be addressed by a PLC directly.

10.2.1 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 and the *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**
Gear Box: Shaft revolutions **1116**
Gear Box: Motor revolutions **1117**

The same formulas can be used for converting acceleration values from a[Hz/s] to a[u/s²] and vice versa. In the formulas, replace speeds f[Hz] and f[u/s] by accelerations a[Hz/s] and a[u/s²].

For more details about the reference system, refer to the "Positioning" application manual.

10.2.2 Modes of operation

In *Override Modes Of Operation* **1454**, you can define the operation mode of the frequency inverter.
The available options depend on the set frequency inverter configuration.

Available values for *Override Modes Of Operation* **1454** in configurations of the frequency inverter with position 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
255 (-1) – Table travel record mode (manufacturer-specific mode of operation)
254 (-2) – Move away from limit switch (manufacturer-specific mode of operation)
253 (-3) – Electronic Gear: Slave (manufacturer-specific mode of operation)

Usable values for *Modes of operation* in frequency inverter configurations without positioning control (Parameter *Configuration* **30** ≠ x40):

Modes of operation
2 – Velocity mode [rpm]

10.2.3 Current position and contouring errors

Parameter *Act. Position* **1108** returns the actual position in user units.

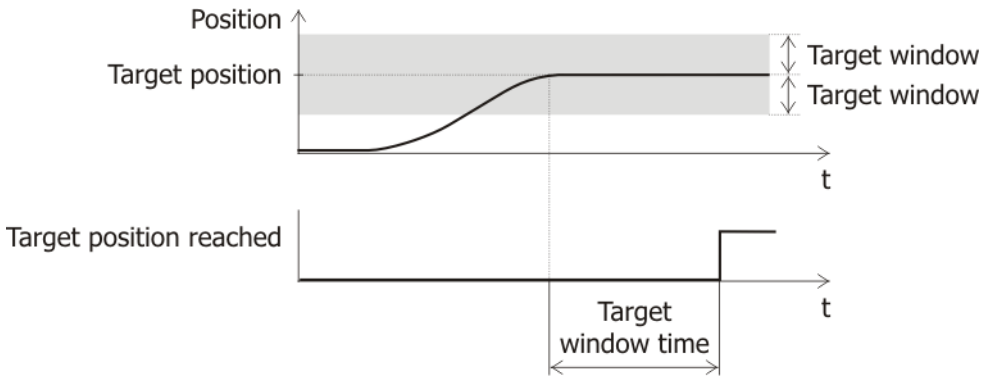
Parameter *Act. Contouring Error* **1109** returns the actual contouring error.

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 application manual “Positioning”.

10.2.4 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 as from 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.

10.2.5 Position Controller

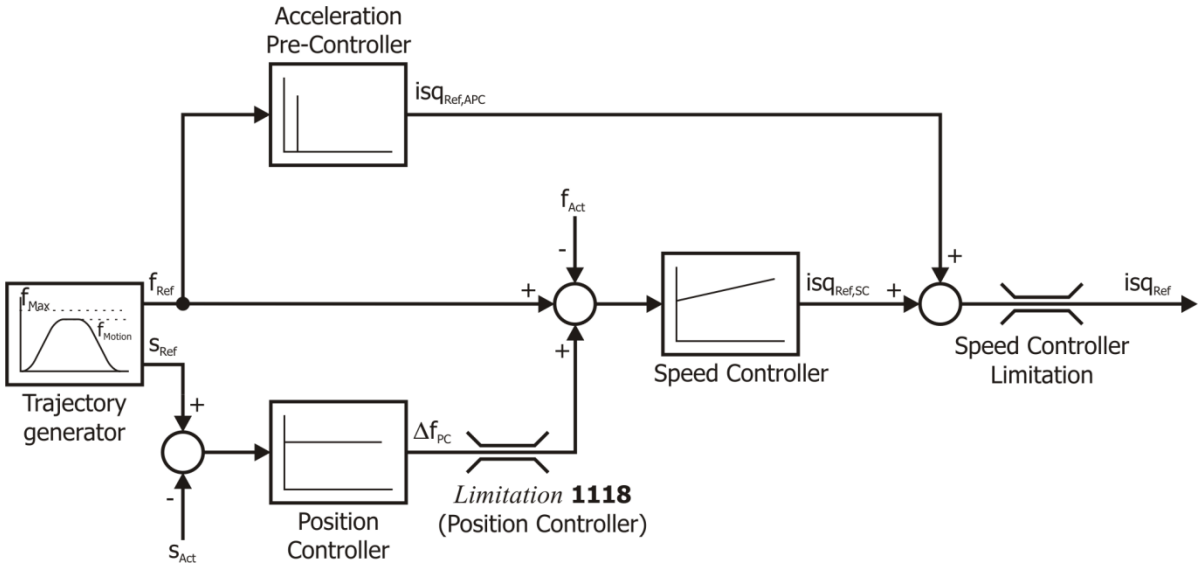
The position controller evaluates the positioning operation (target/actual position) and tries to control the drive such that it comes as close as possible to the specifications. For this purpose, an additional frequency is calculated for compensation of position deviations. By setting the corresponding 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	Limitation	0 u/s	2^{31}-1 u/s	327 680 u/s

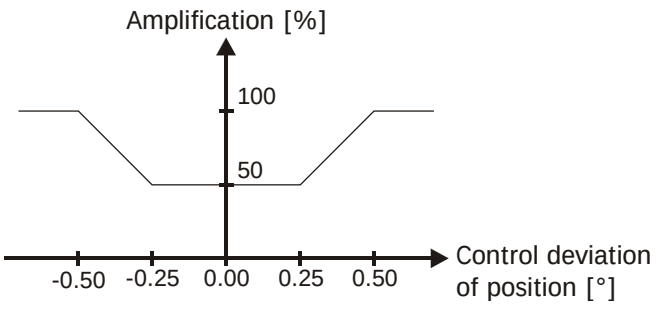
[1)] Factory parameter setting *Configuration* **30** = 240 or 540
[2)] Factory parameter setting *Configuration* **30** = 440

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 accordingly.

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 pilot control, refer to the operating instructions of the frequency inverter.

Optimize the settings in actual operating conditions, as control parameters for speed controller and acceleration pilot control depend on actual load. Optimize with different load types to obtain a good control behavior in all situations.

10.2.6 Homing

When the drive is started, a defined starting position must be identified for absolute-value positioning. 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. Once the limit switches are reached, the direction of rotation of the drive will be reversed, depending on the selected homing mode. The Limit switches can also be used as a reference for homing. For a list of homing modes, refer to chapter "List of Homing Modes".

Relative positioning and moving in velocity mode is possible without homing.

Homing can be started:

- via a digital input
- by a control word via system bus or field bus [1)]
- automatically before the start of a motion block positioning operation

[1)] Extension module with system bus or field bus interface required

If an absolute value encoder with an absolute value encoder module (e.g. EM-ABS-01) is used, homing is not required when power supply is turned on. This is defined by parameter *Operation Mode* **1220**.

For more details about the homing function, refer to the “Positioning” application manual.

10.2.6.1 Start position after homing

After homing:
Initial Position **1185** = -1 → Drive stops at “stopped” position.
Initial Position **1185** ≠ -1 → Drive will be moved actively to the set position.

10.2.6.2 Flying homing

Flying homing can be used in order to update the home position during positioning operations. For a description of this function, refer to the application manual “Positioning”.

10.2.7 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 Clear limit switch” (see Chapter 11.4.6 “Move away from limit switch mode”).

11 Control of frequency inverter

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 CANopen®, only operation modes 0, 1 and 2 are relevant. The other settings refer to the control option via the control unit.

Operation mode	Function
0 - Control via contacts (Chapter 11.1)	The Start and Stop commands as well as the direction of rotation are controlled via digital signals.
1 - Control via state machine (Chapters 11.1.1,11.3, 11.4)	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 11.1)	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.

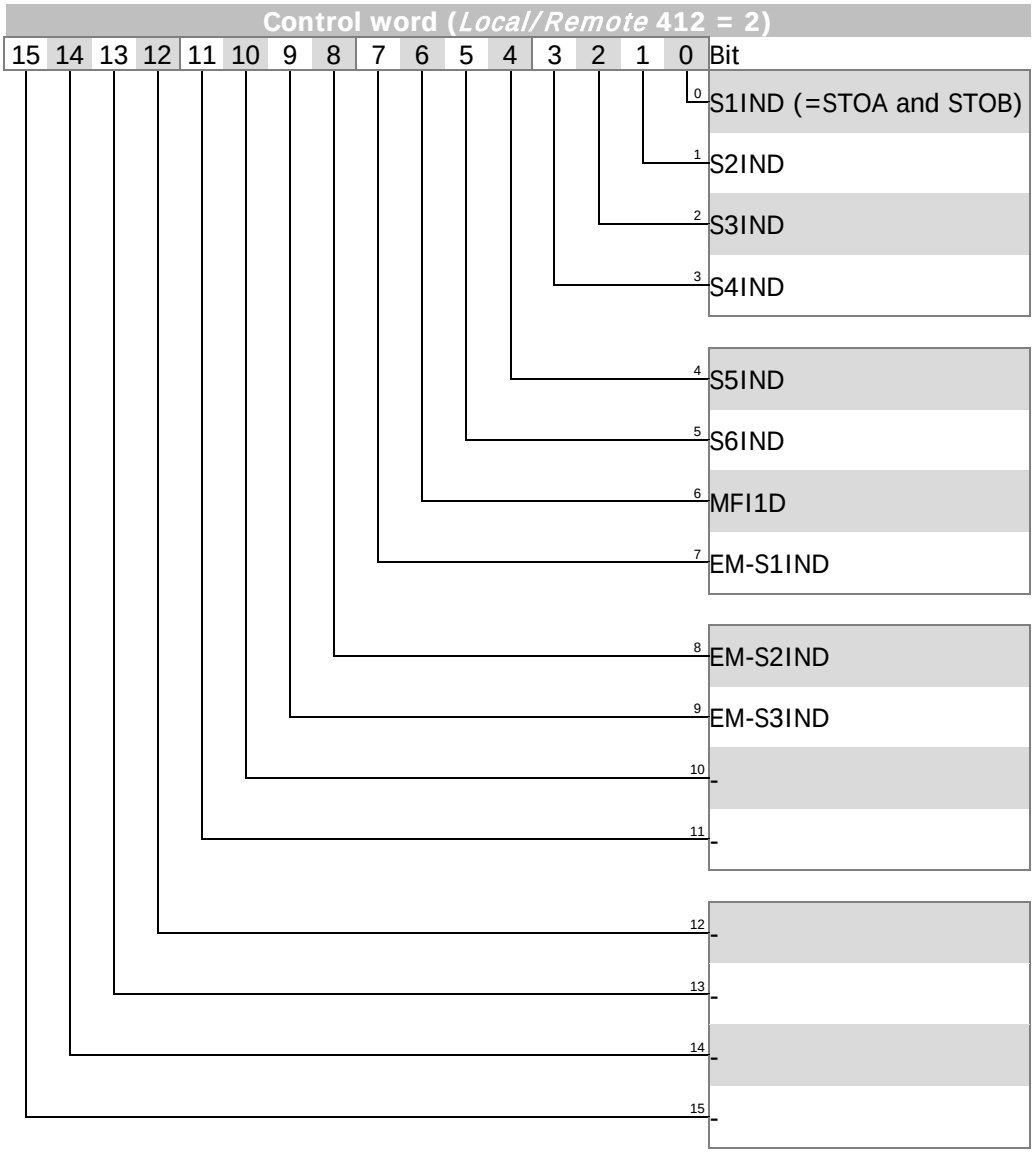
Parameters		Settings		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
414	Data set selection	0	4	0

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.

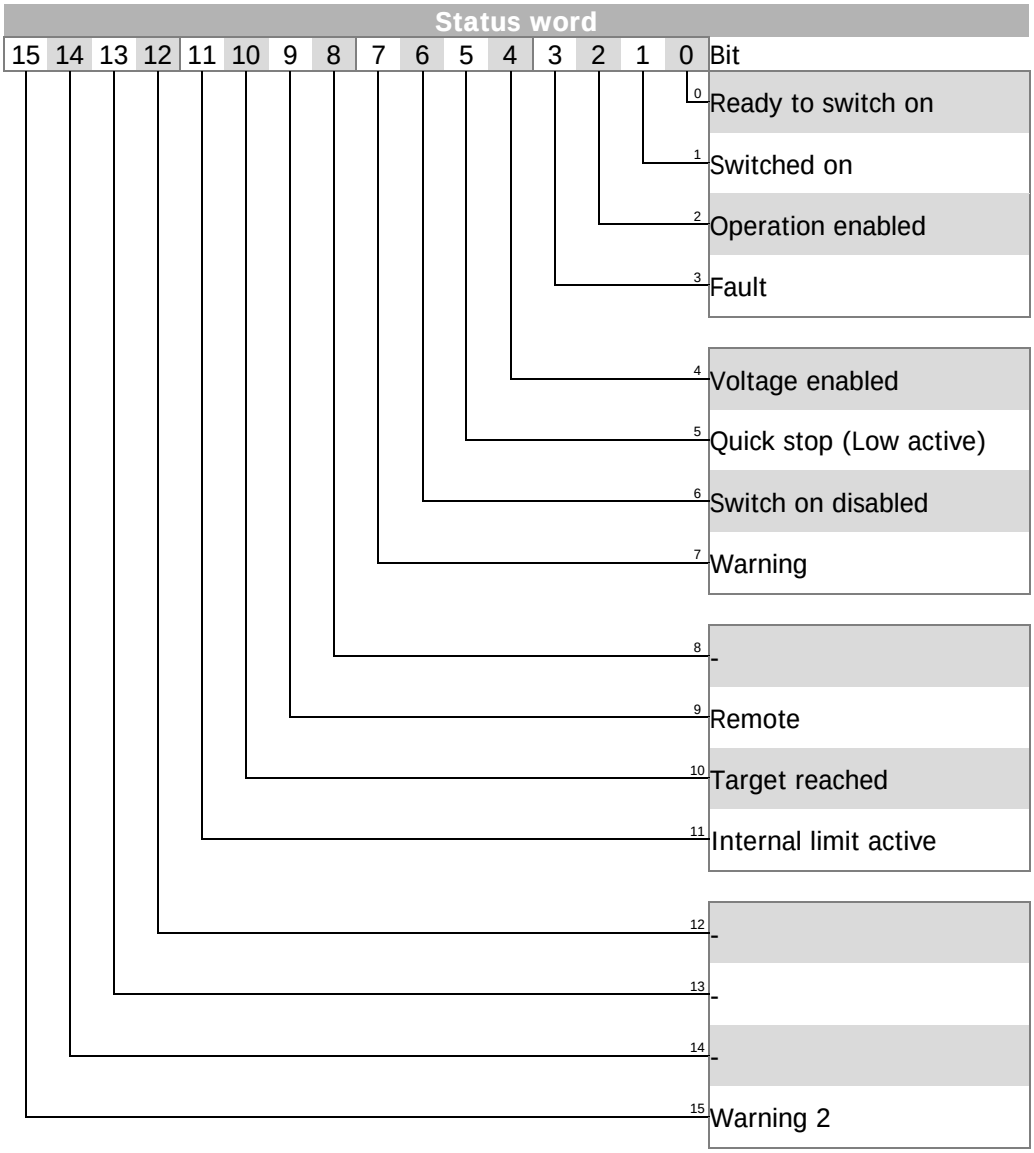
Via parameter *Active Data Set* **249**, the currently selected data set can be read. *Active Data Set* **249**, indicates the Active Data Set (value 1, 2, 3 or 4). This is independent of whether the data set switching was done via contact inputs or *Data set selection* **414**.

11.1 Control via contacts / remote contacts

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 user manual.



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) was set. If the data set switching function is used, please ensure that Parameter *Local/Remote* **412** is set to “2 – Control via remote contacts” is set 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” only support *modes of operation* = “velocity mode”.

ACTIVE CUBE frequency inverters support an external 24 V power supply for the frequency inverter control electronics. Even when mains voltage is disconnected, communication between the controller (PLC) and the frequency inverter is still possible.

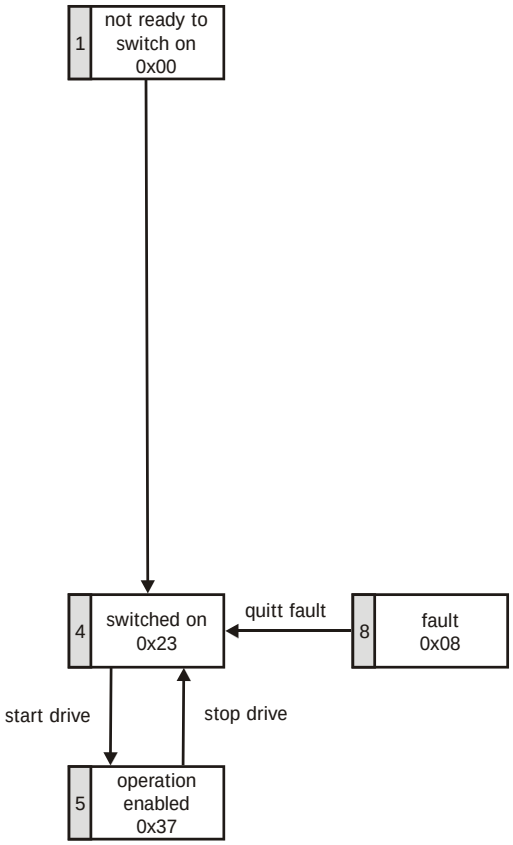
Bit 4 “Power supply – enabled” of the status word shows the current mains power supply status:

Bit 4 “Power supply – enabled” = **0** signals “No mains voltage”, starting of drive not possible.

Bit 4 “Power supply – enabled” = 1 signals “Mains voltage on”, drive ready for starting.

11.1.1 Device state machine

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.

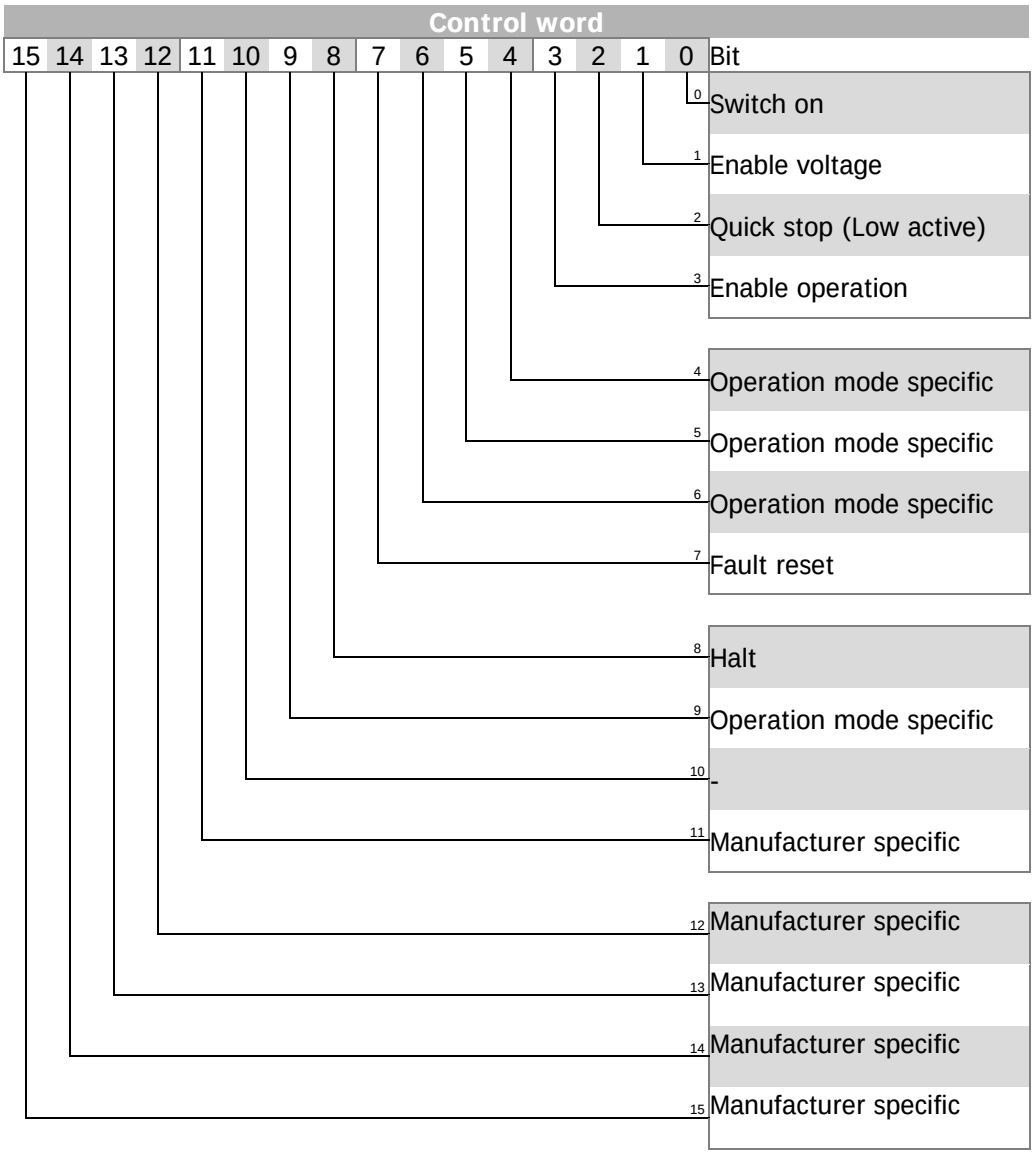
Bit 15 "**Warning 2**" signals a critical operating state which will result in a fault switch-off of the frequency inverter within a short time. This bit is set if there is a delayed warning relating to the motor temperature, heat sink/inside temperature, Ixt monitoring or mains phase failure.

11.2 Control via state machine

In the operation mode “Control via state machine (*Local/Remote* **412** = 1), the frequency inverter is addressed via the control word of the state machine.

Transition 4 to status “Operation enabled” is only possible:
- If, in a configuration for positioning 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)

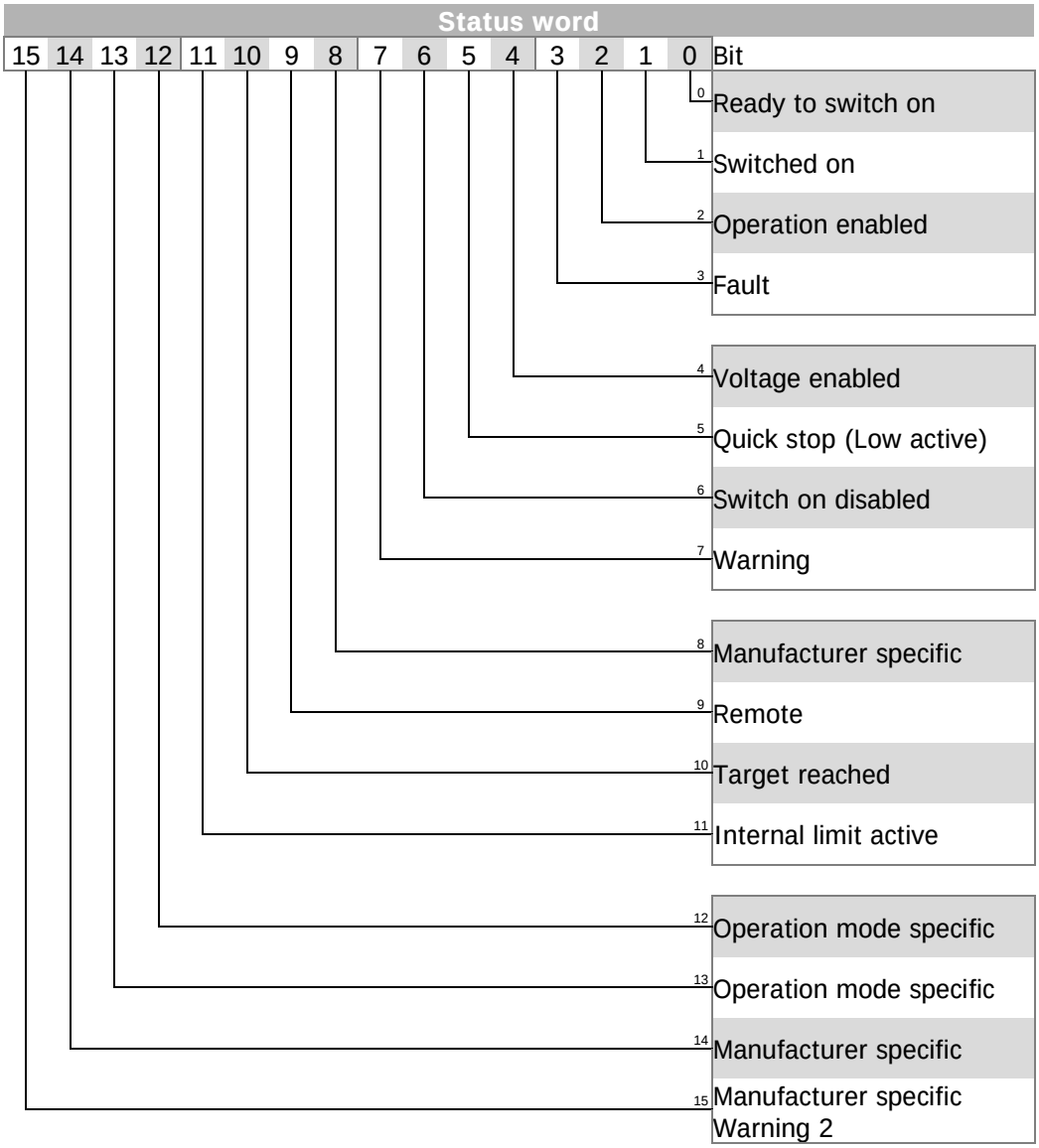
Parameter *Control word* **410** is applicable to the frequency inverter if parameter *Local/Remote* **412** is set to “1 **–** Control via statemachine”.



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.

The actual value parameter *Status word* **411** shows the current operating status.



Bit 14 is not used.

Status word bits 12 and 13 “Operation mode specific” are only used in positioning control configurations (Parameter *Configuration* **30** = x40).

ACTIVE CUBE 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.

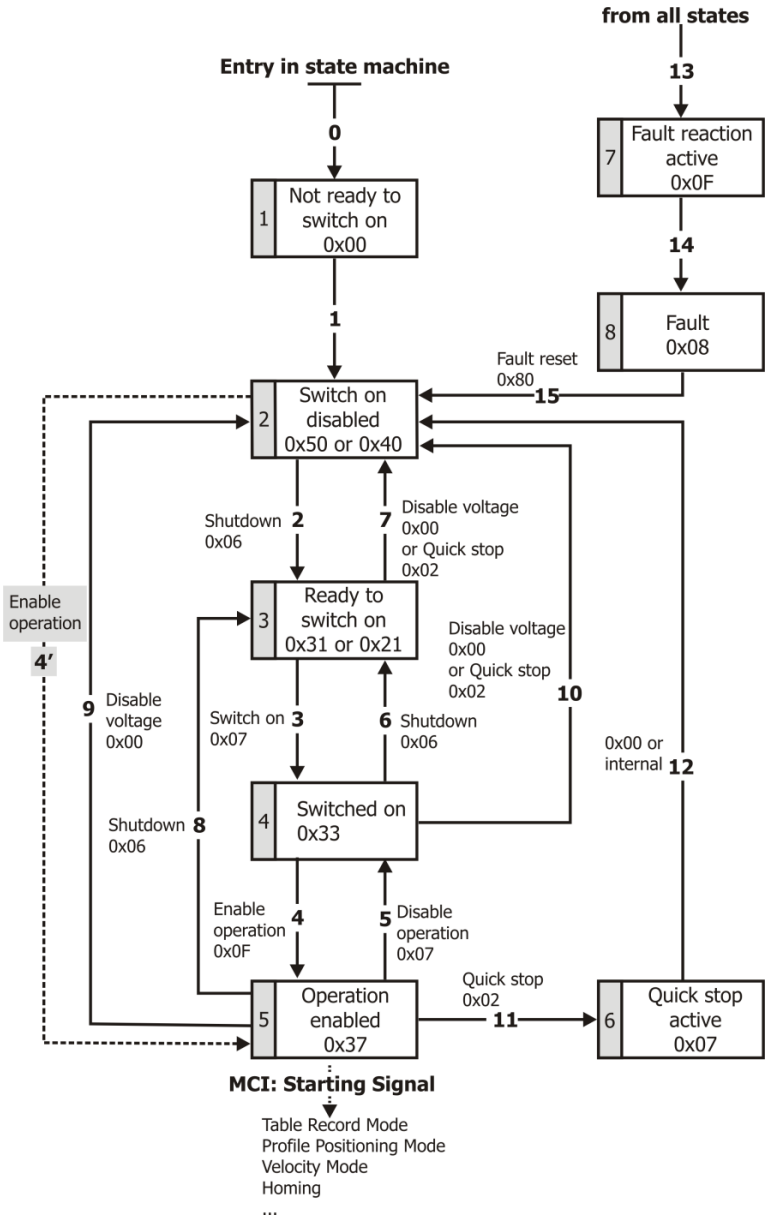
Bit 4 “Voltage enabled” of the status word shows the current mains power supply status:

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.

11.2.1 Statemachine diagram

State machine:



Control word:
The device control commands are triggered by the following bit patterns in the status 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 11.4. Parameter *Override Modes Of Operation* **1454** 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						
	Bit 6	Bit 5	Bit 3	Bit 2	Bit 1	Bit 0
State	**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-PZD2. 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.

11.3 Configurations without Motion Control

In configurations without positioning control (*Configuration* **30** ≠ x40) *Override Modes Of Operation* **1454** is set permanently to "2 - *velocity mode*". This setting cannot be changed.

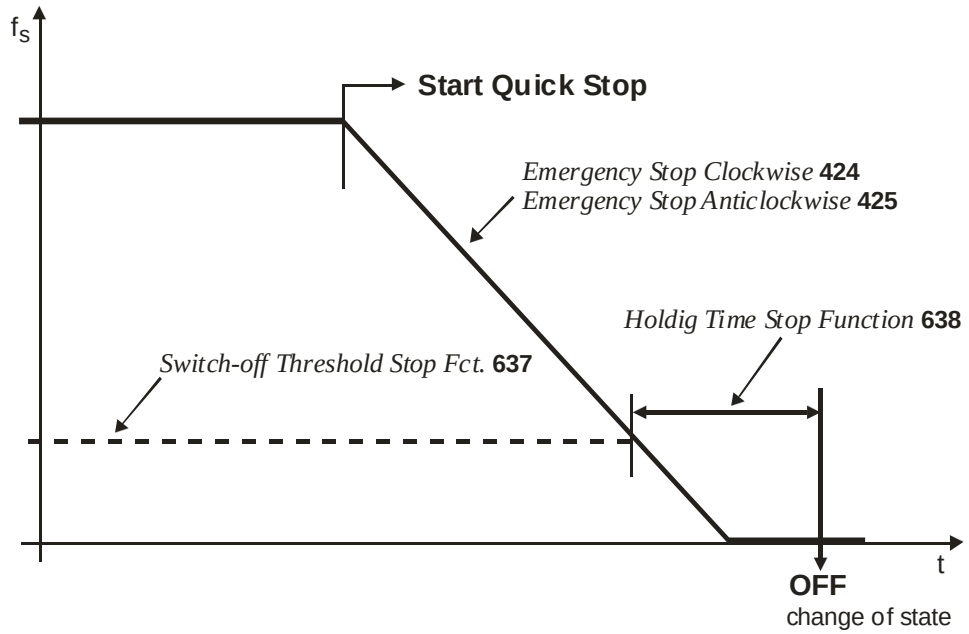
Relevant parameters:

410	*Control word*
411	*Status word*
1459	*Override Target velocity vl [rpm]*
240	*Actual speed*
418	*Minimum Frequency*
419	*Maximum Frequency*
420	*Acceleration (Clockwise)*
422	*Acceleration Anticlockwise*
421	*Deceleration (Clockwise)*
423	*Deceleration Anticlockwise*
424	*Emergency Stop Clockwise*
425	*Emergency Stop Anticlockwise*

The ramp times are specified via parameters **430**...**433**.

11.3.1 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. *Maximum Frequency*. 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 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).

11.3.2 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 “Direct current 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 – coast to stop”.
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** 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.

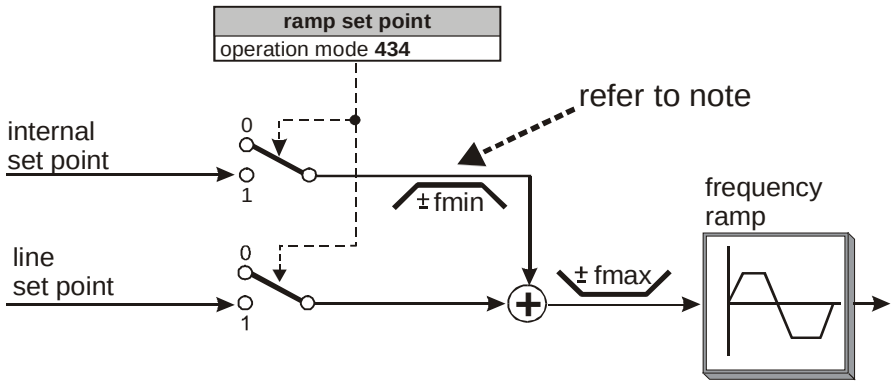
11.3.3 Reference value / actual value

Depending on the settings of Local/Remote as well as Modes of Operations, the controller (PLC) can define the reference frequency for the frequency inverter via parameter *Reference frequency RAM [Hz]* **484** or *Override Target Velocity vl [rpm]* **1459** and receive the actual value via parameter *Actual speed* **240**.

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 use.

The reference value in parameter *Override Target Velocity vl [rpm]* **1459** and the actual value in parameter *Actual speed* **240** are interpreted as values with unit [min^{-1}]. Conversion into a frequency value (reference value) or from a frequency value (actual value) is performed in the frequency inverter.
The entry for parameter *Reference frequency RAM [Hz]* **484** is done in [Hz] directly.

The reference value for the frequency inverter from parameter *Reference frequency RAM [Hz]* **484** or *Override Target Velocity vl [rpm]* **1459** is connected to the reference line value. This reference value will be combined with the internal reference value from the reference frequency channel and directed to the ramp. For information on the reference frequency channel, refer to the operating instructions of the frequency inverter.



Reference percentage **524** can be used for regular changing of reference percentages, e.g. as a reference value for technology controllers or as a reference torque.

Parameters		Settings		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
434	Ramp Setpoint	1	3	3
484	Reference frequency RAM [Hz]	-999.99	999.99	0.00
524	Reference percentage RAM [%]	-300.00	300.00	0.00

Operation mode 434	Function
1 - Internal reference frequency	The internal reference frequency is determined from the reference frequency channel.
2 - Reference line value	The reference value is supplied externally via the bus
3 - Internal reference frequency + reference line value	Addition (considering the sign) of internal reference frequency and reference line value

This function is only relevant in the case of configurations without positioning control (parameter *Configuration* **30** ≠ x40).

If *Ramp Setpoint* **434** = 2 (reference line value only), this reference line value is limited to fmin.
The sign in front of fmin 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 +fmin.

For *Ramp Setpoint* **434** = 3, the sign of the total reference value results from the total of internal reference frequency and reference line value.

The reference values can be controlled at the frequency inverter via the control unit or the control software VPlus via the following parameters:

Actual values		
Parameters	**Contents**	**Format**
Internal Reference Frequency **228**	Internal reference value from the reference frequency channel	xxx.xx Hz
Reference Bus Frequency **282**	Reference line value from Field bus	xxx.xx Hz
Reference Ramp Frequency **283**	= sum of internal reference frequency + reference line value	xxx.xx Hz

11.3.4 Example sequence

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 positioning control (*Configuration* **30** ≠ x40), the second (shortened) sequence can be used, because transition **4'** is available in these configurations.

11.4 Motion control configurations

⚠ WARNING

Dangerous state due to new mode!

If *Override Modes Of Operation* **1454** is changed during operation (control word = 0xnnnF), a dangerous state may occur in the new mode.

- Before changing *Override Modes Of Operation* **1454**, check the status word (e.g. for status 0xnn33).

Definition Motion Control

For the full function of the Motion Control Interfaces/Motion Control Override, 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 parameters described in 11.2 "Control via state machine", i.e. *Control word* **410** and *Status word* **411** 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 *Override Modes Of Operation* **1454**. 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. Default value of *Override Modes Of Operation* **1454**: "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*.

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).

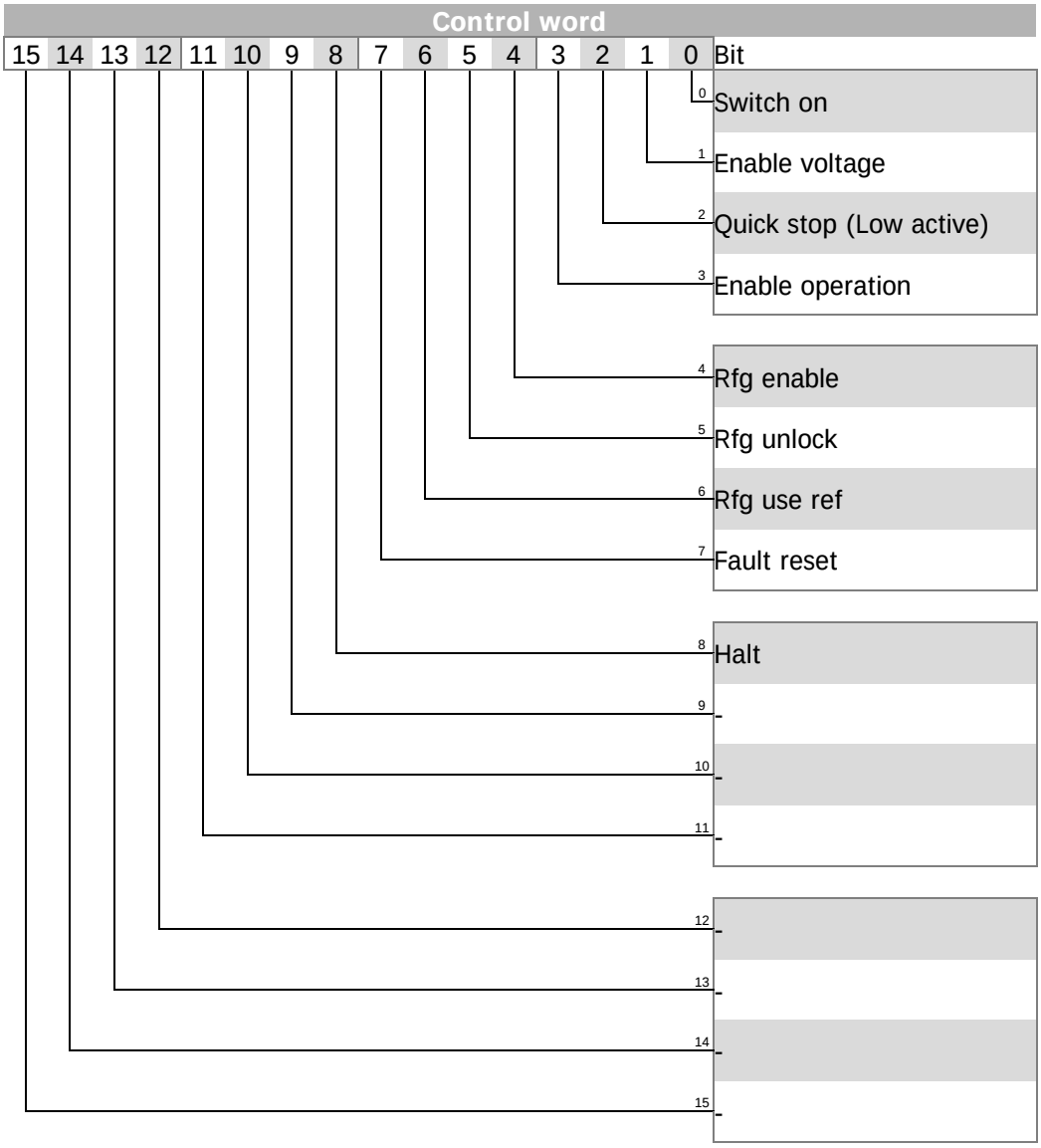
11.4.1 Velocity mode [rpm]

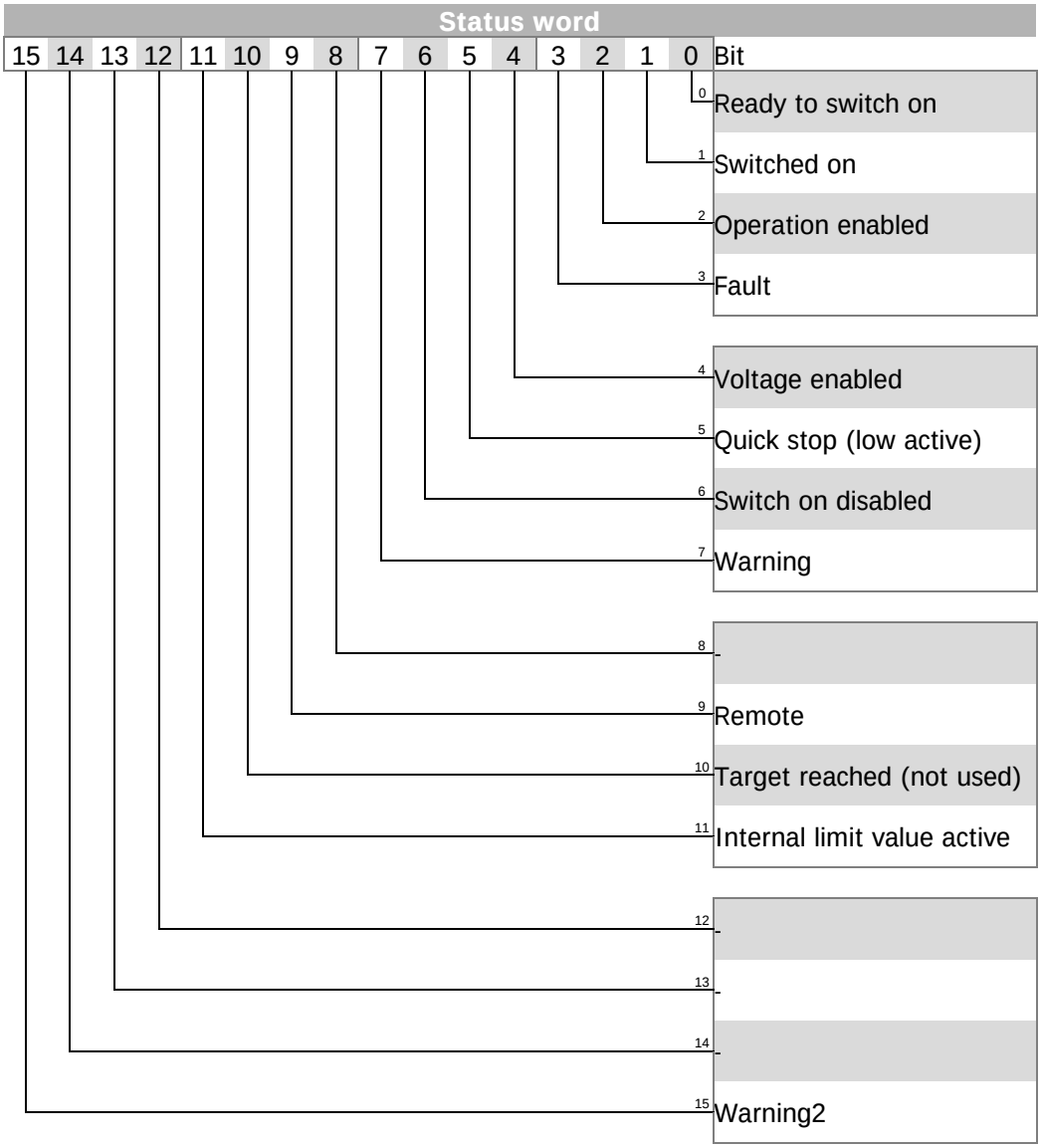
"Velocity mode" can be selected via parameter *Override Modes Of Operation* **1454** = **2**.
In velocity mode, the mode-specific bits of the control word control the ramp generator (RFG – Ramp Function Generator). The block diagram illustrates the function.

Relevant parameters:

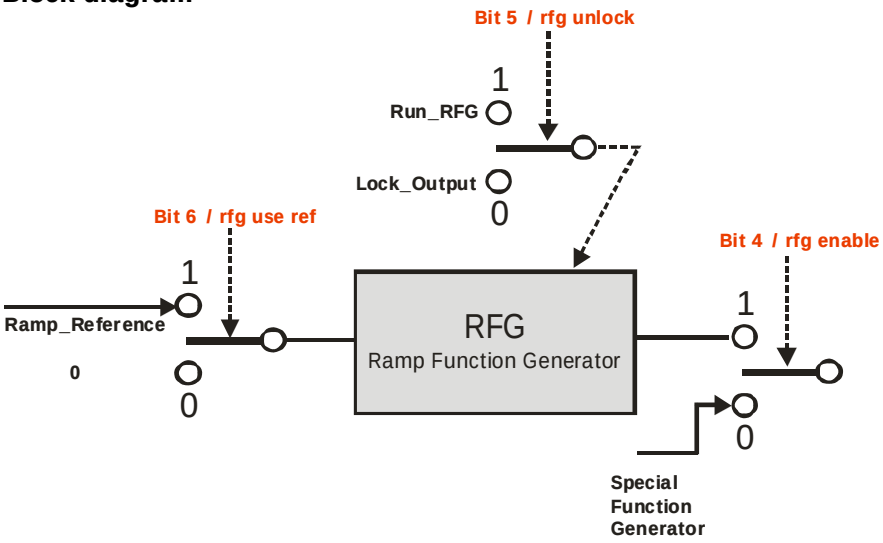
410	*Control word*
411	*Status word*
1459	*Override Target velocity vl [rpm]*
240	*Actual speed*
418	*Minimum Frequency*
419	*Maximum Frequency*
420	*Acceleration (Clockwise)*
422	*Acceleration Anticlockwise*
421	*Deceleration (Clockwise)*
1454	*Override Modes Of Operation*

The ramp times are specified via parameters **430**...**433**.





Block diagram



Bit 4:rfg enable
Rfg enable = 0 The reference speed comes from a manufacturer-specific special function.
Rfg enable = 1 The reference speed corresponds to the ramp output.

The special function will only be evaluated if **1299** *S. Special Function Generator* is not "9-zero".
If **1299** *S. Special Function Generator* = "9-Zero", the value of the ramp output will always be used.

Bit 5:rfg unlock
Rfg unlock = 0 The last speed will be maintained and used.
Rfg unlock = 1 The ramp function is active and changes according to the reference value and the ramp.

Bit 6 / rfg use ref
Rfg use ref = 0 Reference value "0" is used.
Rfg use ref = 1 The reference value from *Override Target Velocity vl [rpm]* **1459** is used.

Bit 8 HALT
HALT = 0 → **Execute positioning.**
HALT = 1 → **Stop axis**. (The frequency inverter remains enabled in "Operation enabled" state.)

If **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*.

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	

11.4.1.1 Example sequence

In order to start “velocity mode”, the correct sequence must be sent by the PLC.

1	Control word =	0x0000	Disable voltage
1	Status word =	0x0050	Switch On Disabled
2	Modes of operation =	2	(Velocity mode)
3	Control word =	0x0006	Shutdown
	Status word =	0x0031	Ready to switch on
4	Control word =	0x0007	Switch On
	Status word =	0x0033	Switched On
5	Control word =	0x000F	Enable operation, no change of previous status if already enabled.
	Status word =	0xnn37	Operation enabled
6a	Control word =	0x007F	Starts “Velocity mode” with reference value from parameter *Override Target Velocity vl [rpm]* **1459**.
	Status word =	0xnn37	Operation enabled
6b	Control word =	0x006F	**1299** *S. Special Function Generator*: = “9-Zero” ➔ Starts “Velocity mode” with reference value from parameter *Override Target Velocity vl [rpm]* **1459**. **1299** *S. Special Function Generator*: ≠ “9-Zero” ➔ Starts with reference value with source from **1299** *S. Special Function Generator*
	Status word =	0xnn37	Operation enabled
6c	Control word =	0x003F	Starts “Velocity mode” with reference value “0”
	Status word =	0xnn37	Operation enabled
6d	Control word =	0x002F	**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*
	Status word =	0xnn37	Operation enabled
6e	Control word =	0x005F	Starts “Velocity mode” at current speed – current ramps will be canceled.
	Status word =	0xnn37	Disable voltage
6f	Control word =	0x004F	**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*
	Status word =	0xnn37	Disable voltage
7	Control word =	0x01xx	HALT: The drive is decelerated at the ramp *Deceleration (Clockwise)* **421** or *Deceleration Anticlockwise* **423**.
	Status word =	0xnn37	Operation enabled

⚠ WARNING

Dangerous state due to new mode!

If *Override Modes Of Operation* **1454** is changed during operation (control word = 0xnnnF), a dangerous state may occur in the new mode.

- Before changing *Override Modes Of Operation* **1454**, check the status word (e.g. for status 0xnn33).

Once the sequence of the first four status words has been processed correctly, the ACU 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 0xnnF to 0x000F, “Velocity mode” will be stopped. Then, the mode can be restarted via 0xnnF.
As long as 0x0007 is active, the “Modes of Operation” can also be changed safely. Once *Override Modes Of Operation* **1454** has been set to another value, operation can be started with a corresponding sequence.

11.4.2 Profile Velocity mode [u/s] (pv)

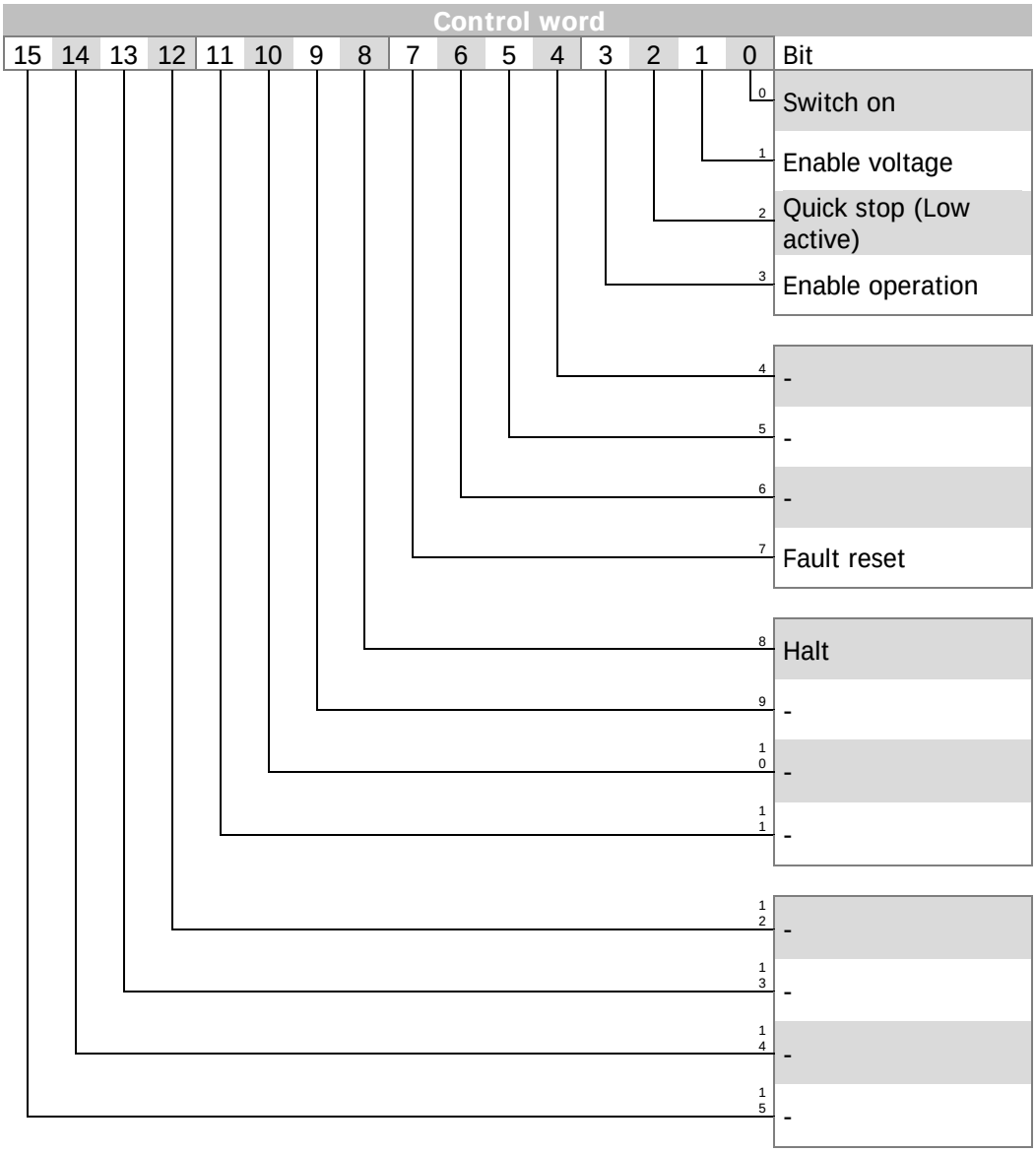
"Profile velocity mode" (pv) can be selected via *Override Modes Of Operation* **1454** = **3**. In "Profile velocity mode" (pv), the frequency inverter receives a target speed in user units per second [u/s].

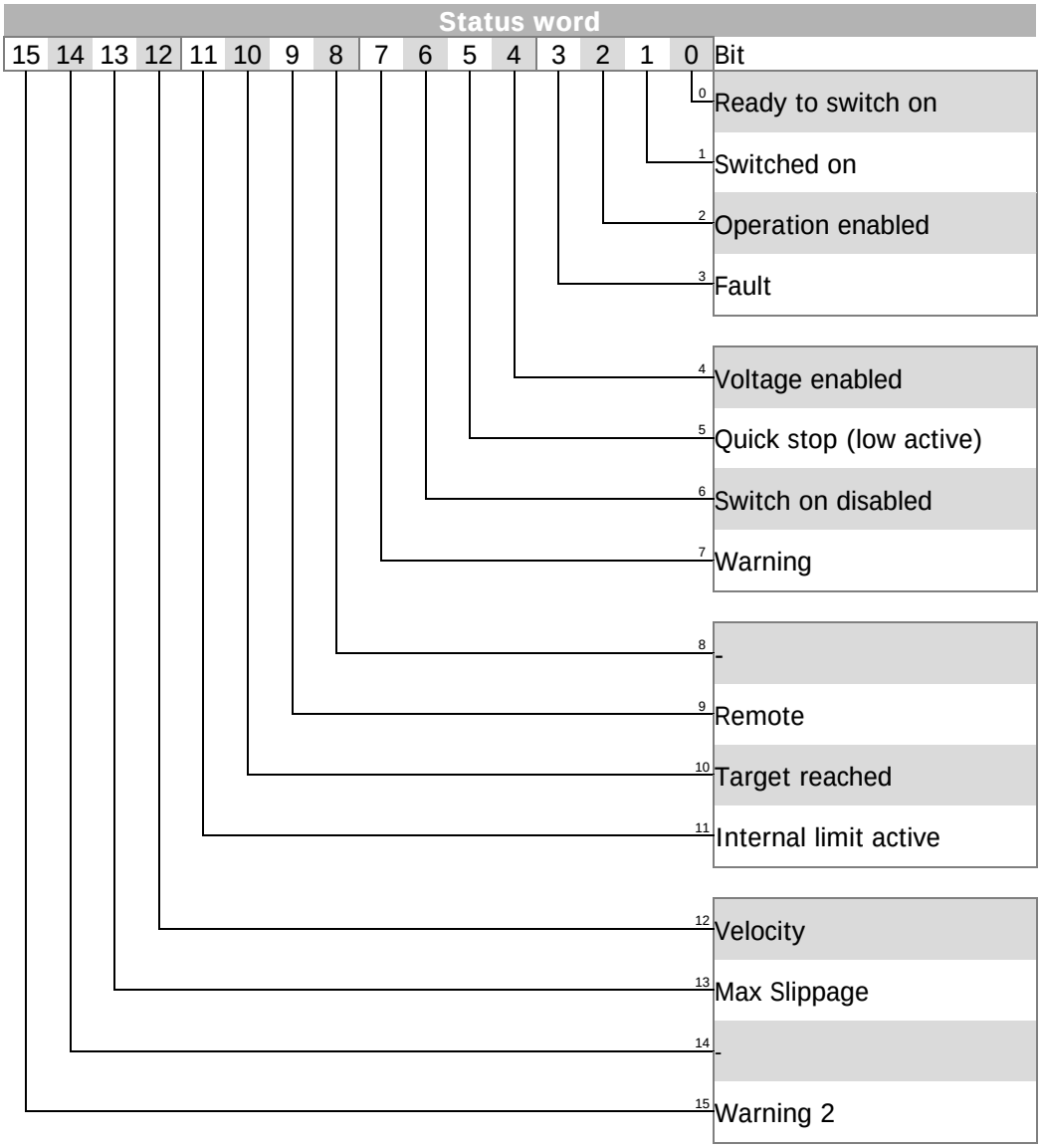
Relevant parameters:

410	*Control word*	**1279**	*Threshold Window Time*
411	*Status word*	**1457**	*Override Profile Acceleration*
418	*Minimum Frequency*	**1458**	*Override Profile Deceleration*
419	*Maximum Frequency*	**1179**	*Emergency ramp*
1454	*Override Modes Of Operation*	**1176**	*Ramp time Accel.*
1107	*Act. Speed*	**1178**	*Ramp time Decel.*
1276	*Velocity Window*	**1275**	*Max Slippage*
1277	*Velocity Window Time*	**1460**	*Override Target Velocity pv [u/s]*
1278	*Threshold Window*		

The ramp times are specified via parameters **1176**...**1178**.

In "Profile velocity mode" (pv), the mode-specific bits of the control word and the status word are used as follows:





Profile velocity mode enables setting of a reference speed in units per second [u/s]. The reference speed *Override Target Velocity pv [u/s]* **1460** will be applied immediately in status "Operation enabled" (0xnn37). The acceleration and deceleration ramps are set via parameters *Override Profile Acceleration* **1457** and *Override Profile Deceleration* **1458**.
If bit 8 "Halt" of the control word is set, the drive will be decelerated and kept at a standstill at the ramp set in parameter *Override Profile Deceleration* **1458**. If bit 8 is reset, the drive will be accelerated to the current reference speed at the ramp set in parameter *Override Profile Acceleration* **1457.**

Control word Bit 8: Halt
HALT = 0 → **Execute Profile Velocity Mode.**
HALT = 1 → **Halt Axis.** (The Frequency inverter remains in state "Operation enabled".)

The current speed in user units per second [u/s] can be displayed in a controller via parameter *Velocity Window* **1276**.

Via parameter *Velocity Window* **1276** and *Velocity Window Time* **1277** Bit 10 “Target reached” of the status word is set.
Via parameter *Threshold Window* **1278** and *Threshold Window Time* **1279** Bit 12 “Velocity” of the status word is set.
Via parameter *Max Slippage* **1275** a slip monitoring via Bit 13 “Max Slippage” of the status word can be set up.

Status word bit 10: Target reached

Target reached =0	→ The actual velocity doesn’t match the reference velocity.
Target reached =1	**→ The actual velocity matches the reference velocity.** The actual velocity differs at least from the defined time period in *Velocity Window Time* **1277** up to the defined amount [us] in *Velocity Window* **1276**.

Status word Bit 12: Velocity

Velocity = 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**).
Velocity = 1	→ The Actual Velocity doesn’t match the Comparison Velocity.

Status word Bit 13: Maximum Slippage

Maximum Slippage = 0	**→ The actual Slippage speed is smaller than defined.** The comparison value of the slippage speed is defined Object *Max Slippage* **1275**.
Maximum Slippage = 1	**→ The actual Slippage speed is bigger than defined.** The comparison value of the slippage speed is defined *Max Slippage* **1275**.

11.4.2.1 Example sequence

In order to start “Profile velocity mode”, the correct sequence must be sent by the PLC.

1	Control word =	0x0000	Disable voltage
1	Status word =	0x0050	Switch On Disabled
2	Modes of Operation =	3	Profile Velocity mode
3	Control word =	0x0006	Shutdown
	Status word =	0x0031	Ready to switch on
4	Control word =	0x0007	Switch On
	Status word =	0x0033	Switched On
5	Control word =	0x0007 ↓ 0x000F	Enable operation. Profile velocity mode is started at the target speed *Override Target Velocity pv [u/s]* **1460** and the ramps *Override Profile Acceleration* **1457** and *Override Profile Deceleration* **1458**. Target speed and ramp values are applied immediately.
	Status word =	0xnn37	Operation enabled

1) A profile comprises the following entries. If a value is not changed, the old value will remain active.

- **1456** *Override Profile Velocity*
- **1457** *Override Profile Acceleration*
- **1458** *Override Profile Deceleration*
- **1460** *Override Target Velocity pv [u/v]*

⚠ WARNING

Dangerous state due to new mode!

If *Override Modes Of Operation* **1454** is changed during operation (control word = 0xnnnF), a dangerous state may occur in the new mode.

- Before changing *Override Modes Of Operation* **1454**, check the status word (e.g. for status 0xnn33).

Once the sequence of the first four status words has been processed correctly, the ACU is ready for operation (dark table area).
In state “operation enabled” (0xnnnF), the state of the Motion Control can be changed (white table area).
As long as 0x0007 is active, the “Modes of Operation” can also be changed safely. Once *Override Modes Of Operation* **1454** has been set to another value, operation can be started with a corresponding sequence.

11.4.3 Profile position mode

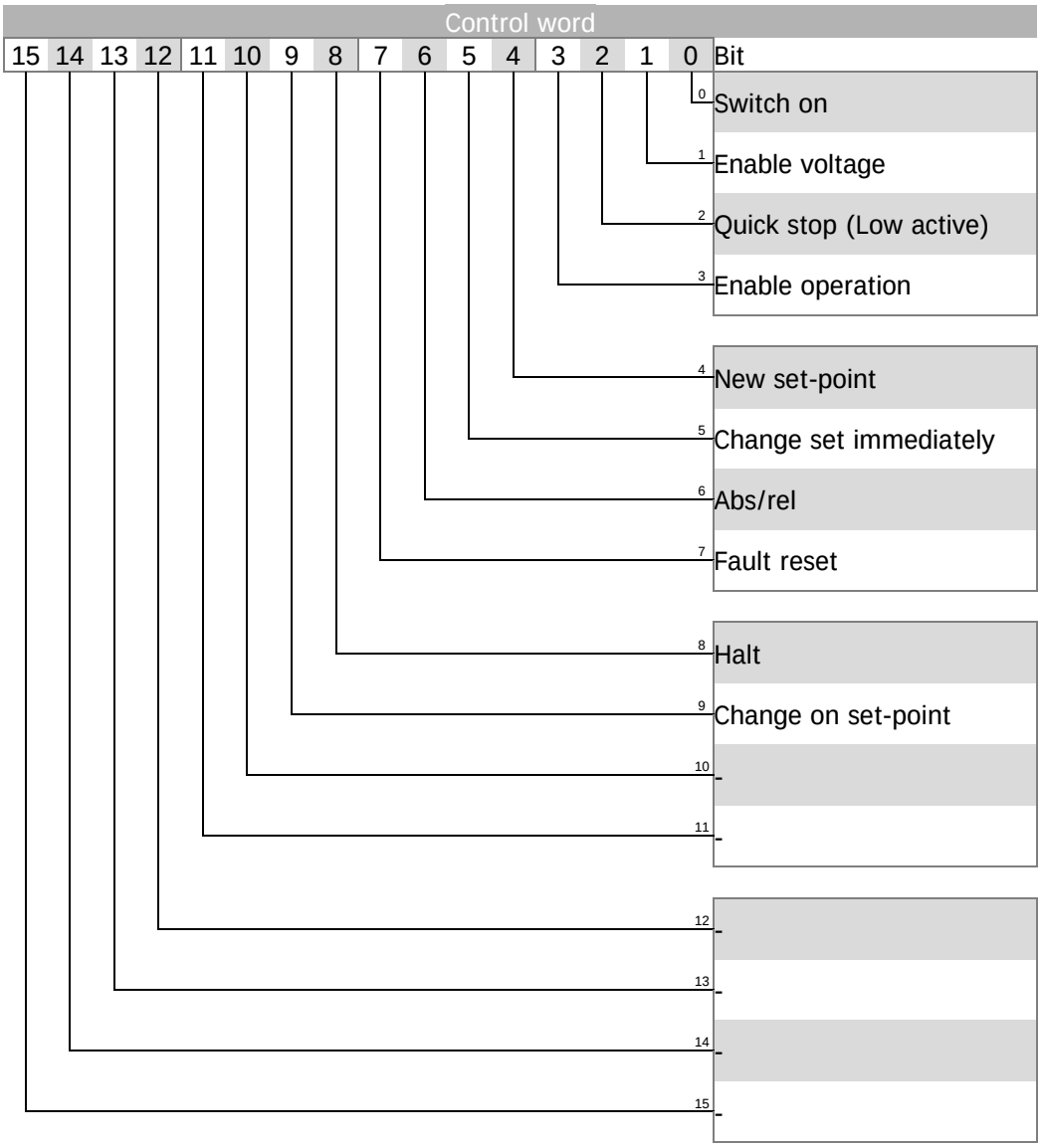
"Profile position mode" can be selected via *Override Modes Of Operation* **1454** = **1**.
In profile position mode, the frequency inverter receives a target position, followed by the command to travel to this target.

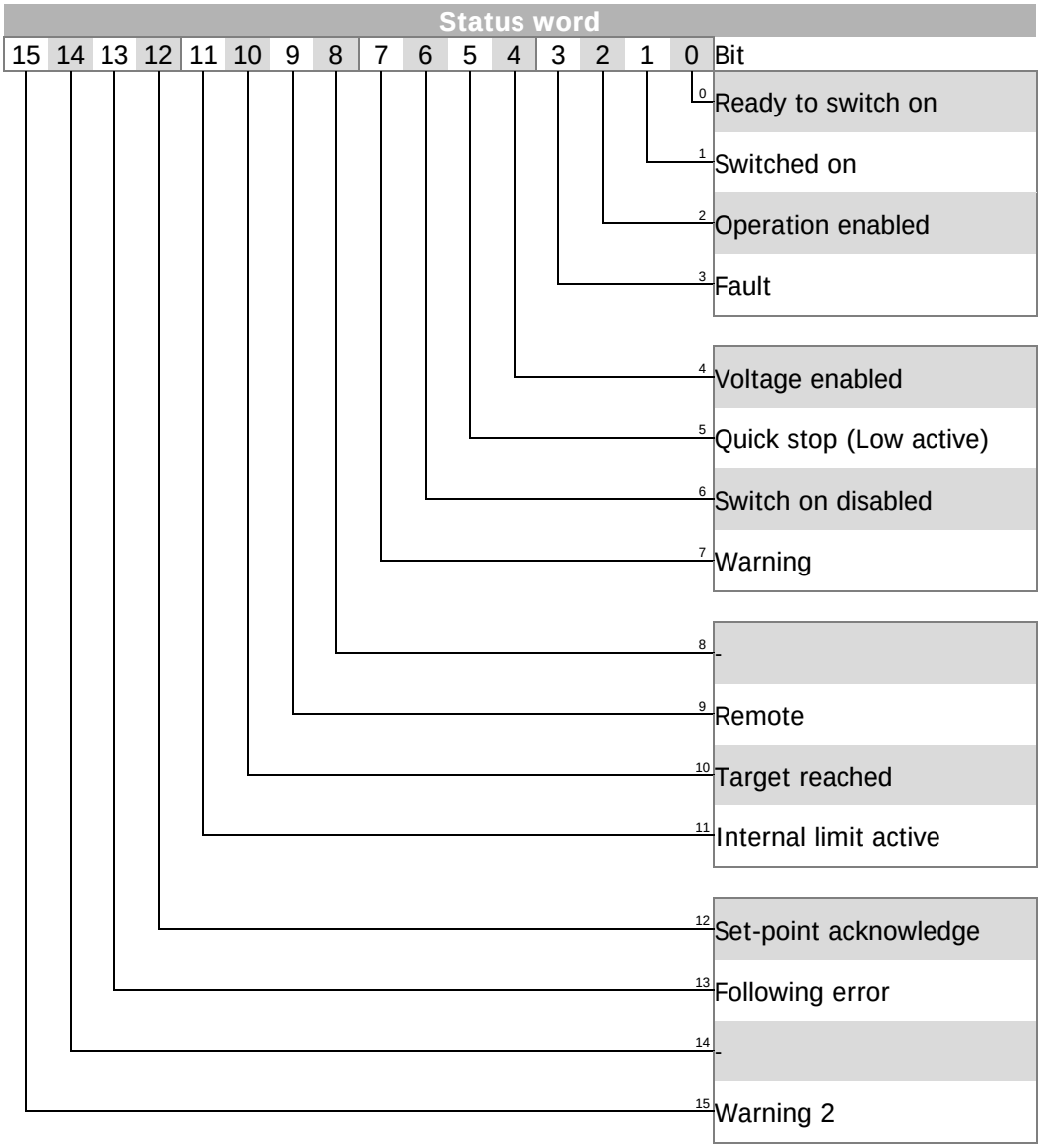
Relevant parameters:

410	*Control word*	**1455**	*Override Target Position*
411	*Status word*	**1456**	*Override Profile Velocity*
418	*Minimum Frequency*	**1457**	*Override Profile Acceleration*
419	*Maximum Frequency*	**1458**	*Override Profile Deceleration*
1454	*Override Modes Of Operation*	**1179**	*Emergency ramp*

The ramp times are specified via parameters **1176** and **1178**.

In "Profile position mode", the mode-specific bits of the control word and the status word are used as follows:




Status word
15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 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	*Override Target Position* **1455** is an absolute value.
	1	*Override Target Position* **1455** is a relative value.
Halt Bit 8	0	Execute positioning operation.
	1	Stop axis with *Override Profile Deceleration* **1458** (if not supported with *Override Profile Acceleration* **1457**), the frequency inverter will remain in status "Operation enabled".

Status word

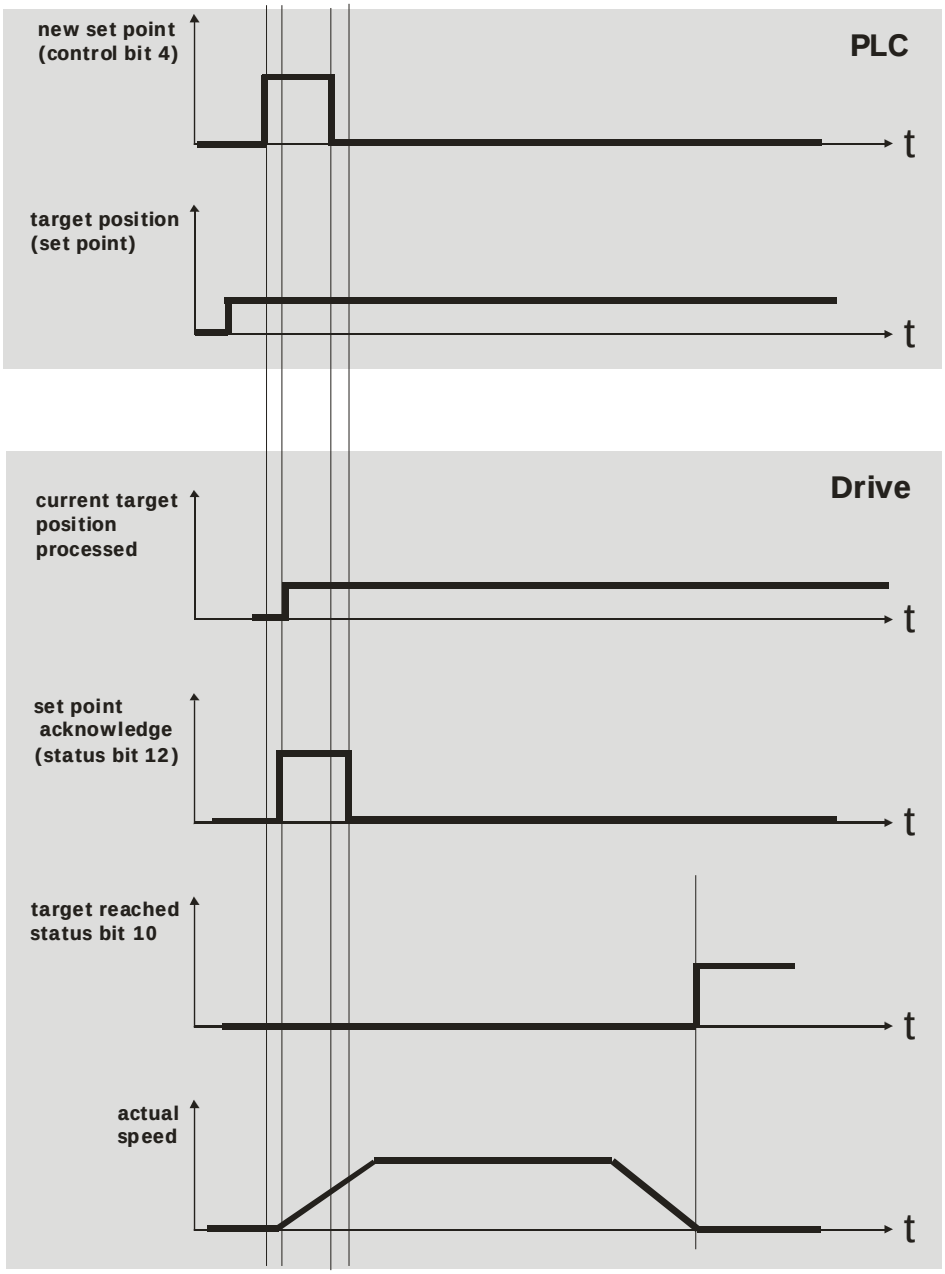
Identification	Value	Description
Target reached Bit 10	0	Halt (control bit 8) = 0: *Override Target Position* **1455** not reached (yet). See also chapter 10.2.4 "Target window".
		Halt (control bit 8) = 1: Axis decelerated
	1	Halt (control bit 8) = 0: *Override Target Position* **1455** reached. See also chapter 10.2.4 "Target window".
		Halt (control bit 8) = 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:

Individual reference value

Control bit “Switch at reference value” = 0
Control bit “Change reference value immediately” = 0

Once a reference value has been transmitted to the drive, the controller signals a permissible value in the control work 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.

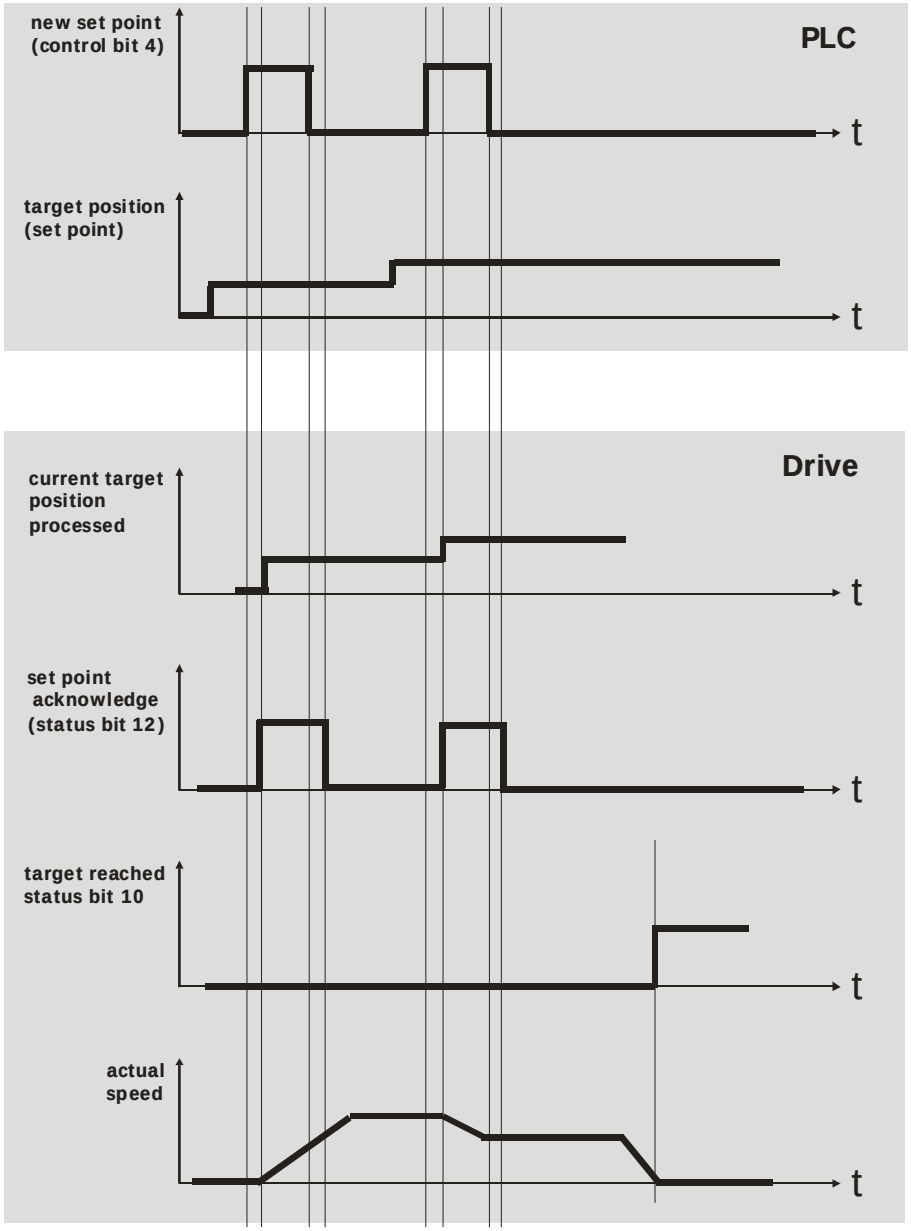


Example:

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.

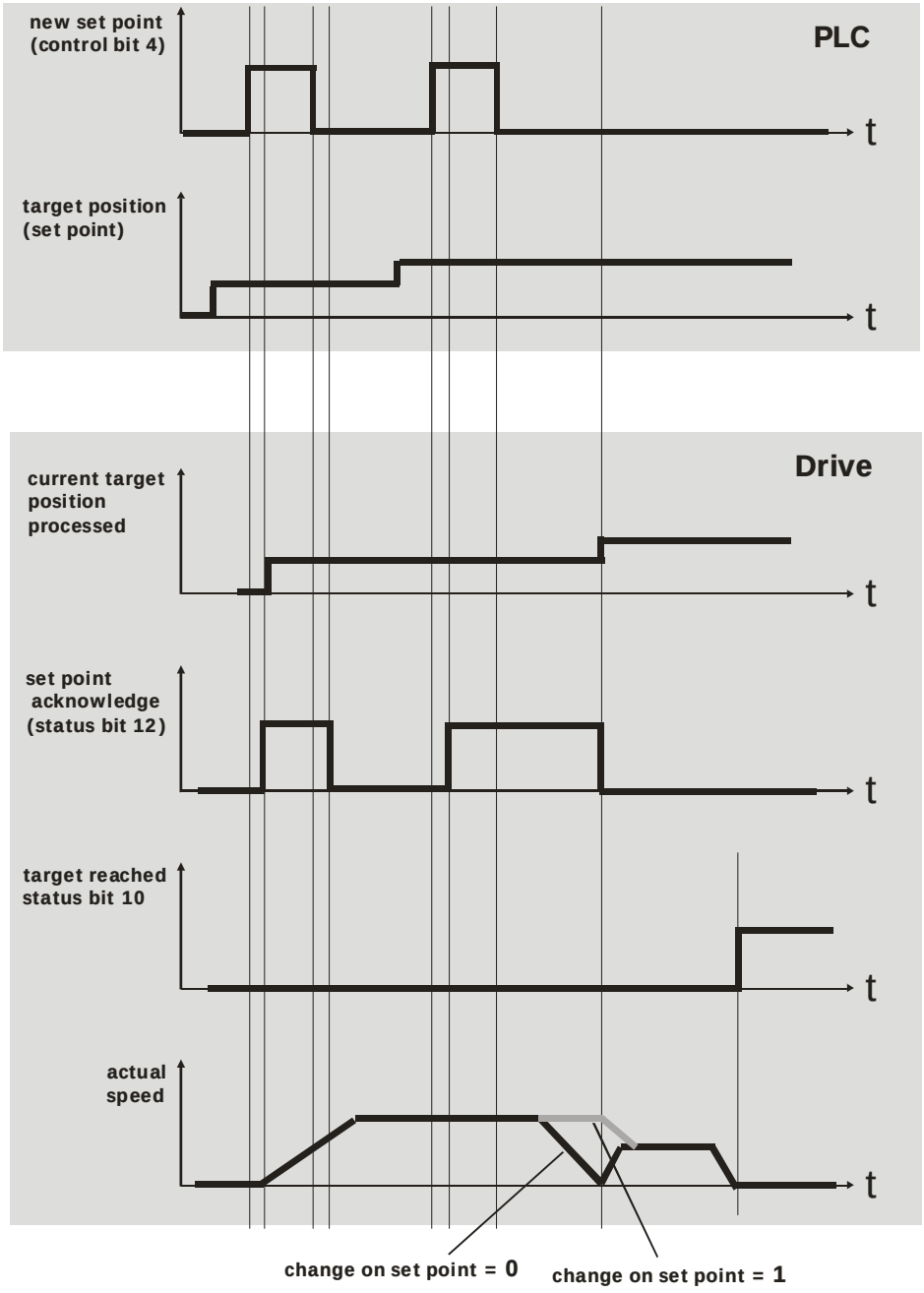


Example: set of set-points
control bit *change on set-point* = **0 / 1**
control bit *change set immediately* = **0**

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.



11.4.3.1 Example sequence

In order to start “Profile position mode”, the correct sequence must be sent by the PLC.

1	Control word =	0x0000	Disable voltage
1	Status word =	0x0050	Switch On Disabled
2	Modes of Operation =	1	(Profile Position mode)
3	Control word =	0x0006	Shutdown
	Status word =	0x0031	Ready to switch on
4	Control word =	0x0007	Switch On
	Status word =	0x0033	Switched On
5	Control word =	0x0007 ↓ 0x000F	Enable operation. Positioning operation is not started.
	Status word =	0xnn37	Operation enabled
6a	Control word =	0x0007 or 0x000F → 0x001F	Operation enabled, start **absolute** positioning with profile[1)]. If a positioning operation is already in process, this operation will be completed. Then, the new profile will be used.
	Status word =	0xnn37	Operation enabled
6b	Control word =	0x0007 or 0x000F → 0x005F	Operation enabled, start **relative** positioning with profile[1)]. If a positioning operation is already in process, this operation will be completed. Then, the new profile will be used.
	Status word =	0xnn37	Operation enabled
6C	Control word =	0x0007 or 0x000F → 0x003F	Operation enabled, start **absolute** positioning with profile[1)]. Running positioning operations will changed and apply the new profile
	Status word =	0xnn37	Operation enabled
6d	Control word =	0x0007 or 0x000F → 0x007F	Operation enabled, start **relative** positioning with profile[1)]. Running positioning operations will changed and apply the new profile
	Status word =	0xnn37	Operation enabled
7	Control word =	0x01nF	HALT: The drive is decelerated at the ramp set in *Deceleration (clockwise)* **421** or *Deceleration anticlockwise* **423**.
	Status word =	0xnn37	Operation enabled

1) A profile comprises the following entries. If a value is not changed, the old value will remain active.

- **1455** *Override Target Position*
- **1456** *Override Profile Velocity*
- **1457** *Override Profile Acceleration*
- **1458** *Override Profile Deceleration*

⚠ WARNING

Dangerous state due to new mode!

If *Override Modes Of Operation* **1454** is changed during operation (control word = 0xnnnF), a dangerous state may occur in the new mode.

- Before changing *Override Modes Of Operation* **1454**, check the status word (e.g. for status 0xnn33).

Once the sequence of the first four status words has been processed correctly, the ACU 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 0xnnF to 0x000F, “Profile position mode” will be stopped. Then, the mode can be restarted via 0xnnF.
As long as 0x0007 is active, the “Modes of Operation” can also be changed safely. Once *Override Modes Of Operation* **1454** 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.
Once a profile has been processed, a new profile can be started with the bit “New reference value” (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 reference value immediately” (bit 5) and “New reference value” (bit 4).

11.4.4 Homing mode

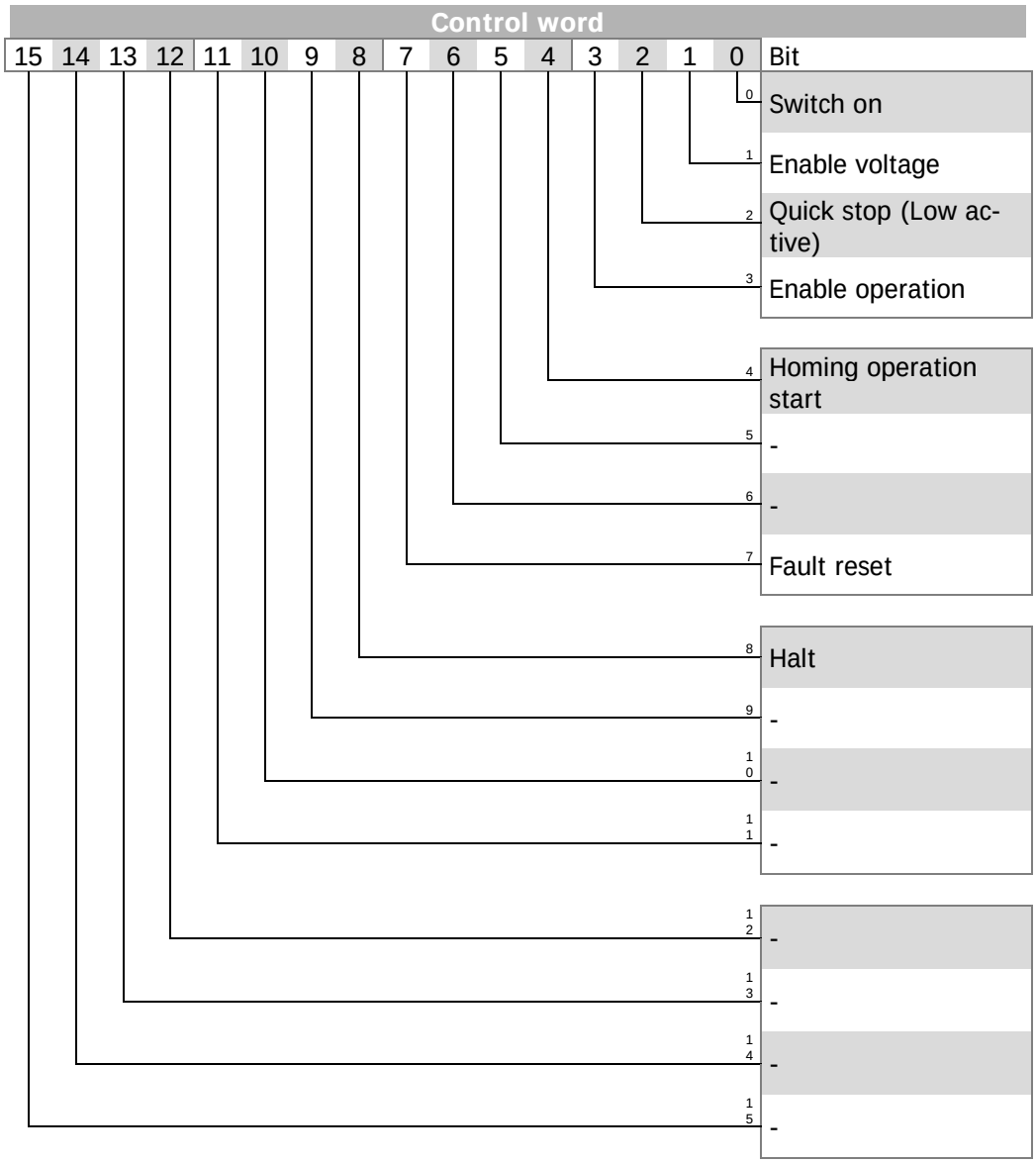
"Homing mode" can be selected via parameter *Override Modes Of Operation* **1454**. In homing mode, the frequency inverter moves the drive to a reference position. The method used for this movement is defined by parameter *Homing mode* **1130**.

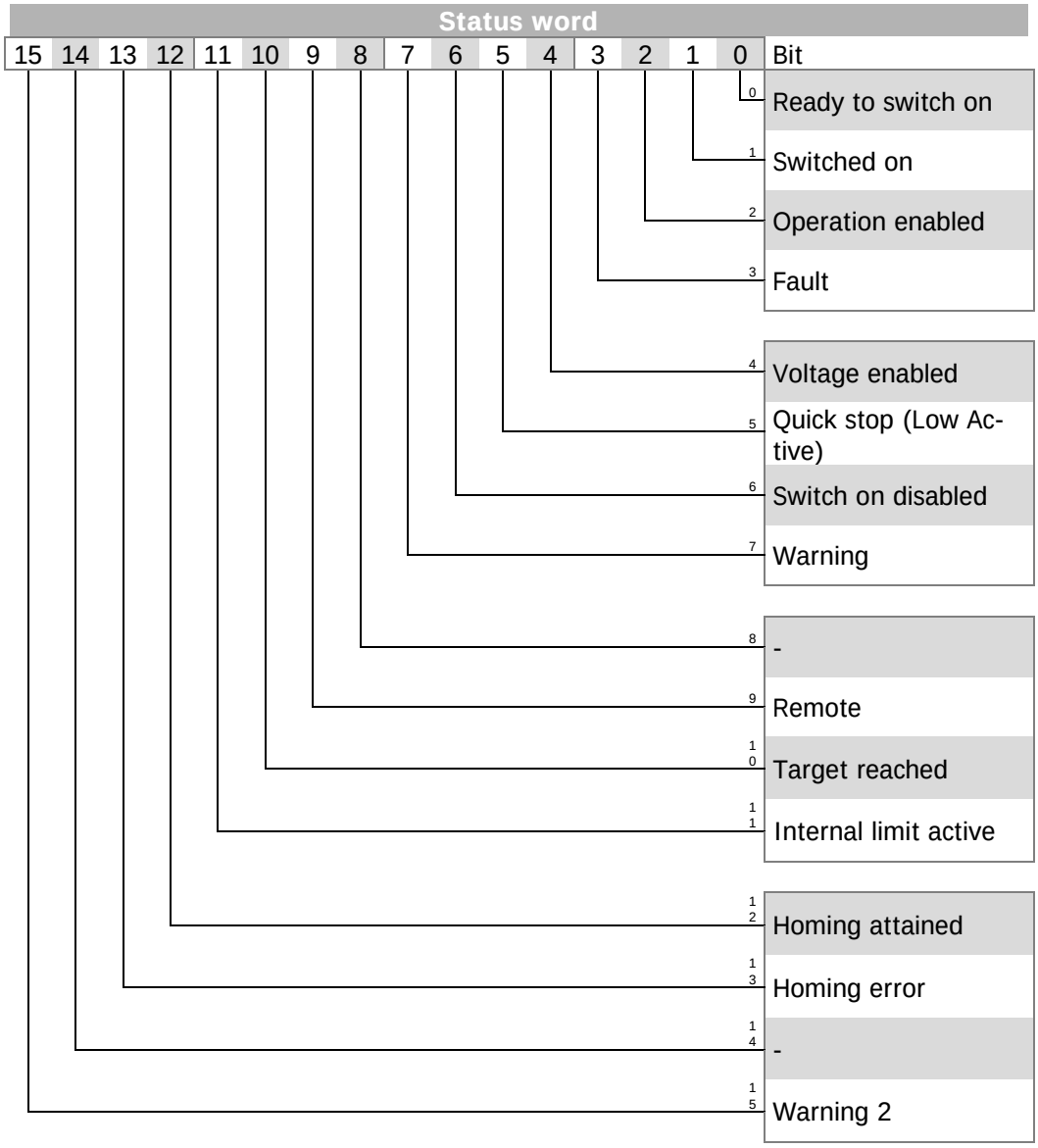
Relevant parameters:

410	*Control word*	**1130**	*Homing mode*
411	*Status word*	**1132**	*Fast speed*
418	*Minimum Frequency*	**1133**	*Creep speed*
419	*Maximum Frequency*	**1134**	*Acceleration*
1454	*Override Modes Of Operation*		

The ramp times are specified via parameter **1135**.

In homing mode, the mode-specific bits of the control word and the status word are used as follows:





Control word

Identification	Value	Description
Homing operation start **Bit 4**	0	Homing not active.
	0 → 1	Start homing with *Acceleration* **1134** and *Fast Speed* **1132** and *Creep Speed* **1133**.
	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	Halt = 0: Home position (still) not reached.
		Halt = 1: Axis decelerated.
	1	Halt = 0: Home position reached.
		Halt = 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 the Application manual “Positioning”.

11.4.4.1 Example sequence

In order to start “homing mode”, the correct sequence must be sent by the PLC.

1	Control word =	0x0000	Disable voltage
1	Status word =	0x0050	Switch On Disabled
2	Modes of operation =	6	(Homing)
3	Control word =	0x0006	Shutdown
	Status word =	0x0031	Ready to switch on
4	Control word =	0x0007	Switch On
	Status word =	0x0033	Switched On
5	Control word =	0x000F	Enable operation.
	Status word =	0xnn37	Operation enabled
6a	Control word =	0x001F	Enable operation and start homing.
	Status word =	0x1n37	Operation enabled and homing attained.

⚠ WARNING

Dangerous state due to new mode!

If *Override Modes Of Operation* **1454** is changed during operation (control word = 0xnnnF), a dangerous state may occur in the new mode.

- Before changing *Override Modes Of Operation* **1454**, check the status word (e.g. for status 0xnn33).

Once the sequence of the first four status words has been processed correctly, the ACU 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. “Home position set” - Bit 12 returns the status in the status word.
As long as 0x0007 is active, the “Modes of Operation” can also be changed safely. Once *Override Modes Of Operation* **1454** has been set to another value, operation can be started with a corresponding sequence.

11.4.5 Table travel record

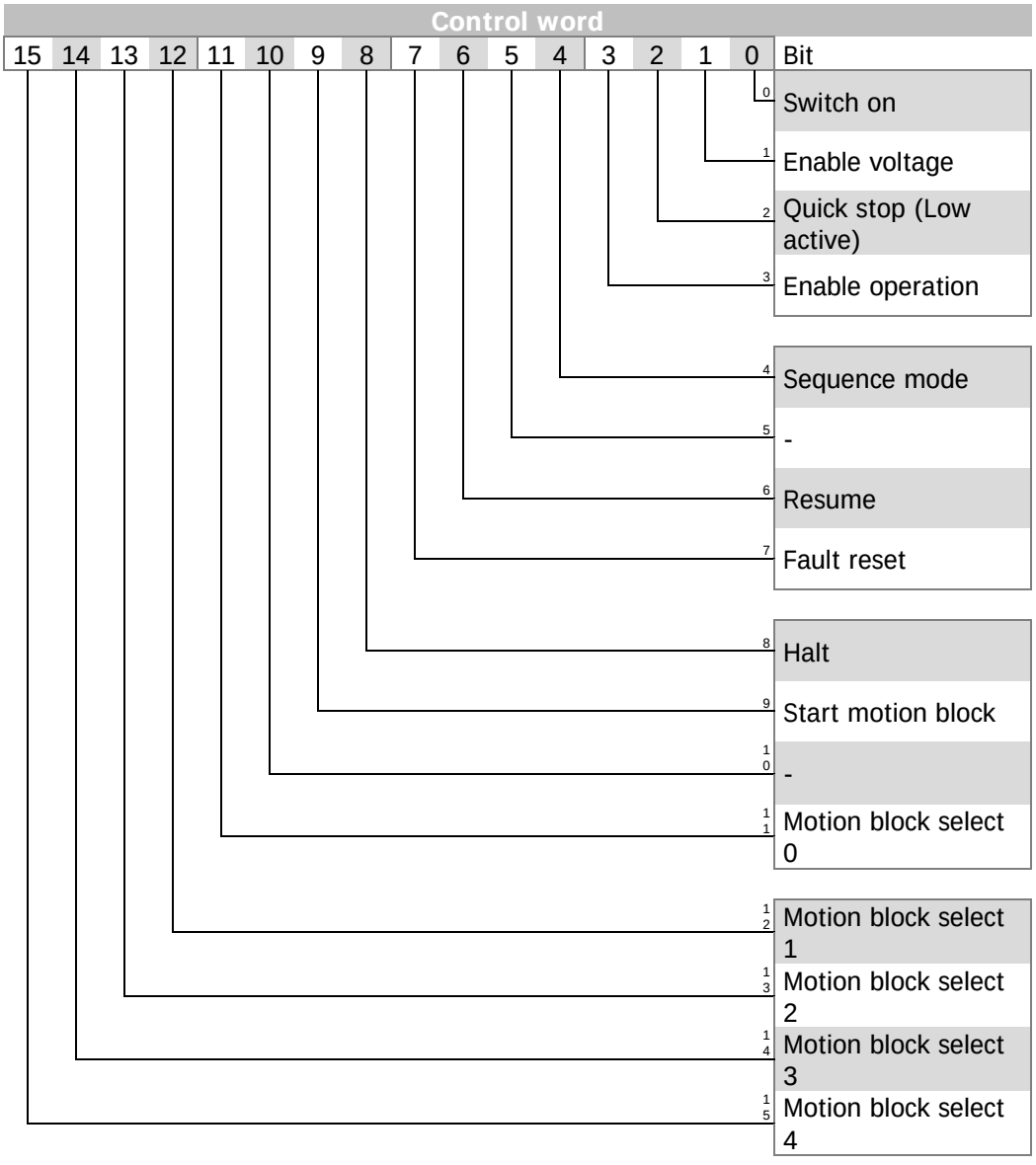
"Table travel record mode" can be selected via parameter *Override Modes Of Operation* **1454**. In "Table travel record mode", the drive moves to successive positions automatically. "Table travel record mode" uses pre-defined positions. Each target position is defined by a motion block. Several motion blocks can be defined.

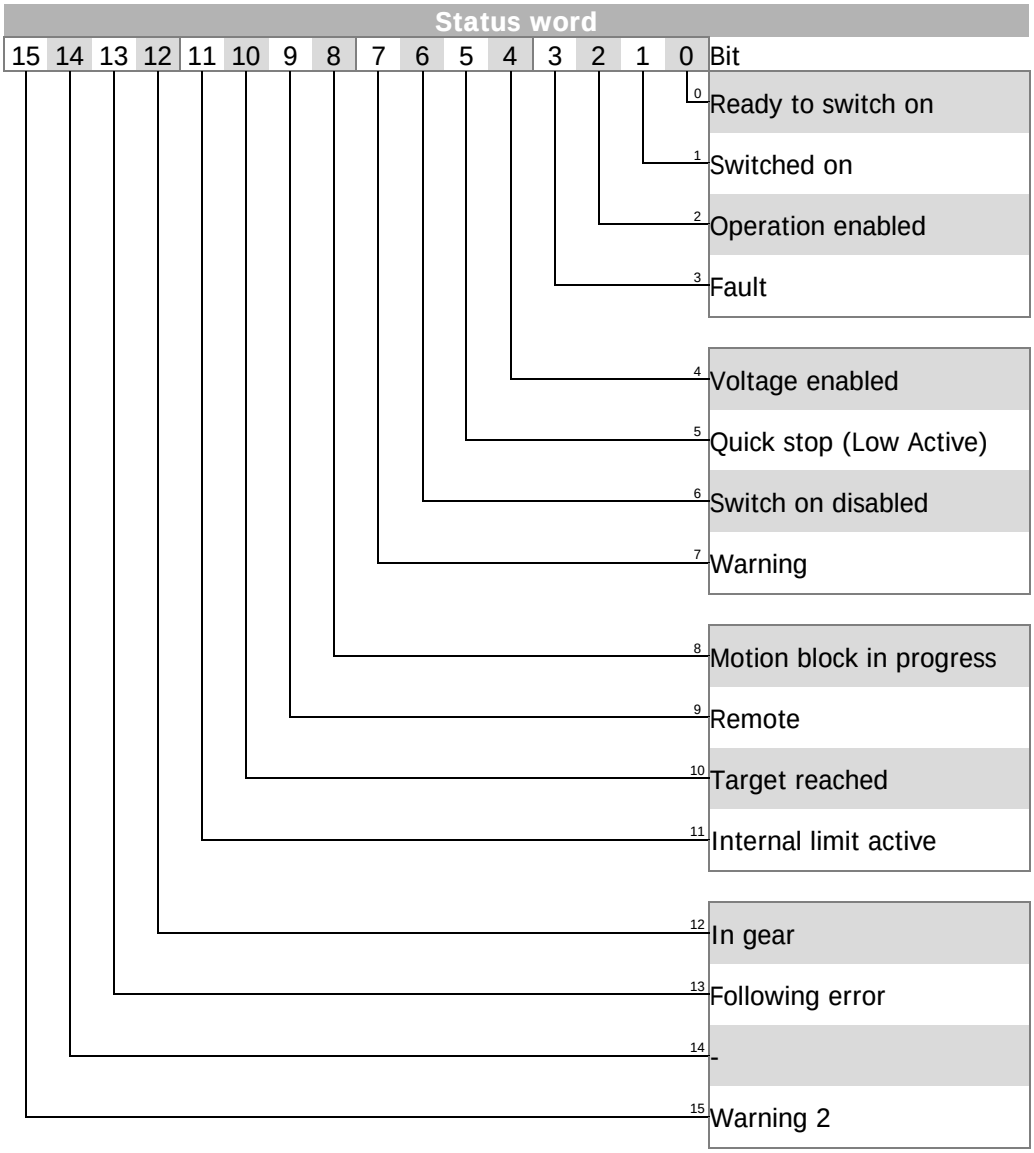
For a description of motion blocks, refer to the Application manual "Positioning".

Relevant parameters:

410	*Control word*	**1108**	*Act. Position*
411	*Status word*	**1106**	*Error Threshold*
418	*Minimum Frequency*	**1119**	*Contouring Error Time*
419	*Maximum Frequency*	**1165**	*Target Window*
1454	*Override Modes Of Operation*	**1166**	*Target Window time*
1246	*Actual Motion Block*	**1179**	*Emergency ramp*
1249	*Motion Block to Resume*		

In "Table travel record mode" the mode-specific bits of the control word and the status word are used as follows:





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 Actual Motion Block The motion block which is resumed can be read via object **1249**.
Halt **Bit 8**	0	Execute command from bit 4 “Automatic sequence”
	1	Stop axis at ramp of current motion block The frequency inverter remains in “Operation – enabled” status.
Start motion block **Bit 9**	0	Stop axis at 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	Halt		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 (control bit 8) = 0:	Target position not reached yet (only motion blocks with positioning). See also chapter 10.2.4 “Target window”.
		Halt (control bit 8) = 1:	Axis decelerated.
	1	Halt (control bit 8) = 0:	Target position reached (only motion blocks with positioning). See also chapter 10.2.4 “Target window”.
		Halt (control bit 8) = 1:	Axis has speed 0.
In gear **Bit 12**	0	Electronic gear not in gear.	
	1	Electronic gear in gear.	
Following error **Bit 13**	0	No contouring error.	
	1	Contouring 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 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.

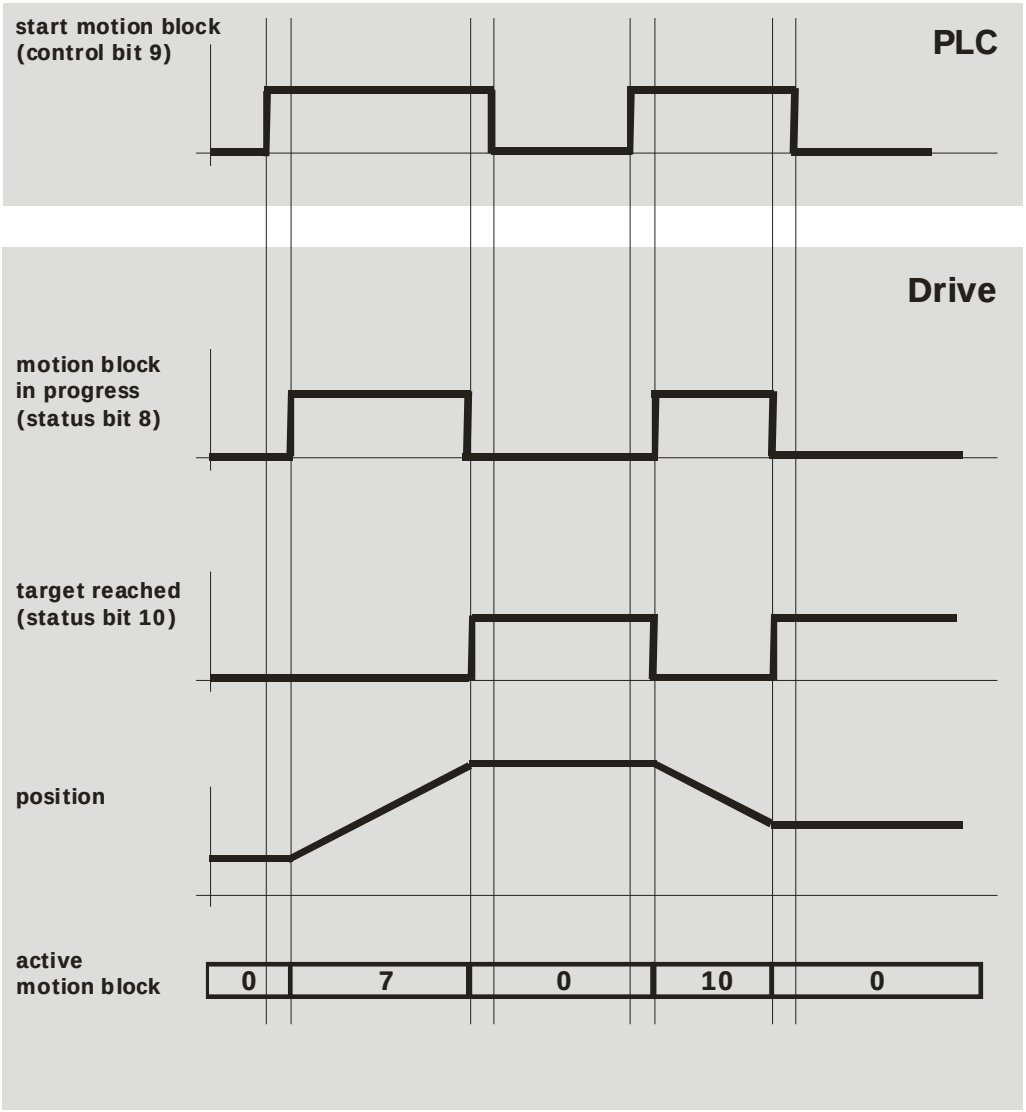
“Target reached” is set if the actual position of motion blocks with absolute or relative positioning reaches the *position window*.

“In Gear” is set when the electronic gear function is used and the electronic gear is coupled (synchronous running).

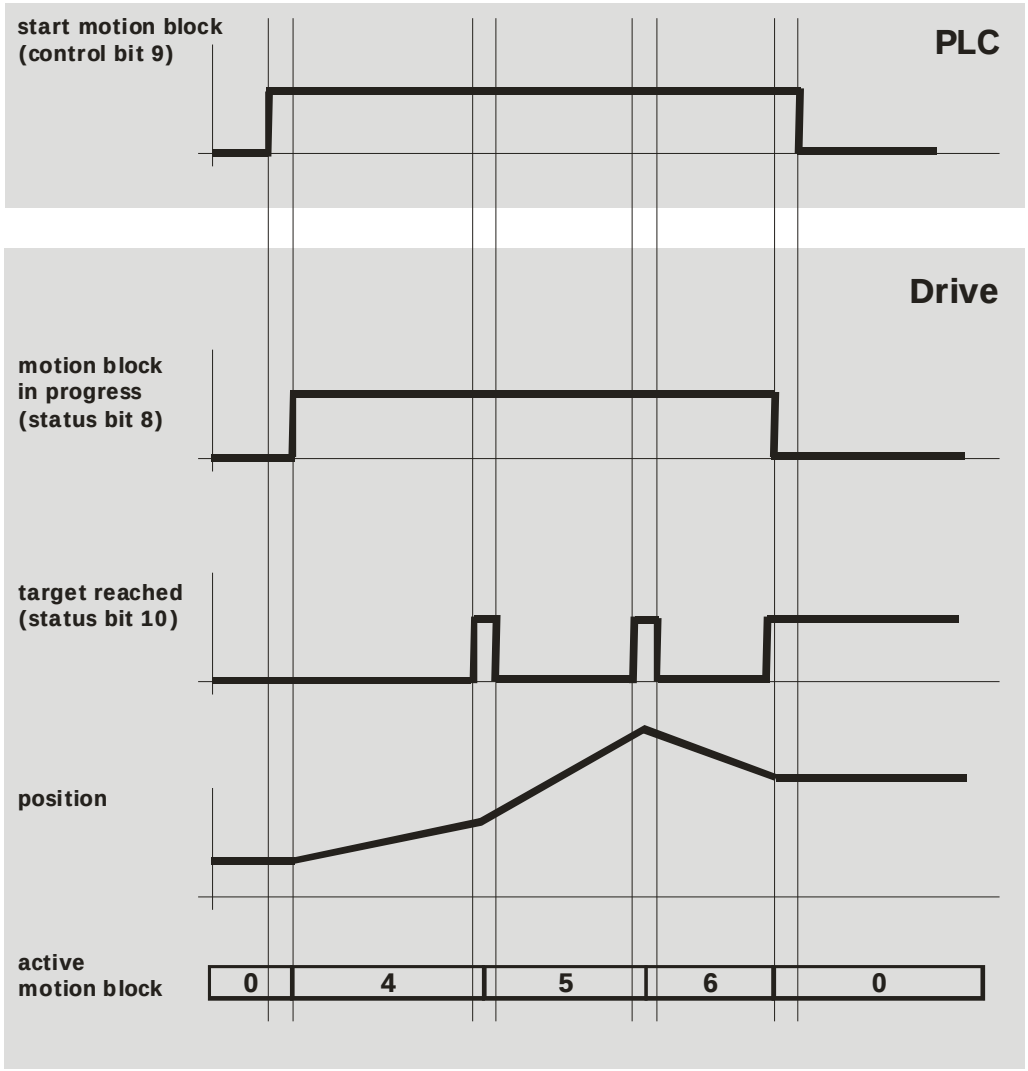
Setting *Halt* to *“*1” will stop a currently executed motion block. The axle is stopped with the ramp set in the current motion block. “Target reached” is set to “1” when the speed reaches value 0. The drive remains in “Operation enabled” status. To continue the interrupted motion block, reset *Halt* to “0”.

Examples:

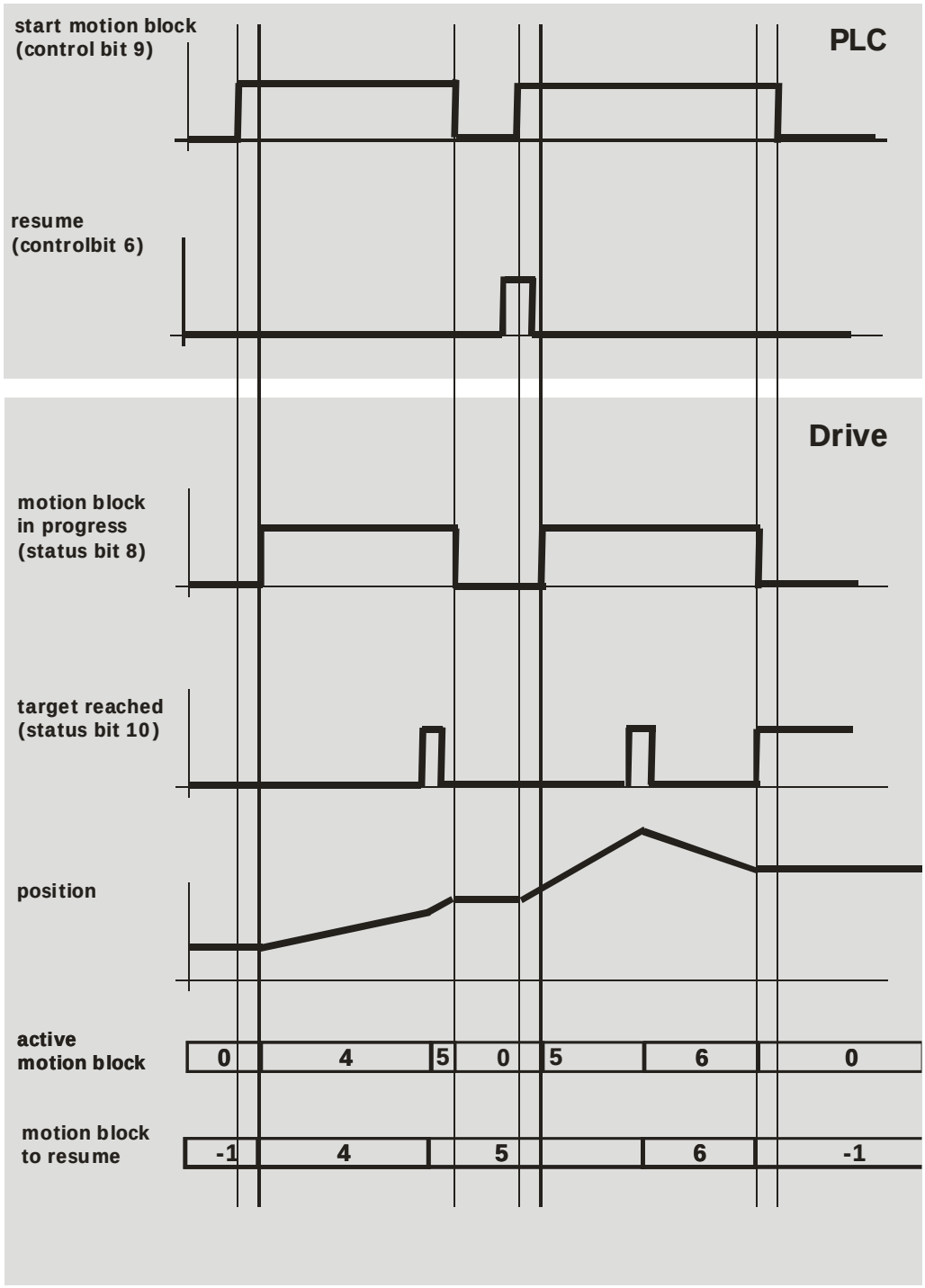
“single motion block” **sequence mode (control bit 4) = 0**
2 motion blocks 7 + 10



“ 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



11.4.5.1 Example sequence

In order to start “Table travel record mode”, the correct sequence must be sent by the PLC.

1	Control word =	0x0000	Disable voltage
1	Status word =	0x0050	Switch On Disabled
2	Modes of operation =	-1	(Table travel record mode)
3	Control word =	0x0006	Shutdown
	Status word =	0x0031	Ready to switch on
4	Control word =	0x0007	Switch On
	Status word =	0x0033	Switched On
5a	Control word =	0x000F	Enable operation
	Status word =	0xnn37	Operation enabled
5b	Control word =	0x020F	Start motion block 1 as single motion block
	Status word =	0xn337	Operation enabled and Positioning active.
	Status word =	0xn637	Operation enabled and Target reached.
5c	Control word =	0x0A0F	Start motion block 2 as single motion block
	Status word =	0xn337	Operation enabled and Positioning active.
	Status word =	0xn637	Operation enabled and Target reached.
5d	Control word =	0x120F	Start motion block 3 as single motion block
	Status word =	0xn337	Operation enabled and Positioning active.
	Status word =	0xn637	Operation enabled and Target reached.
5E	Control word =	0x021F	Start motion block 1 as sequence motion block
	Status word =	0xn337	Operation enabled and Positioning active.
	Status word =	0xn637	Operation enabled and Target reached.
5f	Control word =	0x004F	Resume previous motion block as single motion block
	Status word =	0xn337	Operation enabled and positioning active.
	Status word =	0xn637	Operation enabled and target reached.
5g	Control word =	0x005F	Resume previous motion block as sequence motion block
	Status word =	0xn337	Operation enabled and positioning active.
	Status word =	0xn637	Operation enabled and target reached.

⚠ WARNING

Dangerous state due to new mode!

If *Override Modes Of Operation* **1454** is changed during operation (control word = 0xnnnF), a dangerous state may occur in the new mode.

- Before changing *Override Modes Of Operation* **1454**, check the status word (e.g. for status 0xnn33).

Once the sequence of the first four status words has been processed correctly, the ACU 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 “Modes of Operation” can also be changed safely. Once *Override Modes Of Operation* **1454** has been set to another value, operation can be started with a corresponding sequence.

11.4.6 Move away from limit switch mode

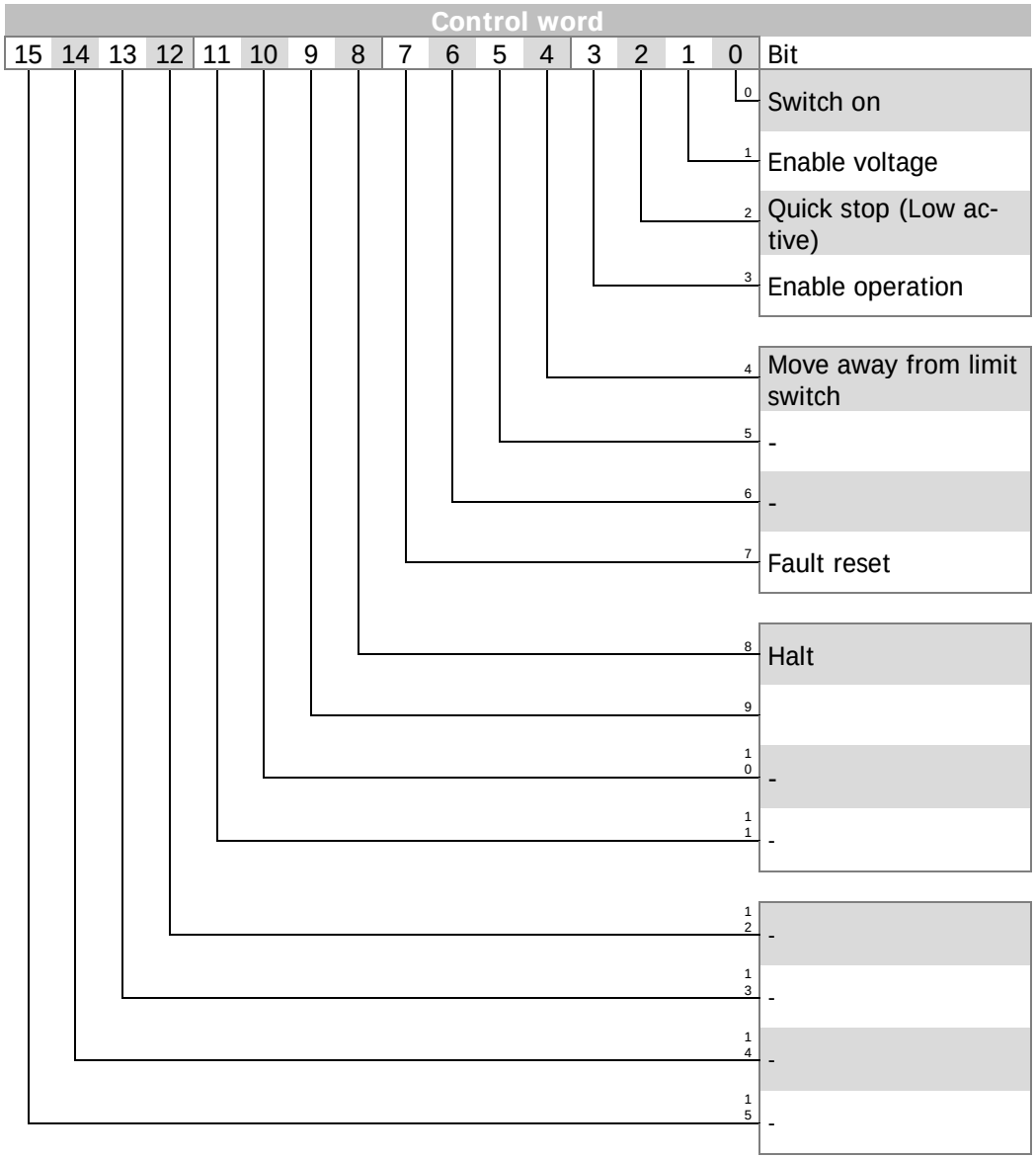
"Move away from limit switch mode" can be selected via *Override Modes Of Operation* **1454** = **-2**.

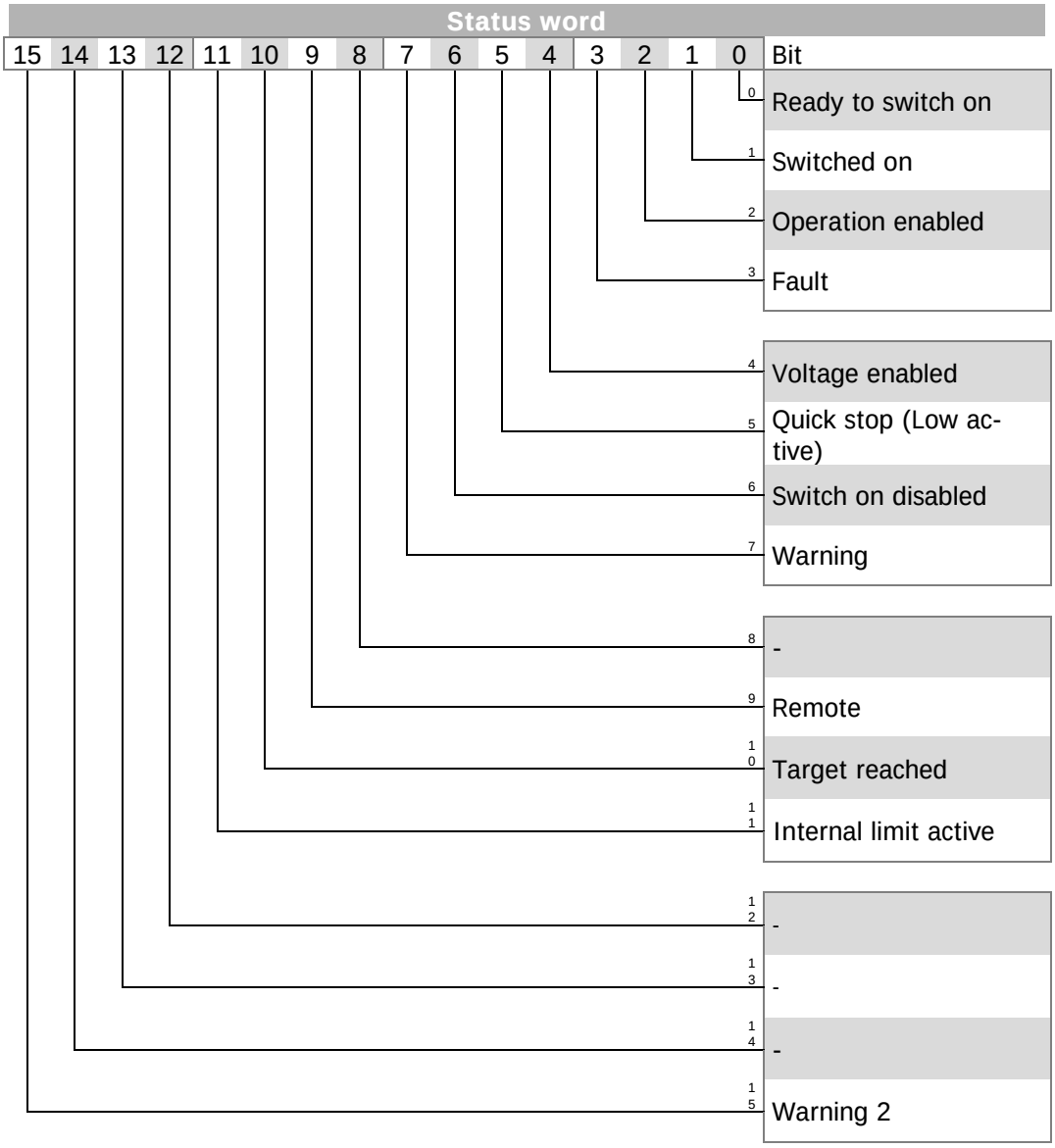
In "Move away from limit switch mode", the drive moves back from a triggered limit switch to the permissible travel range.

Relevant parameters:

410	*Control word*	**1454**	*Override Modes Of Operation*
411	*Status word*	**1179**	*Emergency ramp*
418	*Minimum Frequency*	**1133**	*Creep speed*
419	*Maximum Frequency*	**1134**	*Acceleration*

In "Move away from limit switch mode", the mode-specific bits of the control word and the status word are used as follows:





NOTE

"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.

NOTE

"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:	Axis decelerated
	1	Halt = 0:	Limit switch cleared
		Halt = 1:	Axis 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.

NOTE

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”.

11.4.6.1 Example sequence

In order to clear the limit switches, the correct sequence must be sent by the PLC.

1	Control word =	0x0000	Disable voltage
1	Status word =	0x0050	Switch On Disabled
2	Modes of operation =	-2	(Move away from limit switch)
3	Control word =	0x0006	Shutdown
	Status word =	0x0031	Ready to switch on
4	Control word =	0x0007	Switch On
	Status word =	0x0033	Switched On
5	Control word =	0x000F	Enable Operation.
	Status word =	0xnn37	Operation enabled
6	Control word =	0x001F	Move away from limit switch mode
	Status word =	0xn2B7	Operation enabled, limit switch active, clearing active
	Status word =	0xn637	Operation enabled and limit switch cleared (target reached).

⚠ WARNING

Dangerous state due to new mode!

If *Override Modes Of Operation* **1454** is changed during operation (control word = 0xnnnF), a dangerous state may occur in the new mode.

- Before changing *Override Modes Of Operation* **1454**, check the status word (e.g. for status 0xnn33).

Once the sequence of the first four status words has been processed correctly, the ACU 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 “Modes of Operation” can also be changed safely. Once *Override Modes Of Operation* **1454** has been set to another value, operation can be started with a corresponding sequence.

11.4.7 Electronic gear: Slave

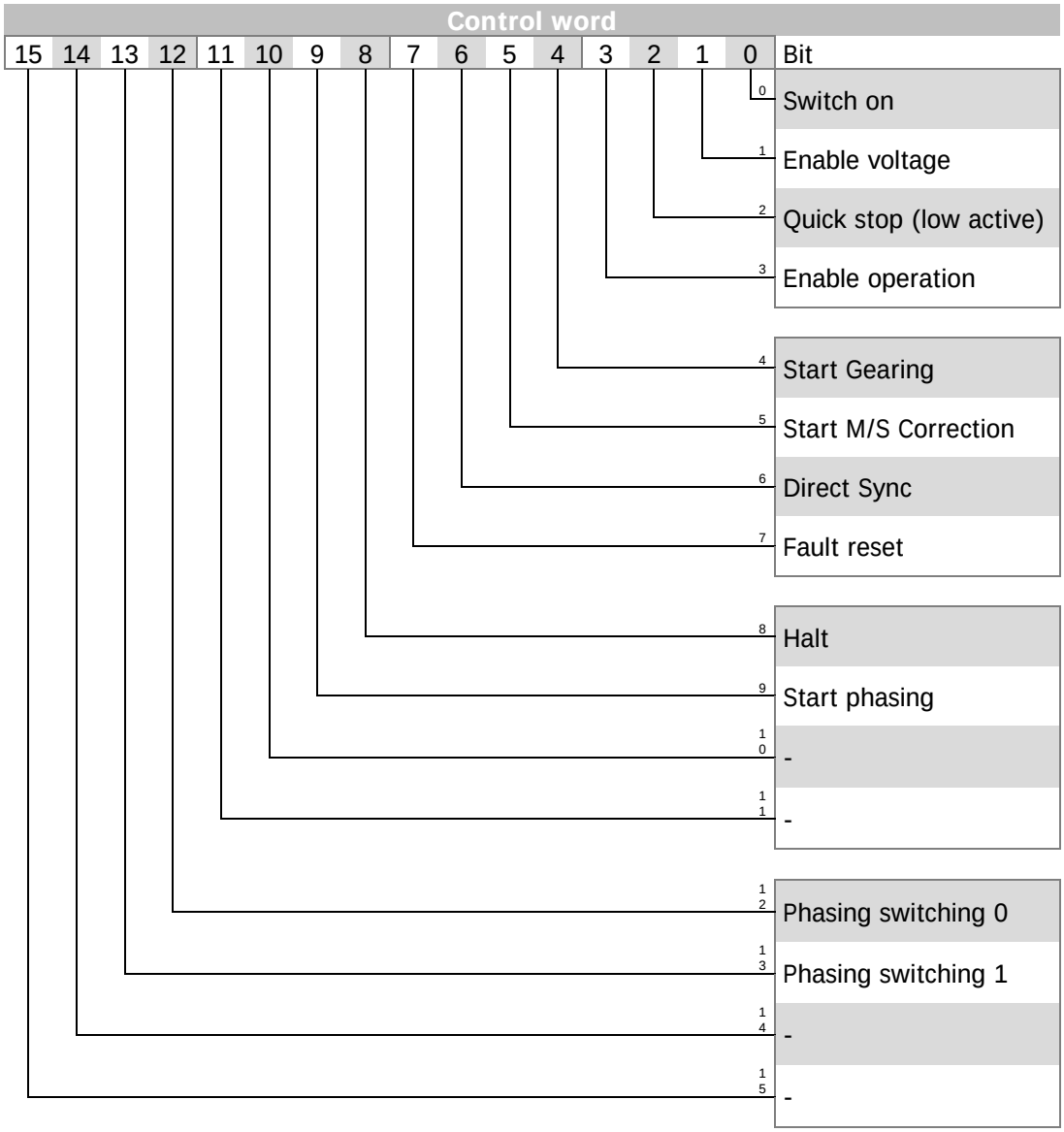
The mode “Electronic gear: Slave” can be selected via parameter *Override Modes Of Operation* **1454** =**-3**.

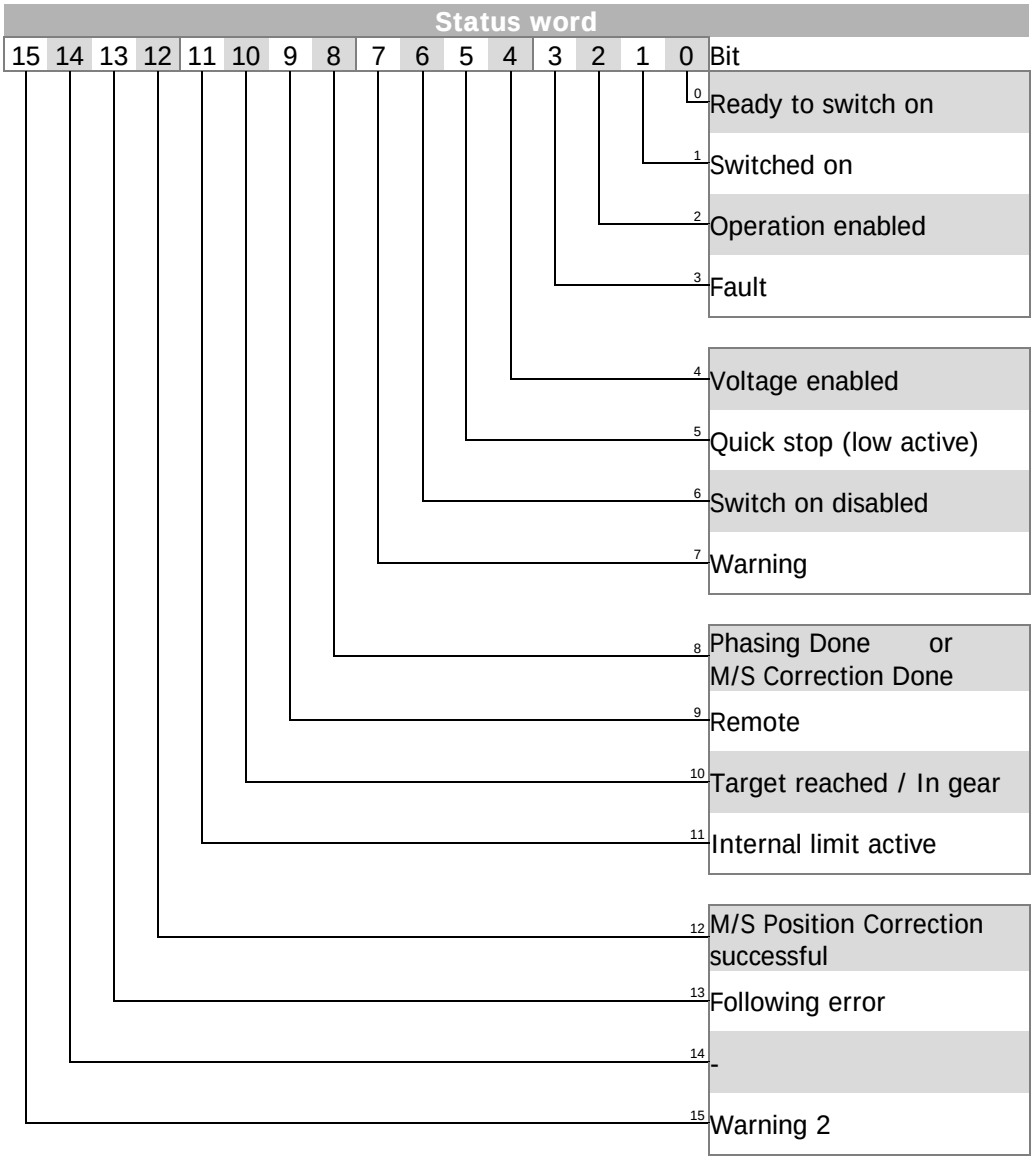
In operation mode “Electronic gear: Slave”, the drive follows a master drive as a slave drive.

Relevant parameters:

410	*Control word*	**1126**	*Phasing: Speed*
411	*Status word*	**1127**	*Phasing: Acceleration*
418	*Minimum Frequency*	**1108**	*Act. Position*
419	*Maximum Frequency*	**1106**	*Error Threshold*
1454	*Override Modes Of Operation*	**1119**	*Contouring Error Time*
1123	*Gear Factor: Numerator*	**1165**	*Target window*
1124	*Gear Factor: Denominator*	**1166**	*Target window time*
1142	*Resync. on Change of Gear-Factor*	**1179**	*Emergency ramp*
1125	*Phasing: Offset*		

In operation mode “Electronic gear: Slave”, the mode-specific bits of the control word and the status word are used as follows:





⚠ 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 11.4.7.1 “Master/Slave Position Correction”.

Control word

Identification	Value	Description
Start electronic gear **Bit 4**	0	Stop drive at ramp *Override Profile Deceleration* **1458**
	1	Start electronic gear at reference master speed at ramp *Override Profile Acceleration* **1457**
Start M/S Correction **Bit 5**	0	M/S Correction not started.
	1	Start Master/Slave Position correction. See chapter 11.4.7.1 “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 switching:

Control word															
15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
		Ph. sw.				Pha	Halt		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/ In gear **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 11.4.7.1 “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**.

Operation mode **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.

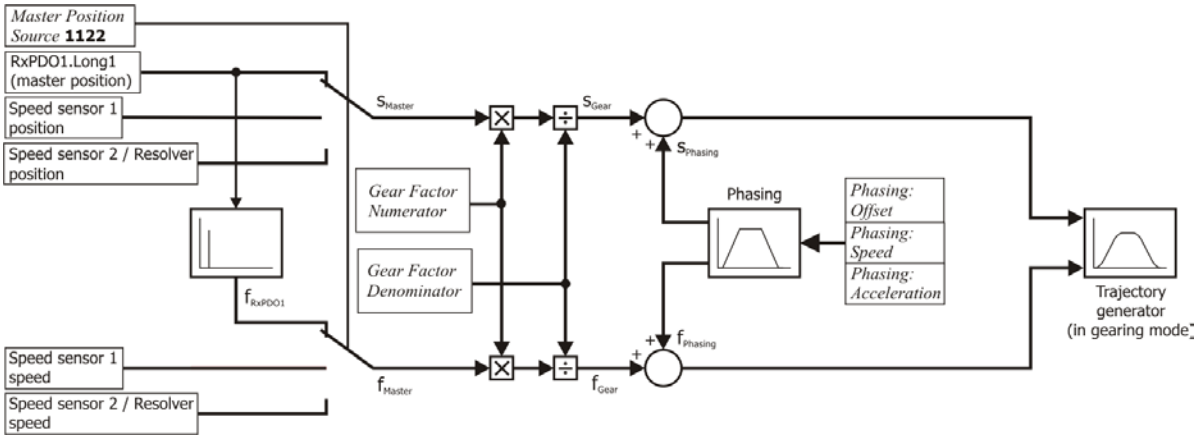
Operation mode **1180**
0 - Off [1]
1 - RxPDO1 [2]
2 - RxPDO2 [3]
3 - RxPDO3 [3]
10 - SYNC

[1] If the error message "F1453 System Bus 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 telegram or cyclic sending of SYNC telegram.
[3] Not recommended for el. gear because no extrapolation done.

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 System Bus, set parameter *SYNC time* **919** to a lower value.
Note that, due to these settings, the bus load of the system bus must provide for sufficient reserves for proper operation.

System Bus is described in the manuals of the extension modules with System Bus 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.

The *Gear factor* is defined via the following parameters:

Parameters	
1123	*Gear Factor Numerator*
1124	*Gear Factor Denominator*
1142	*Resync. on Change of Gear-Factor*

Phasing is defined via the following parameters:

Parameters	
1125.1 **1125.2** **1125.3** **1125.4**	*Phasing: Offset*
1126.1 **1126.2** **1126.3** **1126.4**	*Phasing: Speed*
1127.1 **1127.2** **1127.3** **1127.4**	*Phasing: Acceleration*

Start electronic gear and phasing function
The electronic gear is started by control word bit 4 “Start electronic gear”. The drive accelerates according to parameter *Override Profile Acceleration* **1457**. 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**.

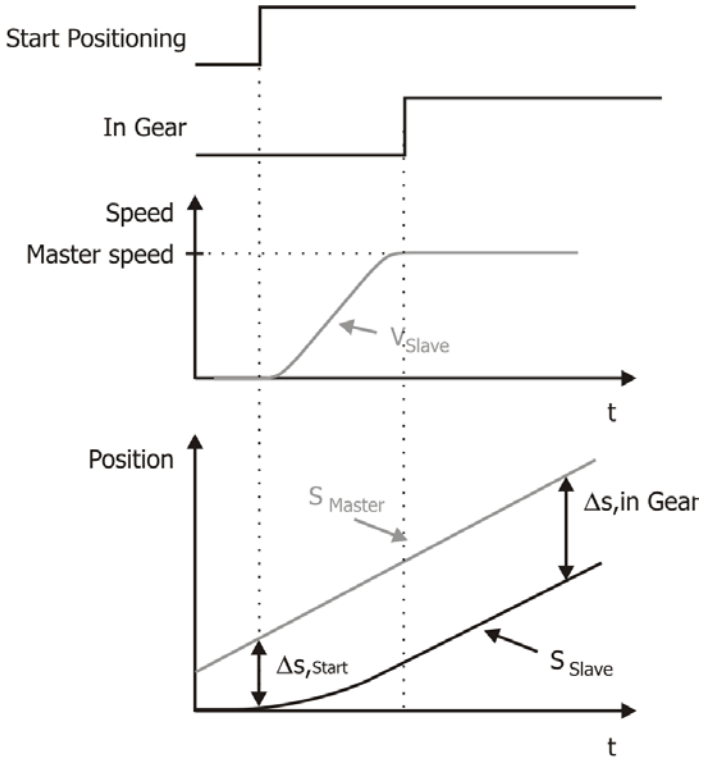
"Target reached/In Gear" is set when the electronic gear function is used and electronic gear synchronous running is reached.

Setting *Halt "*1" will stop a currently executed movement. The axis is stopped at ramp *Override Profile Deceleration* **1458**. "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**.

Phasing is described above in this chapter.

Function without direct synchronization ("Standard Synchronization")
The drive accelerates the master speed at 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 with 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.

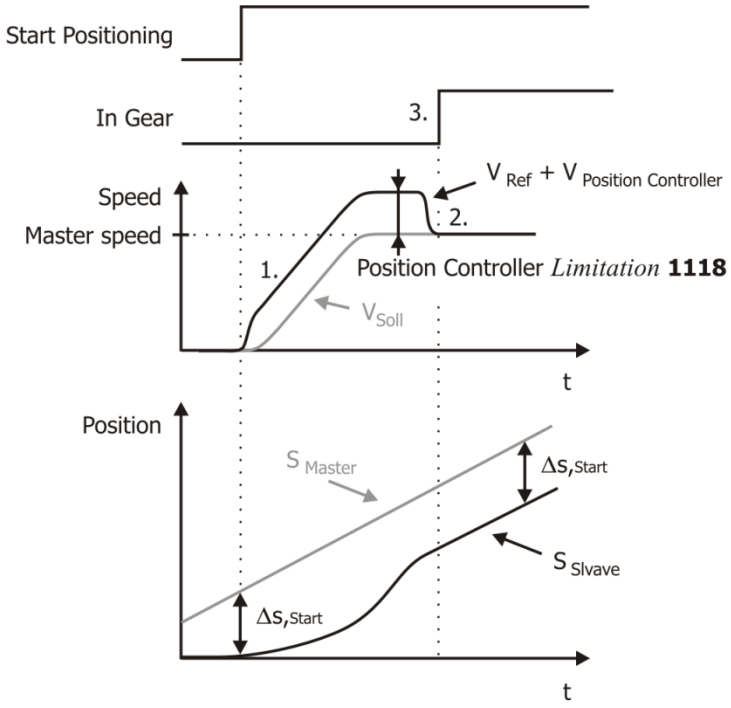


Function with direct synchronization

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.



11.4.7.1 Master/Slave Position Correction

NOTE

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 not used 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 not used 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 Synchronization offset	-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.

11.4.7.2 Example sequence

In order to start “Electronic Gear: Slave mode”, the correct sequence must be sent by the PLC.

1	Control word =	0x0000	Disable voltage
1	Status word =	0x0050	Switch On Disabled
2	Modes of operation =	-3	(Electronic Gear: Slave mode)
3	Control word =	0x0006	Shutdown
	Status word =	0x0031	Ready to switch on
4	Control word =	0x0007	Switch On
	Status word =	0x0033	Switched On
5	Control word =	0x000F	Operation enabled, reference speed “0”
	Status word =	0xnn37	Operation enabled
6a	Control word =	0x001F	Start electronic gear without direct synchronization
	Status word =	0xn327	Operation enabled, Slave not coupled (yet), Phasing not finished.
	Status word =	0xn337	Operation enabled, Slave not coupled (yet), Phasing finished.
	Status word =	0xn727	Operation enabled, Slave coupled, Phasing not (yet) finished.
	Status word =	0xn737	Operation enabled, Slave coupled, Phasing finished.
6b	Control word =	0x005F	Start Electronic Gear with Direct Synchronisation
	Status word =	See 6a	See 6a
7a	Control word =	0x021F	Start Electronic Gear **without** Direct Synchronisation and Phasing Profile 1
	Status word =	See 6a	See 6a
7b	Control word =	0x121F	Start Electronic Gear without Direct Synchronisation and Phasing Profile 2
	Status word =	See 6a	See 6a
7c	Control word =	0x221F	Start Electronic Gear without Direct Synchronisation and Phasing Profile 3
	Status word =	See 6a	See 6a
7d	Control word =	0x321F	Start Electronic Gear without Direct Synchronisation and Phasing Profile 4
	Status word =	See 6a	See 6a
8a	Control word =	0x025F	Start Electronic Gear **with** Direct Synchronisation and Phasing Profile 1
	Status word =	See 6a	See 6a
8b	Control word =	0x125F	Start Electronic Gear **with** Direct Synchronisation and Phasing Profile 2
	Status word =	See 6a	See 6a
8c	Control word =	0x225F	Start Electronic Gear **with** Direct Synchronisation and Phasing Profile 3
	Status word =	See 6a	See 6a
8d	Control word =	0x325F	Start Electronic Gear **with** Direct Synchronisation and Phasing Profile 4
	Status word =	See 6a	See 6a
9	Control word =	0x001F 0x003F	Enable Operation, the Slave drive synchronizes to the Master position.
	Status word =	0xnn37	Operation enabled
		0x1n37	M/S Position Correction finished.

⚠ WARNING

Dangerous state due to new mode!

If *Override Modes Of Operation* **1454** is changed during operation (control word = 0xnnnF), a dangerous state may occur in the new mode.

- Before changing *Override Modes Of Operation* **1454**, check the status word (e.g. for status 0xnn33).

Once the sequence of the first four status words has been processed correctly, the ACU 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 “Modes of Operation” can also be changed safely. Once *Override Modes Of Operation* **1454** 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.

12 Actual values

Actual values		
No.	**Description**	**Function**
11	VABus SST error register	Modbus or VABus error register. See chapter 7.2.9 “Exception condition codes”.
282	Bus reference frequency	Reference value from serial interface / Modbus TCP.
283	Ramp reference frequency	Reference value from reference frequency channel.
411	Status word	Status word. See chapter 11.1 “Control via contacts/remote contacts”.

12.1 Actual values Motion Control Interface / Motion Control Override

Actual values MCI / MCO		
No.	**Description**	**Function**
1107	Act. Speed	Actual Speed in user units/Seconds [u/s]
1108	Actual Position	Actual Position in user units [u]
1109	Act. Contouring Error	Actual Contouring error in user units [u]
1129	Actual Master Speed	Actual Master Speed in user units/Seconds [u/s]

13 Parameter List

The parameter list is sorted numerically. 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 SET-UP routine
- ⊗ This parameter cannot be written when the frequency inverter is in operation.

13.1 Actual values (Menu “Actual”)

Actual value parameter				
No.	**Description**	**Unit**	**Indication range**	**Chapter**
RS485/RS232				
11	VABusSST-Error-Register	-	0 ... 15	7.2.9
Actual values of frequency inverter				
228	Internal reference frequency	Hz	-1000,00 ... 1000.00	11.3.3
240	Actual speed	min^{-1}	-60000 ... 60000	11.3
249	Active dataset	-	0 ... 4	11
260	Current error	-	0 ... 0xFFFF	14.5
270	Warnings	-	0 ... 0xFFFF	14.3
274	Warning application	-	0 ... 0xFFFF	14.4
282	Bus reference frequency	Hz	-999.99 ... 999.99	12
283	Ramp reference frequency	Hz	-999.99 ... 999.99	12
Bus control				
411	Status word	-	0 ... 0xFFFF	11.2
Actual values of Motion Control Interface (MCI)				
1107	Act. Speed	u/s	-2^{31} ... $2^{31}-1$	12.1
1108	Actual Position	u	-2147483647 ... 2147483647	
1109	Act. Contouring Error	u	-2147483647 ... 2147483647	
1129	Act. Master Speed	u/s	-2^{31} ... $2^{31}-1$	
1246	Actual Motion Block	-	-10[1)], -3 ... 32	11.4.5
1249	Motion Block to Resume	-	-1 ... 32	
VABus/TCP				
1431	Module Info		String	VABus/TCP manual

Parameters *Current error* **260,** *Warnings* **270** and *Application warnings* **274** are only accessible via Field Bus. They cannot be addressed via the VPlus control software or the control unit.

13.2 Parameters (Menu “Para”)

Parameters				
No.	**Description**	**Unit**	**Setting range**	**Chapter**
Modbus/TCP				
388	Bus Error Behaviour	-	0 ... 5	6.3
Bus control				
392	State Transition 5	-	Selection	11.3.2
410	Control word	-	0 ... 0xFFFF	11.2
412	Local/Remote	-	Selection	11
Data set switching				
414	Data set selection	-	0 ... 4	11
Frequency ramps				
420	Acceleration (Clockwise)	Hz/s	0.00 ... 9999.99	11.3
421	Deceleration (Clockwise)	Hz/s	0.01 ... 9999.99	
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	
434	Ramp Setpoint	-	Selection	11.3.3
Fixed frequency values				
484	Reference frequency RAM	Hz	-999.99 ... 999.99	11.3.3
Fixed percentages				
524	Reference percentage RAM	%	-300.00 ... 300.00	11.3.3
Max. Control deviation				
549	Max. control deviation	%	0.01 ... 20.00	11
Stop behaviour				
637	Switch-Off Threshold	%	0.0 ... 100.0	11.3.1
638	Holding Time	s	0.0 ... 200.0	
Motion Control Interface (MCI): Position Controller				
1104	Time constant	ms	0 ... 300	10.2.4
MCI: Contouring error monitoring				
1105	Warning Threshold	u	0 ... 2^{31}-1	10.2.3
1106	Error Threshold	u	0 ... 2^{31}-1	
MCI: Reference system				
1115	Feed Constant	-	1 ... 2147483647	10.2.1
1116	Gear Box: Driving Shaft Revolutions	-	1 ... 65535	
1117	Gear Box: Motor Shaft Revolutions	-	1 ... 65535	
MCI: Position Controller				
1118	Limit	u/s	0 ... 2^{31}-1	10.2.5
MCI: Contouring error monitoring				
1119	Contouring error time	ms	0 ... 65535	10.2.3
1120	Fault reaction	-	Selection	
MCI: Electronic gear				
1122	Master Position Source	-	Selection	11.4.7 11.4.5
1123	Gear Factor Numerator	-	-32767 ... 32767	
1124	Gear Factor Denominator	-	1 ... 65535	
1125	Phasing: Offset	u	-(2^{31}-1) ... 2^{31}-1	
1126	Phasing: Speed	u/s	1 ... 2^{31}-1	
1127	Phasing: Acceleration	u/s^2	1 ... 2^{31}-1	

No.	Description	Unit	Setting range	Chapter
MCI: Homing				
1130	Homing Mode	-	0 ... 35	10.2.6 11.4.4
1132	Fast Speed	-	1 ... 2147483647	
1133	Creep Speed	-	1 ... 2147483647	
1134	Acceleration	-	1 ... 2147483647	
1135	Ramp Rise Time	-	0 ... 2000	
MCI: Electronic gear				
1142	Resync. on Change of Gear-Factor	-	Selection	11.4.7
MCI: Limit switch fault reaction				
1143	Fault reaction	-	Selection	10.2.7
MCI: Target window				
1165	Target Window	u	0 ... 2^{20}-1	10.2.4
1166	Target Window Time	ms	1 ... 65535	
MCI: Electronic gear				
1168	In Gear'-Threshold	u	1 ... 2^{31}-1	11.4.7 11.4.5
1169	In Gear'-Time	ms	1 ... 65535	
MCI: Profile Velocity mode [u/s]				
1176	Ramp Rise Time.	ms	0 ... 2000	11.4.2
1178	Ramp Fall Time.	ms	0 ... 2000	
MCI: Emergency Ramp				
1179	Emergency Ramp	u/s^2	1 ... 2147483647	10.1
System Bus				
1180	Operation mode	-	Selection	11.4.7
MCI: Profile Velocity mode [u/s]				
1275	Max. Slippage	ms	0 ... 2147483647	11.4.2
1276	Velocity Window	u/s	0 ... 65535	
1277	Velocity Window Time	ms	0 ... 65535	
1278	Threshold Window	u/s	0 ... 65535	
1279	Threshold Window Time	ms	0 ... 65535	
Modbus/TCP				
1299	S. Special Function Generator	-	Selection	11.4.1
Modbus/TCP				
1432	IP address	-	-	6.2
1433	Netmask	-	-	
1434	Gateway	-	-	
1435	DNS Server	-	-	
1436	DHCP Option	-	Selection	
1437	IP command	-	Selection	
1440	Email Function	-	Selection	
1441	Email Text (Body)	-	Text	
1439	Modbus/TCP Timeout	ms	0 ... 60000	6.2.3
Motion Control Override				
1454	Override Modes Of Operation	-	Selection	10.1
1455	Override Target Position	u	-2^{31}-1...2^{31}-1 u	
1456	Override Profile Velocity	u/s	-1...2^{31}-1 u/s	
1457	Override Profile Acceleration	u/s^2	-1...2^{31}-1 u/s^2	
1458	Override Profile Deceleration	u/s^2	-1...2^{31}-1 u/s^2	
1459	Override Target velocity vl [rpm]	rpm	-32768...32767 rpm	
1460	Override Target velocity pv [u/s]	u/s	-2^{31}-1...2^{31}-1 u/s	

14 Appendix

14.1 List of control words

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		

14.2 Overview of status words

The tables on this page provide an overview of the functions 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

14.3 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 user manual, further warning messages are activated by the Field Bus 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 control panel.

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 System Bus
14	0x4000	Warning Udc
15	0x8000	Warning *Application warning status* **367**

The meanings of the individual warnings are described in detail in the frequency inverter Operating Instructions.

14.4 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.

14.5 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 £ xx £ 32)
		70	No Homing Done
		71	Homing Encoder-Mode w.o. Z-Impulse
		72	Both Directions Locked
		73	No Touch Probe Signal Detected
Ethernet	F27	14	Communication loss to PLC

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.

14.6 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 14.6.2
	Speed into user units per second [u/s]	See Chapter 14.6.4
Speed [1/min] in	Frequency [Hz]	See Chapter 14.6.1
	Speed into user units per second [u/s]	See Chapter 14.6.6
Speed into user units per second [u/s] into	Speed [1/min]	See Chapter 14.6.5
	Frequency [Hz]	See Chapter 14.6.3

14.6.1 Speed [1/min] into frequency [Hz]

$$f\ [\mathrm{Hz}] = \frac{n[\mathrm{min}^{-1}] \times No.\,of\ pole\ pairs\ \ (P.373)}{60}$$

14.6.2 Frequency [Hz] into speed [1/min]

$$n[rpm] = \frac{f\ [\mathrm{Hz}] \times 60}{No.\,of\ pole\ pairs\ (P.373)}$$

14.6.3 Speed in user units per second [u/s] into frequency[Hz]

$$f\ [\mathrm{Hz}] = v\ [\frac{\mathrm{u}}{\mathrm{s}}] \times \frac{No.\,of\ pole\ pairs\ (P.373)}{Feed\ Constant\ (P.1115)} \times \frac{Gear\ Box{:}\,Motor\ Shaft\ Revolutions\ (P.1117)}{Gear\ Box{:}\,Driving\ Shaft\ Revolutions (P.1116)}$$

14.6.4 Frequency [Hz] into speed in user units per second [u/s]

$$v\ [\frac{\mathrm{u}}{\mathrm{s}}] = f\ [\mathrm{Hz}] \times \frac{Feed\ Constant\ (P.1115)}{No.\,of\ pole\ pairs\ (P.373)} \times \frac{Gear\ Box{:}\,Driving\ Shaft\ Revolutions (P.1116)}{Gear\ Box{:}\,Motor\ Shaft\ Revolutions\ (P.1117)}$$

14.6.5 Speed in user units per second [u/s] into speed [1/min]

$$v\ [\frac{\mathrm{u}}{\mathrm{s}}] = f\ [\mathrm{Hz}] \times \frac{Feed\ Constant\ (P.1115)}{No.\,of\ pole\ pairs\ (P.373)} \times \frac{Gear\ Box{:}\,Driving\ Shaft\ Revolutions (P.1116)}{Gear\ Box{:}\,Motor\ Shaft\ Revolutions\ (P.1117)}$$

14.6.6 Speed [1/min] into speed in user units per second [u/s]

$$v\ [\frac{\mathrm{u}}{\mathrm{s}}] = n\ [rpm] \times \frac{Feed\ constant\ (P.1115)}{60} \times \frac{Gear\ Box{:}\,Driving\ Shaft\ Revolutions\ (P.1116)}{Gear\ Box{:}\,Motor\ Shaft\ Revolutions\ (P.1117)}$$

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