

Bonfiglioli Vectron

ACTIVE and ACTIVE Cube

Modbus communication
with CM-232/CM-485/CM-485T
Frequency Inverter 230 V / 400 V



General Information about the Documentation

The present supplement of the operating instructions refers to the frequency inverters of the ACT and ACU line. It contains necessary information for installation and use of the communication modules CM-232 and CM-485.

In order to make it as easy as possible for the user to find his/her way through the documentation, it is structured according to the customer-specific demands made of the frequency inverter.

Brief Instructions

The Brief Instructions describe the basic steps required for mechanical and electrical installation of the frequency inverter. The guided commissioning supports you in the selection of necessary parameters and the configuration of the frequency inverter by the software.

Operating Instructions

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

Application Manual

The Application Manual contains additional information facilitating the installation and commissioning of the frequency inverter, i.e. information on the different issues relating to the specific application realized by the frequency inverter.

Installation Instructions

Complementing the Brief Instructions and the Operating Instructions, the Installation Instructions provide information on how to install and use the additional/optional components.

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

The following pictograms and signal words are used in the documentation:



Danger!

Danger refers to an immediate threat. Non-compliance with the precaution described will result in death, serious injury or material damage.



Warning!

Warning refers to a possible threat. Non-compliance with the warning may result in death, serious injury or material damage.



Caution!

Caution refers to an immediate hazard. Non-compliance may result in personal or material damage.

Attention!

Attention and the related text refer to a possible behavior or an undesired condition which can occur during operation.

Note

Note and the related text provide useful information which supplements the corresponding part of the documentation.



Warning! The specifications and instructions contained in the documentation must be complied with strictly during installation and commissioning. Only qualified staff who has read the documentation and, in particular, the safety instructions carefully is allowed to carry out installation or commissioning work or to operate the frequency inverters. The term „Qualified Staff“ refers to anybody who is familiar with the installation, assembly, commissioning and operation of the frequency inverter and has the proper qualification for the job.

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1 General Safety Instructions and Information on Use

The present documentation was prepared with great care and it was subjected to extensive and repeated reviews. For reasons of clarity, it was not possible to include all details of all types of the product in the documentation. Neither was it possible to consider all conceivable installation, operation or maintenance situations. If you require further information or if you meet with specific problems which are not dealt with in sufficient detail in the documentation, contact your local BONFIGLIOLI agent. We would also like to point out that the contents of this documentation 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. The manufacturer's obligations are exclusively specified in the relevant purchase contract. This contract also contains all and any warranty regulations which may apply to the relevant scope of supply. 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 by the aforementioned reasons.

1.1 General Information



Warning! The DC-link circuit of the frequency inverter is charged during operation, i.e. there is always the risk of contact with high voltage. Frequency inverters are used for driving moving parts and they may become hot at the surface during operation.

Any unauthorized removal of the necessary covers, improper use, wrong installation or operation may result in serious injuries or material damage. In order to avoid such injuries or damage, only qualified staff may carry out the transport, installation, setup or maintenance work required. The standards EN 50178, IEC 60364 (Cenelec HD 384 or DIN VDE 0100), IEC 60664-1 (Cenelec HD 625 or VDE 0110-1), BGV A2 (VGB 4) as well as the applicable national regulations must be complied with. The term „Qualified Staff“ refers to anybody who is familiar with the installation, assembly, commissioning and operation of the frequency inverter as well as the possible hazards and has the proper qualification for the job.

1.2 Purpose of the Frequency Inverters



Warning! 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 98/37/EEC and EN 60204. In accordance with the CE marking requirements, the frequency inverters comply with the Low Voltage Directive 72/23/EEC as well as EN 50178 / DIN VDE 0160 and EN 61800-2. The user shall be responsible for making sure that the requirements of the EMC Directive 89/336/EEC are met. Frequency inverters are only available at specialized dealers and are exclusively intended for professional use as per EN 61000-3-2.

The frequency inverters are also marked with the UL label according to UL508c, which proves that they also meet the requirements of the CSA Standard C22.2-No. 14-95.

The technical data, connection specifications and information on ambient conditions are indicated on the name plate and in the documentation and must be complied with in any case. Anyone involved in any kind of work at the device must have read the instructions carefully and understood them before starting the work.

1.3 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 little temperature deviations only. Observe the climatic conditions according to EN 50178 and the marking on the packaging. The units must not be stored for more than one year without connecting them to the rated mains voltage.

1.4 Handling and Installation



Warning! Damaged or destroyed components must not be put into operation because they may be a health hazard.

The frequency inverters are to be used in accordance with the documentation as well as the applicable directives and standards. They must be handled carefully and protected against mechanical stress. Do not bend any components or change the isolating distances. Do not touch electronic components or contacts. The devices are equipped with components which are sensitive to electrostatic energy and can easily be damaged if handled improperly. Any use of damaged or destroyed components shall be considered as a non-compliance with the applicable standards. Do not remove any warning signs from the device.

1.5 Electrical Connection



Warning! Before any assembly or connection work, discharge the frequency inverter. Verify that the frequency inverter is discharged. Do not touch the terminals because the capacitors may still be charged. Comply with the information given in the operating instructions and on the frequency inverter label.

When working at the frequency inverters, comply with the applicable standards BGV A2 (VBG 4), VDE 0100 and other national directives. Comply with the electrical installation instructions given in the documentation as well as the relevant directives. Responsibility for compliance with and examination of the limit values of the EMC product norm EN 61800-3 for variable-speed electrical drive mechanisms is with the manufacturer of the industrial plant or machine.

The documentation contains information on EMC-conforming installation. The cables connected to the frequency inverters may not be subjected to high-voltage insulation tests unless appropriate circuitry measures are taken before. Otherwise the unit may be damaged.

1.6 Information on Use



Warning! The frequency inverter may be connected to power supply every 60 s. Consider this for a jog operation of a mains contactor. For commissioning or after an emergency stop, a non-recurrent, direct restart is permissible. After a failure and restoration of the power supply, the motor may start unexpectedly if the AutoStart function is activated. Install protective equipment if personal injury or material damage is possible. Before commissioning and start of the operation fix all covers and check the terminals. Check the additional monitoring and protective devices according to EN 60204 and applicable the safety directives (e.g. Working Machines Act, Accident Prevention Directives etc.). No connection work may be performed, while the system is in operation.

1.7 Maintenance and Service



Warning! Unauthorized opening and improper interventions 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.

2 Introduction

This document describes the Modbus protocol of the communication modules CM-232 with RS232 port and CM-485 with RS485 port. This protocol can be used alternatively to the VABus via the same hardware (CM-232/CM-485). Both protocols can not be operated at the same time. The Modbus operation modes RTU and ASCII are available.

For the RS232 connection, the frequency inverter must be equipped with the RS232 communication module CM-232.

For the RS485 connection, the frequency inverter must be equipped with the RS485 communication module CM-485.

The communication modules CM-232 and CM-485 are separate components and must be mounted to the frequency inverter by the user. This is described in detail in chapter "Assembly".

Note: This document only describes the communication modules CM-232 and CM-485. It does not provide basic information on the serial interfaces RS232 and RS485. Neither does it contain any basic information on the operation of the frequency inverters. Basic knowledge of the methods and function of the RS232 and RS485 serial interfaces and Modbus protocol is required in order to understand and use the instructions contained in this document.

Note: In some chapters of these instructions, setting and display options via the PC software VPlus are described as an alternative to the KP500 control unit. In this case, VPlus communicates with the frequency inverter

- via the module CM-232 or CM-485 **or**
- via the interface adapter KP232.

If the serial interface of the module CM-232/CM-485 is connected to a PLC, for example, VPlus cannot access the frequency inverter via this interface directly.

In this case, the PC must be connected via the optional interface adapter KP232.

Attention! Via the RS232 port at CM-232 or the RS485 port at CM-485, a controller can access **all** parameters of the frequency inverter. Any change of parameters, the meaning of which is unknown to the user, may result in the frequency inverter becoming inoperative.

RS485 connection:

Frequency inverters can be connected to a bus system by extension with CM-485 communication modules. The bus structure is linear and designed as a 2-wire line. Via a bus master, up to 247 frequency inverters can be addressed.

The frequency inverters can be parameterized and controlled easily. Additionally, frequency inverter data can be polled and positioning commands can be transmitted during operation via the bus system by means of a PC or a PLC.

RS232 connection:

The RS232 connection enables a peer-to-peer connection between two clients.

3 Installation/Disassembly of the communication module

3.1 Installation

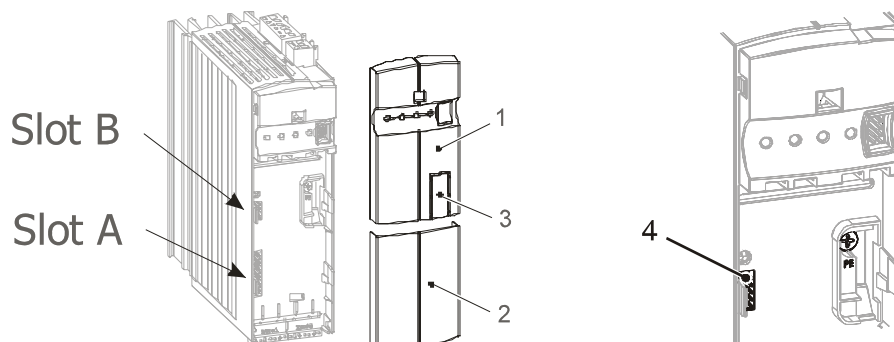
The communication module is pre-assembled in a case. Additionally, a PE spring is enclosed for PE connection (shield).



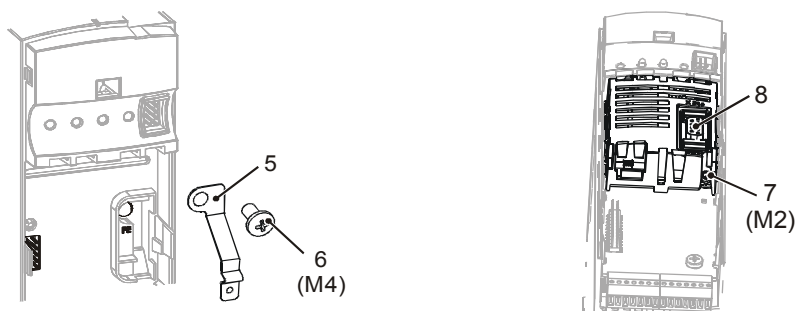
Caution! The frequency inverter must be disconnected from power supply before installation of the communication module. Assembly under voltage is not permissible and will destroy the frequency inverter and/or the communication module. Do not touch the PCB visible on the back of the module, otherwise components may be damaged.

Work steps:

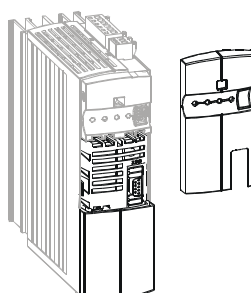
- Disconnect the frequency inverter from mains voltage and protect it against being energized unintentionally.
- Remove covers **(1)** and **(2)** of the frequency inverter. Slot B **(4)** for the communication module is now accessible.



- 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 by screwing the M2 screw **(7)** of the module to the PE spring **(5)**.

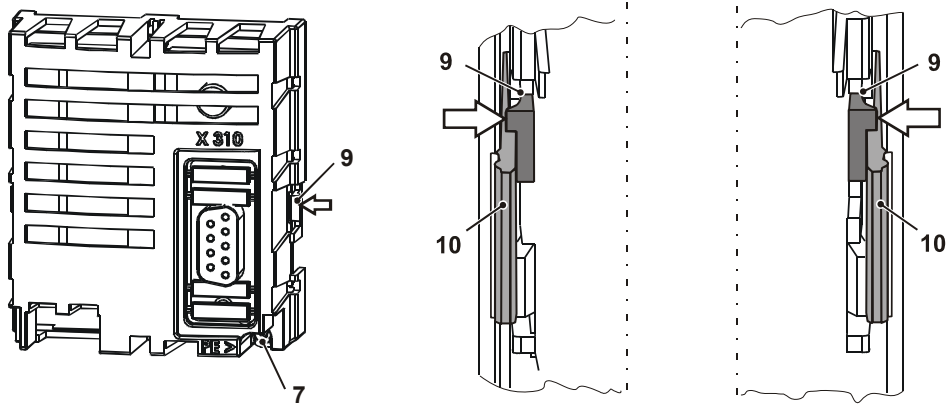


- In the upper cover **(1)**, break out the pre-punched cutout **(3)** for the plug X310 **(8)**.
- Mount the two covers **(1)** and **(2)**.



3.2 Disassembly

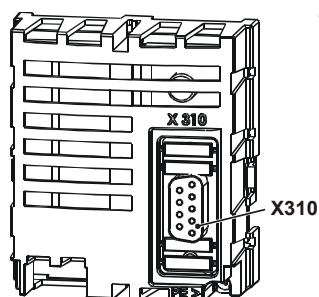
- Disconnect the frequency inverter from mains voltage and protect it against being energized unintentionally.
- Remove covers **(1)** and **(2)** of the frequency inverter.



- Loosen the M2 screw **(7)** 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 (\leftarrow). 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 (\Rightarrow).
 - Pull the module out of the slot by gently pulling on the right and left side alternately.
- Disassemble the PE spring **(5)**.
- Mount the two covers **(1)** and **(2)**.

4 Plug Assignment/Bus Termination/Cable

4.1 RS232 module CM-232



The RS232 interface is connected to a PC or a controller via the 9-pin D-Sub socket **X310**. The assignment complies with the standard, thus a RS232 connection cable (1:1) is required for connection only.

Part. no.
179 675-100

Bus Connector X310 CM-232 (9p Sub-D)

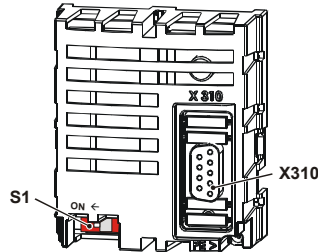
pin	name	function
Housing	Shield	connected with PE
1	–	n. c.
2	RxD	receive Data (input)
3	TxD	transmit Data (output)
4	–	n. c.
5	0 V	Ground
6	–	n. c.
7	–	n. c.
8	–	n. c.
9	–	n. c.

- If no pre-assembled connection cable is used for the RS232 connection, a twisted and shielded cable is to be used
- 1:1 assignment of the pin contacts
- The shield must be a harness shield (**not a foil shield**)
- The shield is to be connected to PE properly on both sides

4.2 RS485 module

- For the bus cable RS485, the twisted and shielded line is to be used
- The shield must be a harness shield (**not a foil shield**)
- The shield is to be connected to PE properly on both sides.
- The pin assignment of the RS485 cable is different from that of the RS232 cable; if you use the wrong cable, no communication is possible

4.2.1 RS485 module CM-485 DB9



The RS485 interface is connected via the 9-pin D-Sub socket **X310**.

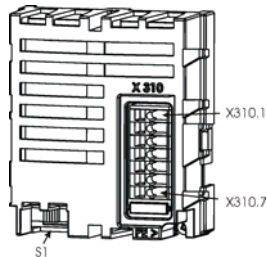
For details on the pin assignment, refer to the following table.

Part. No.
179 675-110

Bus Connector X310 CM-485 DB9

pin	name	function
Housing	Shield	connected with PE
1	Data Line B	short-circuit proof and functionally insulated; max. current 60 mA
2	Data Line B'	same as pin 1 – for cable network
3	0 V	GND/earth
4	–	n. c.
5	+5 V	Supply voltage interface converter +5 V
6	–	n. c.
7	Data Line A	short-circuit proof and functionally insulated; max. current 60 mA
8	Data Line A'	same as pin 7 – for cable network
9	–	n. c.

4.2.2 RS485 module CM-485 T



The RS485 interface is connected via the 7-pin terminal socket **X310**

For details on the pin assignment, refer to the following table.

Part. no.
179 675-111

Busstecker X310 CM-485T (7p terminal)

terminal	name	function
1	Data Line A	short-circuit proof and functionally insulated; max. current 60 mA
2	Data Line A'	same as terminal 1 – for cable network
3	Data Line B	short-circuit proof and functionally insulated; max. current 60 mA
4	Data Line B'	same as terminal 3 – for cable network
5	+5 V	Supply voltage interface converter +5 V
6	0 V	GND/ earth
7	PE	Shield/PE

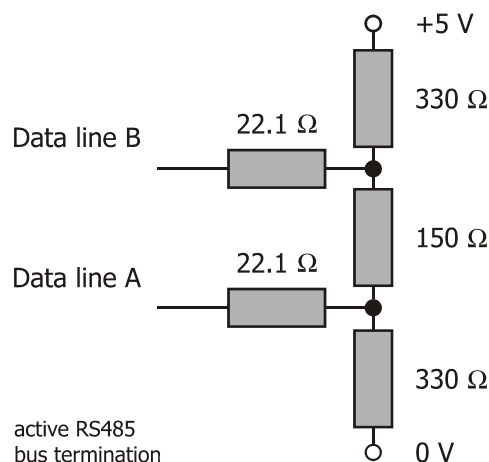
4.2.3 Bus termination

Attention! The passive bus termination (connection of a termination resistor) is required at the physically first and last client. It can be activated by the DIP Switch S1 of the CM-232 and CM-485.

By default, the bus termination is set to **OFF**.

It is important to realize the correct termination. If not, no communication is possible by the RS485 interface!

As an alternative the active bus termination is possible via corresponding circuit:

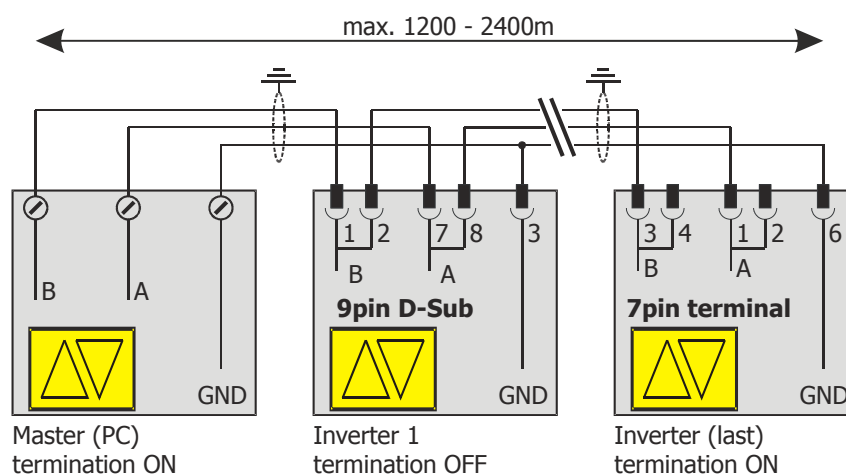


The active termination is only allowed once each branch. The bus termination via an external circuit and via DIP switch at the same time is not allowed.

Take care for the ground wiring; this will protect the communication bus for a high noise level.

For easy wiring the signal terminals A and B have parallel contacts.

Example of wiring with different CM-485 modules:



5 Startup

By default, the parameters of the communication modules CM-232 and CM-485 are set as follows:

Parameter		Settings
No.	Description	Factory setting
395	Protocol Type	0 - VCB bus protocol
413	Watchdog Timer	0

Parameter		Settings
No.	Description	Factory setting
10	Baud Rate	4 - 19200
1375	Modbus Parity	0 – EVEN
1376	Modbus Address	1

5.1 General Information on configuration

The CM-232 / CM-485 communication modules can be configured in different ways:

- **Direct connection CM-232 to PC / PLC**

Direct connection between the 9-pin Sub-D socket (X310) of the CM-232 and the serial interface of a PC / PLC.
Configuration of the installed communication module via the control software VPlus or the control unit KP500.

In the case of the CM-232 the connection to a PC / PLC is realized via a RS232 connection cable (1:1).

- **Direct connection CM-485 to PC / PLC**

Direct connection between the 9-pin Sub-D socket (X310) of the CM-485 and the serial interface of a PC via an interface converter.

Attention! For connection of the CM-485 to the RS232 interface of the PC / PLC, an appropriate interface converter must be installed in the signal line.

Configuration of the installed communication module via the control software VPlus or the control unit KP500.

- **Connection of interface adapter KP232 to PC**

Connection of the interface adapter KP232 at slot A of the frequency inverter. Connection to PC via a RS232 connection cable (1:1). Configuration of the installed communication module via the control software VPlus.

- **Configuration via Control Unit KP500**

Configuration via the pluggable control unit KP500 at slot A of the frequency inverter.

Attention! The transmitter and receiver must be set to the same transmission rate (Baud rate).

The setting of the Baud rate effects the communication of the modules CM-232 and CM-485. The KP232 interface adapter adjusts the Baud rate automatically to the PC or control transmission rate.

Work steps:

- Install module CM-232/CM-485 on the frequency inverter.
- **In the case of module CM-232:**
Connect CM-232 and PC/PLC via RS232 cable.
- **In the case of module CM-485:**
Connect CM-485 via RS485 cable with interface converter.
Connect the RS232 port of the interface converter with the PC/PLC.
- Plug in control unit KP500 or interface adapter KP232 to slot A of the frequency inverter.
- In the case of KP232: Connect interface adapter KP232 to PC via a serial cable.

Protocol type settings

By default, the communication modules CM-232/CM-485 are set to the BONFIGLIOLI VECTRON standard protocol (VCB-Bus). Communication with the VPlus control software is only possible with this protocol type.

Attention! If another protocol type or a wrong setting is selected, no communication is possible via CM-232/CM-485.
In this case, correct the protocol type using the control unit KP500.

For detailed information, see chapter 6 "Modbus over Serial Line Protocol".

Note: The interface adapter KP232 operates with the BONFIGLIOLI VECTRON standard protocol VCB-Bus independent of the communication module CM-232 or CM-485 and can communicate with VPlus at any time.

5.2 RS232 Module CM-232

5.2.1 Setting the Modbus Baud Rate and Parity

The transmission speed and parity of the CM-232 are set via parameters *Baud Rate* **10** and *Modbus Parity* **1375**.

The transmission speed of the CM-232 depends on various application-specific parameters. For example, the cable length limits the transmission speed due to signal propagation delays.

<i>Baud Rate</i> 10	Function	max. cable length ¹⁾
1 – 2400 Baud	Transmission rate 2400 Baud	30 m
2 – 4800 Baud	Transmission rate 4800 Baud	30 m
3 – 9600 Baud	Transmission rate 9600 Baud	30 m
4 – 19200 Baud	Transmission rate 19200 Baud	30 m
5 – 57600 Baud	Transmission rate 57600 Baud	10 m
6 – 115200 Baud	Transmission rate 115200 Baud	10 m

¹⁾ The indicated cable lengths are recommended maximum values which depend, among other things, on the quality of the cable.

<i>Modbus Parity</i> 1375	Function
0 – EVEN	EVEN Parity is used in transmission
1 – ODD	ODD Parity is used in transmission
2 – None	No Parity is used in transmission

Attention! Baud rate and parity changes are only active after a reset of the frequency inverter via the software or Mains Off/On.

In the case of the software reset, proceed as follows:

- Via the control unit KP500 or the control software VPlus open parameter *Program(ming)* **34**.
- Set parameter value "123".
- Confirm by pressing "ENT".

After the reset, the frequency inverter is initialized and is ready for operation after a few seconds.

5.2.2 Setting the Modbus Address

The address of the CM-232 can be set via parameter *Modbus Address* **1376**.

Parameter		Settings		
No.	Description	Min.	Max.	Fact. sett.
1376	Modbus Address	1	247	1

Note: Normally, it is not necessary to change the default setting (Address 1). In the case of special operating conditions, the address can be adjusted.

Attention! An address change is effective immediately, i.e. without a restart of the frequency inverter.

For details on addressing, see chapter 6.2 "Addressing Rules".

5.3 RS485 Module CM-485

5.3.1 Setting the Modbus Baud Rate and Parity

The transmission speed and parity of the CM-485 are set via parameters *Baud Rate* **10** and *Modbus Parity* **1375**.

The transmission speed of the CM-485 depends on various application-specific parameters. For example, the cable length limits the transmission speed due to signal propagation delays. In case of using very long cables, it is possible to take RS485 repeater units.

<i>Baud Rates</i> 10	Function	max. line length
1 – 2400 Baud	Transmission rate 2400 Baud	2400 m
2 – 4800 Baud	Transmission rate 4800 Baud	2400 m
3 – 9600 Baud	Transmission rate 9600 Baud	1200 m
4 – 19200 Baud	Transmission rate 19200 Baud	1200 m
5 – 57600 Baud	Transmission rate 57600 Baud	600 m
6 – 115200 Baud	Transmission rate 115200 Baud	300 m

- Attention!**
- All bus clients must be set to the same baud rate.
 - Baud rate changes are only active after a reset of the frequency inverter via the software or Mains Off/On.
In the case of the software reset, proceed as follows:
 - Via the control unit KP500 or the control software VPlus open parameter *Program(ming)* **34**.
 - Set parameter value "123".
 - Confirm by pressing "ENT".
 After the reset, the frequency inverter is initialized and is ready for operation after a few seconds.

<i>Modbus Parity</i> 1375	Function
0 – EVEN	EVEN Parity is used in transmission
1 – ODD	ODD Parity is used in transmission
2 – None	No Parity is used in transmission

5.3.2 Setting the Modbus Node Address

The node address of the CM-485 is set via parameter *Modbus Address* **1376**. Up to 247 frequency inverters can be used on the RS485 bus. The frequency inverters are assigned unambiguous addresses in the range from 1 to 247.

Parameter		Settings		
No.	Description	Min.	Max.	Fact. sett.
1376	Modbus Address	1	247	1

- Attention!**
- For operation with the CM-485 module, each client must be assigned an address.
 - Bus addresses may only be assigned once, i.e. no double assignments.
 - An address change is effective immediately, i.e. without a restart of the frequency inverter.

For details on addressing, see 6.2.

6 Modbus over Serial Line Protocol

The Modbus protocol described in the following has been incorporated into the standard ACT/ACU software of BONFIGLIOLI VECTRON. It defines and describes the communication via the serial interfaces RS232/RS485 using the Modbus RTU and ASCII transmission modes.

By default, the frequency inverters are set to the standard VCB bus protocol. The Modbus protocol type can be set via parameter *Protocol* **395**:

<i>Protocol 395</i>	Function
0 - VCB Bus	BONFIGLIOLI VECTRON standard protocol (default setting)
1 - P-Bus	Application-specific bus protocol ¹⁾
2 - Modbus RTU	Modbus over serial line (with RTU Transmission Mode)
3 - Modbus ASCII	Modbus over serial line (with ASCII Transmission Mode)

Note ¹⁾ This bus protocol is only used for special applications. It cannot be used for standard applications.
For more detailed information, refer to the application-specific instructions.

Attention !

- Changes of the parameter *Protocol* **395** are effective immediately, i.e. without a restart of the frequency inverter.
- If the wrong protocol is selected, communication via CM-232/CM-485 is not possible.
In this case, correct the protocol type using the control unit KP500 or KP232 and VPlus.

The Modbus protocol enables the operation as a pure Master/Slave system. A PC, a PLC or any type of computer system is the bus master.

6.1 Master/Slaves Protocol Principle

The Modbus Serial Line protocol is a Master-Slaves protocol. Only one master (at the same time) is connected to the bus, and one or several (maximum 247) slave nodes are also connected to the same serial bus. A Modbus communication is always initiated by the master. The slave nodes will never transmit data without receiving a request from the master node. The slave nodes will never communicate with each other. The master node initiates only one Modbus transaction at a time.

The master node issues a Modbus request to the slave nodes in two modes:

- In **unicast mode**, the master addresses an individual slave. After receiving and processing the request, the slave returns a message (a 'response') to the master. In this mode, a Modbus transaction consists of 2 messages: a request from the master, and a response from the slave. Each slave must have a unique address (from 1 to 247) so that it can be addressed independently from other nodes.
- In **broadcast mode**, the master can send a request to all slaves. No response is returned to broadcast requests sent by the master. The broadcast requests are necessarily writing commands. **All devices must accept the broadcast for writing function.** Address 0 is reserved to identify a broadcast exchange.

6.2 Addressing Rules

Up to 247 frequency inverters can be used on a Modbus. These are assigned the addresses 1...247. By address 0, all clients can be addressed simultaneously. Address 0 is also referred to as the Broadcast Address.

6.3 Message Description

A Modbus over serial line message is made up of the following fields:

Address	Function Code	Data	CRC (or LRC)
---------	---------------	------	--------------

- On MODBUS Serial Line, the Address Field only contains the slave address.

Valid slave node addresses are in the range of 0 – 247 decimal. The individual slave devices are assigned addresses in the range of 1 – 247. A master addresses a slave by placing the slave address in the address field of the message. When the slave returns its response, it places its own address in the response address field to let the master know which slave is responding.
- The *Function Code* indicates to the inverter what kind of action to perform. The function code can be followed by a *Data* field that contains request parameters (or, in the case of the inverter's response, the response parameters).

If no error occurs related to a correctly received Modbus request then the data field contains the data requested. If an error occurs then the field contains an Exception Code to indicate to the master that the request was unsuccessful. Exception Responses and Codes are described in detail in chapter 6.5.

If a request is not received correctly (communication error, checksum error) then no response is sent. The inverter waits for the next request.
- The Error Checking Field is the result of a "Redundancy Checking" calculation that is performed on the message contents. Two kinds of calculation methods are used depending on the transmission mode that is being used (RTU or ASCII) - see chapter 6.7, "The two serial Transmission Modes".

6.4 Supported Function Codes

Modbus definitions for reading/writing data in a device do not fit directly to parameter access of inverters (independent of inverter manufacturer). Modbus is defined for reading/writing bits and registers in a different way. Furthermore, data access is limited to 16 bit wide data.

To fulfill the Modbus requirements the data access to parameters in the devices (inverters) will use the following defined function codes:

- Function Code 3 Read ONE 16 bit wide data (*Read Holding Register*)
- Function Code 6 Write ONE 16 bit wide data (*Write Single Register*)

For data access to 32 bit wide data two new inverter specific function codes are defined:

- Function Code 100 Read ONE 32 bit wide data
- Function Code 101 Write ONE 32 bit wide data

With the help of these two new functions (which are not defined by the Modbus descriptions), data access to 32-bit "long" variables/parameters inside the inverters is made possible.

For diagnostic purposes the Modbus function code "8" (*Diagnostics*) is also supported.

These function codes and their corresponding data fields are described in detail in the following chapters.

Remark: In all data fields with more than one byte, the **highest** order byte is transmitted first.

Message examples for all supported function codes in both RTU and ASCII transmission modes can be found in chapters 8.

6.4.1 Function Code 3, Read 16-bit Parameter

This function code is used to read the value of integer or unsigned integer parameters in the inverter.

Request:

Function Code	1 Byte	0x03
Start Address (Data Set / Para-No.)	2 Bytes	0x0000 – 0x963F
No. of Registers	2 Bytes	0x0001 (always)

Response:

Function Code	1 Byte	0x03
Byte Count	1 Byte	0x02 (always)
Register Value (Parameter Value)	2 Bytes	0 – 0xFFFF

Exception Response:

Error Code	1 Byte	0x83
Exception code	1 Byte	2, 3 or 4

Start Address

This field is used to store the parameter number and data set number. The parameter number ranges from 0 - 1599 and is stored in the lower 12bits; the data set number ranges from 0 – 9 and is stored in the upper 4 bits.

Example: Parameter **372** (hex. 0x174), data set 2 (hex. 0x2) is stored 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 example above:																	
Hex.		0	0	1	0	0	0	0	1	0	1	1	1	0	1	0	0
Bin.		2				1				7				4			

No. of Registers

This field is used to store the no. of parameters to be written. The value must always be **1** as it is only possible to write one parameter at a time.

Byte Count

This field must be set to **2** as the parameter value always contains two bytes.

Register Value

This field is used to store the 16-bit parameter value.

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

Example:

A current value of 10.3A is to be transmitted. The numerical value actually transmitted is 103, which corresponds to 0x67 in HEX format.

Exception Code

The following exception codes can occur:

2	ILLEGAL DATA ADDRESS	<ul style="list-style-type: none"> • No. of Registers field not equal to 1. • Parameter unknown
3	ILLEGAL DATA VALUE	<ul style="list-style-type: none"> • No. of bytes in the data field too small or too large
4	SLAVE DEVICE FAILURE	<ul style="list-style-type: none"> • Error on reading the parameter

Exception Codes are described in detail in Chapter 6.6

6.4.2 Function Code 6, Write 16-bit Parameter

This function code is used to write the value of an integer or unsigned integer parameter in the inverter.

Request:

Function Code	1 Byte	0x06
Start Address (Data Set / Para-No.)	2 Bytes	0x0000 – 0x963F
Register Value (Parameter Value)	2 Bytes	0 – 0xFFFF

Response:

Function Code	1 Byte	0x06
Start Address (Data Set / Para-No.)	2 Bytes	0x0000 – 0x963F
Register Value (Parameter Value)	2 Bytes	0 – 0xFFFF

Exception Response:

Error Code	1 Byte	0x86
Exception code	1 Byte	2, 3 or 4

Start Address

This field is used to store the parameter number and data set number. The parameter number ranges from 0 – 1599 and is stored in the lower 12 bits; the data set number ranges from 0 – 9 and is stored in the upper 4 bits.

e.g.: Parameter **372** (hex. 0x174), data set 2 (hex. 0x2) is stored 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

Register Value

This field is used to store the 16-bit parameter value.

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

Example:

A current value of 10.3A is to be transmitted. The numerical value actually transmitted is 103, which corresponds to 0x67 in HEX format.

Exception Code

The following exception codes can occur:

- | | | |
|---|----------------------|---|
| 2 | ILLEGAL DATA ADDRESS | • Parameter unknown |
| 3 | ILLEGAL DATA VALUE | • No. of bytes in the data field too small or too large |
| 4 | SLAVE DEVICE FAILURE | • Error on writing the parameter |

Exception Codes are described in detail in Chapter 6.6

6.4.3 Function Code 100, Read 32-bit Parameter

Request:

Function Code	1 Byte	0x64
Start Address (Data Set / Para-No)	2 Bytes	0x0000 – 0x963F

Response:

Function Code	1 Byte	0x64
Register Value (Parameter Value)	4 Bytes	0 – 0x FFFF FFFF

Exception Response:

Error Code	1 Byte	0xE4
Exception code	1 Byte	2, 3 or 4

Start Address

This field is used to store the parameter number and data set number. The parameter number ranges from 0 – 1599 and is stored in the lower 12 bits; the data set number ranges from 0 – 9 and is stored in the upper 4 bits.

e.g.: Parameter **372** (hex. 0x174), data set 2 (hex. 0x2) is stored 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

Register Value

This field is used to store the 32-bit parameter value.

Note: *Parameter Values* with decimal places are transferred without the 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 transmitted. The numerical value actually transmitted is 10025, which corresponds to 0x2729 in HEX format.

Exception Code

The following exception codes can occur:

- | | | |
|---|----------------------|---|
| 2 | ILLEGAL DATA ADDRESS | • Parameter unknown |
| 3 | ILLEGAL DATA VALUE | • No. of bytes in the data field too small or too large |
| 4 | SLAVE DEVICE FAILURE | • Error on reading the parameter |

Exception Codes are described in detail in Chapter 6.6

6.4.4 Function Code 101, Write 32-bit Parameter

Request:

Function Code	1 Byte	0x65
Start Address (Data Set / Para-No)	2 Bytes	0x0000 – 0x963F
Register Value (Parameter Value)	4 Bytes	0 – 0xFFFF FFFF

Response:

Function Code	1 Byte	0x65
Start Address (Data Set / Para-No)	2 Bytes	0x0000 – 0x963F
Register Value (Parameter Value)	4 Bytes	0 – 0xFFFF FFFF

Exception Response:

Error Code	1 Byte	0xE5
Exception code	1 Byte	2, 3 or 4

Start Address

This field is used to store the parameter number and data set number. The parameter number ranges from 0 – 1599 and is stored in the lower 12 bits; the data set number ranges from 0 – 9 and is stored in the upper 4 bits.

e.g.: Parameter **372** (hex. 0x174), data set 2 (hex. 0x2) is stored 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

Register Value

This field is used to store the 32-bit parameter value.

Note: *Parameter Values* with decimal places are transferred without the 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 transmitted. The numerical value actually transmitted is 10025, which corresponds to 0x2729 in HEX format.

Exception Code

The following exception codes can occur:

2	ILLEGAL DATA ADDRESS	• Parameter unknown
3	ILLEGAL DATA VALUE	• No. of bytes in the data field too small or too large
4	SLAVE DEVICE FAILURE	• Error on writing the parameter

Exception Codes are described in detail in Chapter 6.6

6.4.5 Function Code 8, Diagnostics

This function code is used to access the modbus diagnostic counters that are supported by the inverter. Each counter can be obtained by a sub function code bound to the counter number. All of the counters can be cleared using the hexadecimal sub-function code 0x0A.

The following sub function codes are supported:

Sub function	Name	Comments
0x0A	Clear all counters	Sets all counters to zero
0x0B	Return Bus Message Count	No. of valid messages received (with all addresses)
0x0C	Return Bus Communication Error Count	No. of messages with CRC or Parity/Framing/Overrun error.
0x0D	Return Bus Exception Error Count	No. of Exception Responses sent
0x0E	Return Slave Message Count	No. of messages received (with slave address)
0x0F	Return Slave No Response Count	No. of Broadcast messages received
0x10	Return Slave NAK Count	not used, return value is always 0
0x11	Return Slave Busy Count	not used, return value is always 0
0x12	Return Bus Character Overrun Count	No. of messages with Overrun error

Request (Sub function 0x0A, Clear all Counters):

Function Code	1 Byte	0x08
Sub function	2 Bytes	0x000A
Data	2 Bytes	0x0000

Response:

Function Code	1 Byte	0x08
Sub function	2 Bytes	0x000A
Data	2 Bytes	0x0000

Exception Response:

Error Code	1 Byte	0x88
Exception code	1 Byte	1, 3 or 4

Data

This field is always 0x0000.

Exception Code

- | | | |
|---|-----------------------|---|
| 1 | ILLEGAL FUNCTION CODE | • Sub function not supported |
| 3 | ILLEGAL DATA VALUE | • No. of bytes in the data field too small or too large
• "data field" not equal to 0x0000 |
| 4 | SLAVE DEVICE FAILURE | • Error on carrying out the function |

Exception Codes are described in detail in Chapter 6.6

Request (Sub function 0x0B – 0x12, Return Counter Value):

Function Code	1 Byte	0x08
Sub function	2 Bytes	0x000B – 0x0012
Data	2 Bytes	0x0000

Response:

Function Code	1 Byte	0x08
Sub function	2 Bytes	0x000B – 0x0012
Data (Counter Value)	2 Bytes	0 – 0xFFFF

Exception Response:

Error Code	1 Byte	0x88
Exception code	1 Byte	1, 3 or 4

Data

This field is always set to 0x0000 in the request and contains the actual counter value in the response.

Exception Code

The following exception codes can occur:

- | | | |
|---|-----------------------|---|
| 1 | ILLEGAL FUNCTION CODE | • Sub function not supported |
| 3 | ILLEGAL DATA VALUE | • No. of bytes in the data field too small or too large
• "data field" not equal to 0x0000 |
| 4 | SLAVE DEVICE FAILURE | • Error on Reading the Diagnostic Counter |

Exception Codes are described in detail in Chapter 6.6

6.5 Exception Responses

When the master device sends a request to the inverter it expects a normal response. One of four possible events can occur from the master's query:

- If the inverter receives the request without a communication error and can handle the query normally, it returns a normal response.
- If the inverter does not receive the request due to a communication error, no response is returned. The master will eventually process a timeout condition for the request.
- If the inverter receives the request, but detects a communication error (parity, LRC, CRC, ...), no response is returned. The master will eventually process a timeout condition for the request.
- If the inverter receives the request without a communication error, but cannot handle it (for example, if the request is to read an unknown parameter, the inverter will return an exception response informing the client of the nature of the error.

The exception response message has two fields that differentiate it from a normal response:

Function Code Field:

In a normal response, the inverter echoes the function code of the original request in the function code field of the response. All function codes have a most-significant bit (MSB) of 0 (their values are all below 0x80 hexadecimal). In an exception response, the inverter sets the MSB of the function code to 1. This makes the function code value in an exception response exactly 0x80 hexadecimal higher than the value would be for a normal response. With the function code's MSB set, the master can recognize the exception response and can examine the data field for the exception code.

Data Field:

In a normal response, the inverter may return data or statistics in the data field (any information that was requested in the request). In an exception response, the inverter returns an exception code in the data field. This defines the server condition that caused the exception.

The Exception Codes generated by the inverter are listed below

6.6 Exception Codes

The following exception codes are generated by the inverter.

Code	Modbus Name	Cases when generated by the Inverter
1	ILLEGAL FUNCTION	<ul style="list-style-type: none"> • Function Code unknown • Subfunction Code unknown (Diagnostics Function)
2	ILLEGAL DATA ADDRESS	<ul style="list-style-type: none"> • No. of Registers field incorrect (must always be 0x01) • Unknown Parameter or Parameter Data Type mismatch
3	ILLEGAL DATA VALUE	<ul style="list-style-type: none"> • Error in dataset of frame - No. of bytes too small or too large - Certain fields not set to specific values
4	SLAVE DEVICE FAILURE	<ul style="list-style-type: none"> • Read or Write Parameter failed <p>The reason for the error can be obtained by reading out Parameter <i>VABus SST Error Register 11</i> (see next page).</p>

VABus SST Error Register 11

Error no.	Meaning
0	no error
1	inadmissible parameter value
2	inadmissible data set
3	parameter not readable (write-only)
4	parameter not writable (read-only)
5	read error EEPROM
6	write error EEPROM
7	checksum error EEPROM
8	parameter cannot be written while the drive is running
9	values of the data sets differ from one another
10	wrong parameter type
11	unknown parameter
12	checksum error in received telegram
13	syntax error in received telegram
14	data type of parameter does not correspond to the number of bytes in the telegram
15	unknown error

When the error register *VABus SST Error Register 11* is read out, it is automatically cleared at the same time.

6.7 The two serial Transmission Modes

Two different serial transmission modes are defined: the **RTU mode** and the **ASCII mode**. They define the bit contents of message fields transmitted serially on the line. They determine how information is packed into the message fields and decoded.

The transmission mode (and serial port parameters) must be the same for all devices on a MODBUS Serial Line.

6.7.1 RTU Transmission

When devices communicate on a MODBUS serial line using the RTU (Remote Terminal Unit) mode, each 8-bit byte in a message contains two 4-bit hexadecimal characters. The main advantage of this mode is that its greater character density allows better data throughput than ASCII mode for the same baud rate. Each message must be transmitted in a continuous stream of characters.

6.7.1.1 Character Format

One character consists of 11 bits:

- 1 start bit
- 8 data bits, least significant bit sent first
- 1 parity bit
- 1 stop bit

Note If no parity is used then an extra stop bit is added.

Character format with parity checking:

Start	B1	B2	B3	B4	B5	B6	B7	B8	Parity	Stop
-------	----	----	----	----	----	----	----	----	--------	------

Character format without parity checking:

Start	B1	B2	B3	B4	B5	B6	B7	B8	Stop	Stop
-------	----	----	----	----	----	----	----	----	------	------

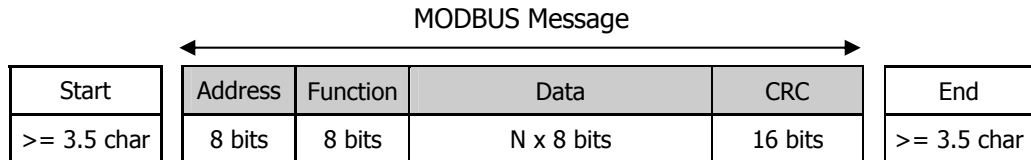
6.7.1.2 Frame Description

Slave Address	Function Code	Data	CRC
1 byte	1 byte	0 up to 252 bytes	2 bytes (CRC-Lo, CRC-Hi)

The maximum size of a MODBUS RTU frame is 256 bytes.

6.7.1.3 Modbus Message RTU Framing

A MODBUS message is placed by the transmitting device into a frame that has a known beginning and ending point. This allows devices that receive a new frame to begin at the start of the message, and to know when the message is completed. Partial messages must be detected and errors must be set as a result. In RTU mode, message frames are separated by a silent interval of at least 3.5 character times



The entire message frame must be transmitted as a contiguous stream of characters.

If a silent interval of more than 1.5 character times occurs between two characters, the message frame is declared incomplete and is discarded by the inverter.

6.7.1.4 CRC Checking

The RTU mode includes an error-checking field that is based on a Cyclical Redundancy Checking (**CRC**) method performed on the message contents.

The CRC field checks the contents of the entire message. It is applied regardless of any parity checking method used for the individual characters of the message.

The CRC field contains a 16-bit value implemented as two 8-bit bytes.

The CRC field is appended to the message as the last field in the message. It is appended in the sequence “low-order byte”, “high-order byte”. The CRC high-order byte is the last byte to be sent in the message.

The CRC value is calculated by the sending device, which appends the CRC to the message. The receiving device recalculates a CRC during receipt of the message, and compares the calculated value to the actual value it received in the CRC field. If the two values are not equal, an error results.

The CRC calculation is started by first pre-loading a 16-bit register to all 1’s (0xFFFF). Then a process begins of applying successive bytes of the message to the current contents of the register.

During generation of the CRC, each 8bit character is ExOR with the register contents. Then the result is shifted in the direction of the least significant bit (LSB), with a zero filled into the most significant bit (MSB) position. The LSB is extracted and examined. If the LSB was a 1, the register is then ExOR with the fixed value **0xA001**. If the LSB was a 0, no ExOR takes place.

This process is repeated until eight shifts have been performed. After the last (eight) shift, the next 8bit char is ExOR with the register’s current value, and the process repeats for eight more shifts as described above. The final content of the register, after all the bytes of the message have been applied, is the CRC value.

When the CRC is appended to the message, the low-order byte is appended first, followed by the high-order byte.

Example for CRC calculating for the frame : "0x02 0x07"

	MSB		LSB		
Start CRC	1111	1111	1111	1111	0xFFFF
1. char	0000	0000	0000	0010	0x02
ExOR					
CRC	1111	1111	1111	1101	
1.shift right	0111	1111	1111	1110	⇒1 = ExOR
0xA001	1010	0000	0000	0001	
ExOR					
CRC	1101	1111	1111	1111	
2.shift right	0110	1111	1111	1111	
0xA001	1010	0000	0000	0001	
ExOR					
CRC	1100	1111	1111	1110	
3.shift right	0110	0111	1111	1111	⇒0 = no ExOR
4.shift right	0011	0011	1111	1111	⇒1 = ExOR
0xA001	1010	0000	0000	0001	
ExOR					
CRC	1001	0011	1111	1110	
5.shift right	0100	1001	1111	1111	⇒0 = no ExOR
6.shift right	0010	0100	1111	1111	⇒1 = ExOR
0xA001	1010	0000	0000	0001	
ExOR					
CRC	1000	0100	1111	1110	
7.shift right	0100	0010	0111	1111	⇒0 = no ExOR
8.shift right	0010	0001	0011	1111	⇒1 = ExOR
0xA001	1010	0000	0000	0001	
ExOR					
CRC	1000	0001	0011	1110	
2. char	0000	0000	0000	0111	0x07
ExOR					
CRC	1000	0001	0011	1001	
1.shift right	0100	0000	1001	1100	⇒1 = ExOR
0xA001	1010	0000	0000	0001	
ExOR					
CRC	1110	0000	1001	1101	
2.shift right	0111	0000	0100	1110	⇒1 = ExOR
0xA001	1010	0000	0000	0001	
ExOR					
CRC	1101	0000	0100	1111	
3.shift right	0110	1000	0010	0111	⇒1 = ExOR
0xA001	1010	0000	0000	0001	
ExOR					
CRC	1100	1000	0010	0110	
4.shift right	0110	0100	0001	0011	⇒0 = no ExOR
5.shift right	0011	0010	0000	1001	⇒1 = ExOR
0xA001	1010	0000	0000	0001	
ExOR					
CRC	1001	0010	0000	1000	
6.shift right	0100	1001	0000	0100	⇒0 = no ExOR
7.shift right	0010	0100	1000	0010	⇒0 = no ExOR
8.shift right	0001	0010	0100	0001	⇒0 = no ExOR
result	1	2	4	1	CRC = 0x41 0x12

Example : program sequence (C#)

```
private int Modbus_CRC(string frame)
{
    int poly    = 0xA001;           // polynomial
    int CRC     = 0xFFFF;          // start CRC

    for (int i = 0; i < (int) frame.Length; i++) // for each sign
    {
        CRC ^= Convert.ToInt16(frame[i]);      // ExOR

        for (int j = 0; j < 8; j++)           // eight times
        {
            if ((CRC & 0x01) == 0x01)        // lsb == 1 ?
            {
                CRC >>= 1;                   // shift left
                CRC ^= poly;                  // ExOR
            }
            else
            {
                CRC >>= 1;                   // shift left
            }
        }
    }
    return CRC;
}
```

Call the function for the frame : "0x02 0x07"

```
string temp_s = Convert.ToString((char) (0x2)) + Convert.ToString((char) (0x7));
Console.WriteLine(Modbus_CRC(temp_s));
```

Result : 4673 = 0x1241

CRC Low Byte = 0x41

CRC High Byte = 0x12

The Modbus CRC sequence is :

⇒	CRC	Low Byte / High Byte	0x41	0x12
---	-----	----------------------	------	------

6.7.2 ASCII Transmission

When devices are setup to communicate on a MODBUS serial line using 7-bit ASCII (American Standard Code for Information Interchange) mode, each 8 bit character in a message is sent as two ASCII characters. This mode is used when the physical communication link or the capabilities of the device does not allow the conformance with RTU mode requirements regarding timers management.

Remark: this mode is less efficient than RTU since each byte needs two characters.
 Example: The byte 0x5B is encoded as two characters: 0x35 and 0x42 (0x35 ="5", and 0x42 ="B" in ASCII).

6.7.2.1 Character Format

One character consists of 10 bits:

- 1 start bit
- 7 data bits, least significant bit sent first (value = 0x00 .. 0x7F)
- 1 parity bit
- 1 stop bit

Note If no parity is used then an extra stop bit is added.

Character format with parity checking:

Start	B1	B2	B3	B4	B5	B6	B7	Parity	Stop
-------	----	----	----	----	----	----	----	--------	------

Character format without parity checking:

Start	B1	B2	B3	B4	B5	B6	B7	Stop	Stop
-------	----	----	----	----	----	----	----	------	------

6.7.2.2 Modbus Message ASCII Framing

A MODBUS message is placed by the transmitting device into a frame that has a known beginning and ending point. This allows devices that receive a new frame to begin at the start of the message, and to know when the message is completed. Partial messages must be detected and errors must be set as a result.

The address field of a message frame contains two characters.

In ASCII mode, a message is delimited by specific characters as Start-of-Frame and End-of-Frame. A message must start with a trigger "colon"- character (":" = ASCII 0x3A) and ends with a "carriage return/line feed" pair (ASCII 0x0D and 0x0A).

The allowable characters transmitted for all other fields are hexadecimal 0–9, A–F (ASCII coded). The devices monitor the bus continuously for the colon character. When this character is received, each device decodes the next character until it detects the End-of-Frame (EoF)-character.

Intervals of up to one second may elapse between characters within the message. Unless the user has configured a longer timeout, an interval greater than 1 second means an error has occurred.

A typical message frame is shown below.

SoF	Address	Function	Data	LRC	EoF
1 char :	2 chars	2 chars	0 up to 2* 252 chars	2 chars	2 chars CR, LF

6.7.2.3 LRC Checking

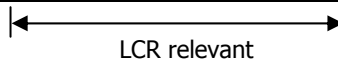
In ASCII mode, messages include an error-checking field that is based on a Longitudinal Redundancy Checking (**LRC**) calculation that is performed on the message contents, exclusive of the beginning 'colon' and terminating CRLF pair characters. It is applied regardless of any parity checking method used for the individual characters of the message.

The LRC field is one byte, containing an 8-bit binary value. The LRC value is calculated by the device that emits, which appends the LRC to the message. The device that receives calculates an LRC during receipt of the message, and compares the calculated value to the actual value it received in the LRC field. If the two values are not equal, an error results.

The LRC is calculated by adding together successive each byte of the message and then two's complementing the result. It is performed on the ASCII message field contents excluding the 'colon' character that begins the message, and excluding the CRLF pair at the end of the message. In ASCII mode, the resulting LRC is ASCII encoded into two bytes and placed at the end of ASCII mode frame prior to the CRLF.

Example:

Field:	SoF	Adr		Fct.Code		Excep. Code		LRC		EoF	
ASCII	:	0	1	8	3	0	2	7	A	CR	LF
Hex	3A	30	31	38	33	30	32	37	41	0D	0A



Adr.	0x01 =	1	
Fct.Code	0x83 =	131	
Excep.	0x02 =	2	

Sum:		134	LRC
2'comp.		122 = 0x7A	⇒ "7" = 0x37
			"A" = 0x41

6.8 Monitoring Timing Function

The Modbus protocol defines a pure Master/Slave operation. If a frequency inverter is addressed by the bus master, other frequency inverters will only be addressed after the protocol with the first frequency inverter has been completed or the Time-out time has expired.

After a frequency inverter has sent a message, a waiting time of **2 ms** must be kept. This time is needed by the frequency inverter in order to switch off the RS485 transmitter. The bus master may not send a new message before this time has elapsed.

The frequency inverter replies **10 ms** after receipt of a message, at the earliest. This means that the bus master must have switched off its RS485 transmitter after 10 ms, at the latest.

If the bus master does not receive an answer from the frequency inverter within **500 ms**, it can start a new transmission to any frequency inverter.

Attention! If the degree of utilization of the CPU is high (> 90%), the response time can be more than 500 ms.

Note: The specified times are valid for operation with RS485 and RS232.

6.9 Watchdog

If the frequency inverter is operated via the serial interface (RS232, RS485), it may be important to monitor the presence of the communication line. For example it may be that the frequency inverter is switched on/off in Remote Mode, or it only receives its reference value cyclically via the serial interface. If the communication fails, no or faulty data are transmitted. This is recognized by the communication watchdog.

The watchdog function monitors the time in which no correct communication takes place. This time can be adjusted via parameter *RS232/RS485 Watchdog Timer* **413**. The adjusted value is the time in seconds (0...10000 seconds) within which at least one correct exchange of data must have occurred.

If the adjusted monitoring time has elapsed, the frequency inverter signals a fault. The fault message **F2010 Watchdog RS232/RS485** is displayed.

Parameter		Settings		
No.	Name/Meaning	Min.	Max.	fact. sett.
413	RS232/RS485 Watchdog Timer [sec]	0	10000	0

Note: If parameter *RS232/RS485 Watchdog Timer* **413** is set to 0 (default), the monitoring function is deactivated.

7 Handling of Data Sets/Cyclic Writing

Access to the parameter values is carried out on the basis of the parameter number and the required data set.

There are parameters which only have one data value (data set 0) as well as parameters which have four data values (data sets 1...4). These are used for data set change-over.

If parameters with four data values are set via data set = 0, all four data sets are set to the same value.

A read access with data set = 0 to such parameters is only successful if all four data sets are set to the same value. If this is not the case an Exception Response with exception code 4 "SLAVE DEVICE FAILURE" will be sent and parameter *V_A-Bus SST Error Register* **11** set to the value 9 (values of data sets differ from one another).

In this case, you must read out each data set separately for the relevant parameter.

The values are entered automatically into the EEPROM on the controller. If values are to be written cyclically at a high repetition rate, there must be no entry into the EEPROM as it only has a limited number of admissible writing cycles (about 1 million cycles).



Caution! If the number of admissible writing cycles is exceeded, the EEPROM is destroyed.

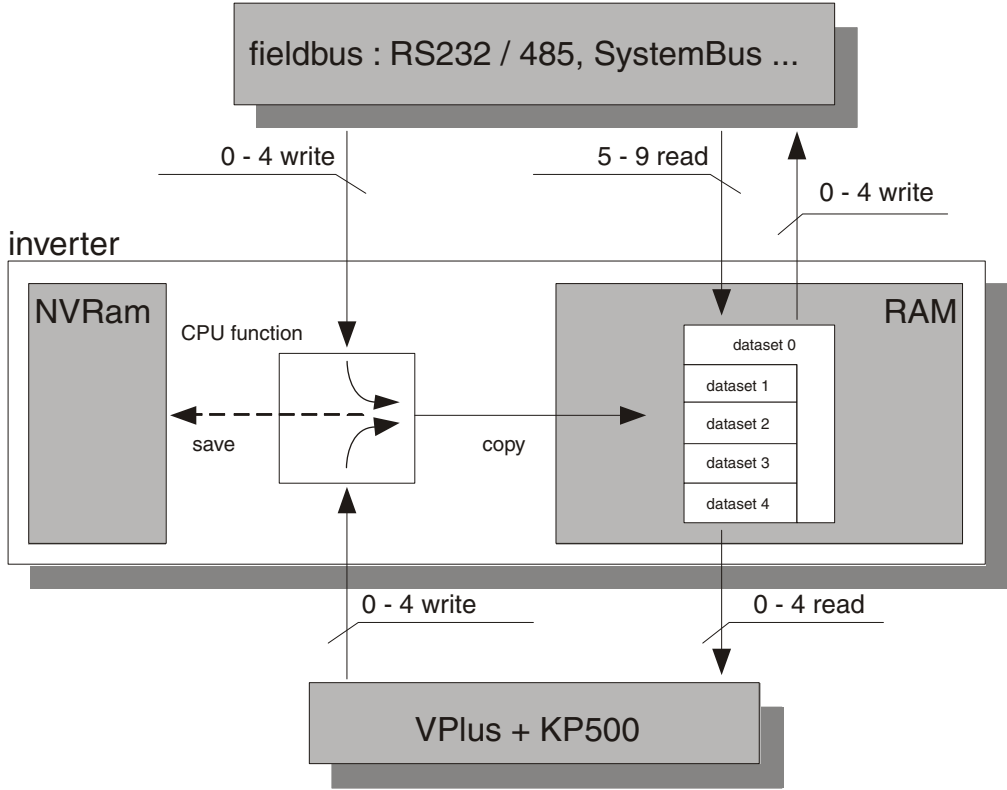
In order to avoid the destruction of the EEPROM, data which are to be written cyclically can be entered exclusively into the RAM without a writing cycle to the EEPROM. In this case, the data are volatile, i.e. they are lost when the supply voltage is switched off (Mains Off). They must be written into the RAM again after the restart (Mains On).

The RAM writing operation is activated by increasing the number of the target data set by five.

Access to the data sets of the frequency inverter

Parameter	EEPROM	RAM
Data set 0	0	5
Data set 1	1	6
Data set 2	2	7
Data set 3	3	8
Data set 4	4	9

Note: The data set for the parameter *Control Word* **410**, *Reference Frequency RAM* **484** and *Reference Percentage RAM* **524** is always zero. Internally they are not written into the EEPROM.



8 Modbus Message Examples

8.1 Modbus RTU-Message Examples

8.1.1 Function Code 3, Read 16-bit Parameter

Example 1:

Reading parameter *Rated Speed* **372** (0x0174) in data set 2 from the frequency inverter with address 1

Request: Master → Frequency Inverter

Field:	Addr.	Func.	DSet/Par-No.		No. of Regs		CRC	
Hex	01	03	21	74	00	01	CE	2C

Response: Frequency Inverter → Master

Field:	Addr.	Func.	No.Bytes	Par-Value		CRC	
Hex	01	03	02	05	6E	3A	F8

The hexadecimal value sent is 0x056E = 1390. Parameter *Rated Speed* **372** has no decimal places.

Therefore, the rated speed is 1390 min⁻¹.

Example 2:

Reading parameter *Rated Speed* **372** (0x0174) in data set 0 from the frequency inverter with address 1 and No. of Regs field set to 2 (invalid value)

Request: Master → Frequency Inverter

Field:	Addr.	Func.	DSet/Par-No.		No. of Regs		CRC	
Hex	01	03	01	74	00	02	85	ED

Error Response: Frequency Inverter → Master

Field:	Addr.	Func.	Except.	CRC	
Hex	01	83	02	C0	F1

The exception code sent is hexadecimal value 0x02 = ILLEGAL DATA ADDRESS.

8.1.2 Function Code 6, Write 16-bit Parameter

Example 1:

Writing parameter *Rated Mech. Power* **376** (0x0178) in data set 4 to the 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.
Therefore the value to be sent is 15 = 0x000F.

Request: Master → Frequency Inverter

Field:	Addr	Func	DSet/Par-No.		Par-Value		CRC	
Hex	03	06	41	78	00	0F	5C	09

Response: Frequency Inverter → Master

Field:	Addr	Func	DSet/Par-No.		Par-Value		CRC	
Hex	03	06	41	78	00	0F	5C	09

The response is an echo of the request message.

Example 2:

Writing out of range value 0 to parameter **376** (0x0178) in data set 2 to the frequency inverter with address 3

Request: Master → Frequency Inverter

Field:	Addr	Func	DSet/Par-No.		Par-Value		CRC	
Hex	03	06	21	78	00	00	02	0D

Error Response: Frequency Inverter → Master

Field:	Addr	Func	Except.	CRC	
Hex	03	86	04	E2	63

The exception code sent is hexadecimal value 0x04 = SLAVE DEVICE FAILURE

8.1.3 Function Code 100, Read 32-bit Parameter

Example 1:

Reading parameter *Fixed Frequency 2* **481** in data set 0 from the frequency inverter with address 1

Request: Master → Frequency Inverter

Field:	Adr	Funct.	DSet/Par-No.		CRC	
Hex	01	64	01	E1	81	DF

Response: Frequency Inverter → Master

Field:	Adr	Funct.	Par-Value				CRC	
Hex	01	64	00	00	03	E8	70	BC

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

Example 2:

Reading unknown parameter **1600** (0x0640) in data set 2 from the frequency inverter with address 1.

Request: Master → Frequency Inverter

Field:	Adr	Funct.	DSet/Par-No.		CRC	
Hex	01	64	26	40	5B	97

Error Response: Frequency Inverter → Master

Field:	Adr	Funct.	Except.	CRC	
Hex	01	E4	04	6A	C3

The exception code sent is hexadecimal value 0x04 = SLAVE DEVICE FAILURE.

8.1.4 Function Code 101, Write 32-bit Parameter

Example 1:

Writing parameter *Rated Frequency* **375** (0x0177) in data set 2 from the frequency inverter with address 1

The rated frequency is to be set to 10.00Hz.

Parameter *Rated Frequency* **375** has two decimal places.

Therefore the value to be sent is 1000 = 0x03E8.

Request: Master → Frequency Inverter

Field:	Adr	Funct.	DSet/Par-No.		Par-Value				CRC	
Hex	01	65	21	77	00	00	03	E8	46	C5

Response: Frequency Inverter → Master

Field:	Adr	Funct.	DSet/Par-No.		Par-Value				CRC	
Hex	01	65	21	77	00	00	03	E8	46	C5

The response is an echo of the request message.

Example 2:

Writing out of range value 9.00 Hz to parameter **375** in data set 2 from the frequency inverter with address 1.

As **376** has 2 decimal places the value to be sent is 900 = 0x0384

Request: Master → Frequency Inverter

Field:	Adr	Funct.	DSet/Par-No.		Par-Value				CRC	
Hex	01	65	21	77	00	00	03	84	46	E8

Error Response: Frequency Inverter → Master

Field:	Adr	Funct.	Except	CRC	
Hex	01	E5	04	6B	53

The exception code sent is hexadecimal value 0x04 = SLAVE DEVICE FAILURE.

8.1.5 Function Code 8, Diagnostics

Example 1a:

Clearing all Diagnostic Counters (Sub function 0x0A) in the frequency inverter with address 1.

Request: Master → Frequency Inverter

Field:	Adr	Funct.	Sub function		Data		CRC	
Hex	01	08	00	0A	00	00	C0	09

Response: Frequency Inverter → Master

Field:	Adr	Funct.	Sub function		Data		CRC	
Hex	01	08	00	0A	00	00	C0	09

The response is an echo of the request. All counters are now set to zero.

Example 1b:

With all counters set to zero, read Diagnostic Counter 4, "Slave Message Count" (Sub function 0x0E) from the frequency inverter with address 1.

Request: Master → Frequency Inverter

Field:	Adr	Funct.	Sub function		Data		CRC	
Hex	01	08	00	0E	00	00	81	C8

Response: Frequency Inverter → Master

Field:	Adr	Funct.	Sub function		Data		CRC	
Hex	01	08	00	0E	00	01	40	08

The counter value is 1(as this is the 1st message received after setting all counters to zero).

Example 2:

Reading unknown Diagnostic Counter 8 (Sub function 0x13) from the frequency inverter with address 1

Request: Master → Frequency Inverter

Field:	Adr	Funct.	Sub function		Data		CRC	
Hex	01	08	00	13	00	00	11	CE

Error Response: Frequency Inverter → Master

Field:	Adr	Funct.	Except.	CRC	
Hex	01	88	01	87	C0

The exception code sent is hexadecimal value 0x01 = ILLEGAL FUNCTION.

8.2 Modbus ASCII-Message Examples

8.2.1 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	SoF	Adr		Fct.Code		DSet/Par-No.				No. of Regs				LRC		EoF	
ASC	:	0	1	0	3	2	1	7	4	0	0	0	1	6	6	CR	LF
Hex	3A	30	31	30	33	32	31	37	34	30	30	30	31	36	36	0D	0A

Response: Frequency Inverter → Master

Field:	SoF	Adr		Fct.Code		no.Bytes		Par-Value				LRC		EoF	
ASC	:	0	1	0	3	0	2	0	5	6	E	8	7	CR	LF
Hex	3A	30	31	30	33	30	32	30	35	36	45	38	37	0D	0A

The hexadecimal value sent is 0x056E = 1390.
 Parameter *Rated Speed* **372** has no decimal places.
 Therefore, the rated speed is 1390 min⁻¹.

Example 2:

Reading parameter *Rated Speed* **372** (0x0174) in data set 0 from the frequency inverter with address 1 and No. of Regs field set to 2 (invalid value)

Field:	SoF	Adr		Fct.Code		DSet/Par-No.				No. of Regs				LRC		EoF	
ASC	:	0	1	0	3	0	1	7	4	0	0	0	2	8	5	CR	LF
Hex	3A	30	31	30	33	30	31	37	34	30	30	30	32	38	35	0D	0A

Error Response: Frequency Inverter → Master

Field:	SoF	Adr		Fct.Code		Excep. Code		LRC		EoF	
ASC	:	0	1	8	3	0	2	7	A	CR	LF
Hex	3A	30	31	38	33	30	32	37	41	0D	0A

The sent exception code is hexadecimal value 0x02 = ILLEGAL DATA ADDRESS.

8.2.2 Function Code 6, Write 16-bit Parameter

Example 1:

Writing parameter *Rated Mech. Power* **376** (0x0178) in data set 4 to the 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:	SoF	Adr		Fct.Code		DSet/Par-No.				Para-Value				LRC		EoF	
ASC	:	0	3	0	6	4	1	7	8	0	0	0	F	2	F	CR	LF
Hex	3A	30	33	30	36	34	31	37	38	30	30	30	46	32	46	0D	0A

Response: Frequency Inverter → Master

Field:	SoF	Adr		Fct.Code		DSet/Par-No.				Para-Value				LRC		EoF	
ASC	:	0	3	0	6	4	1	7	8	0	0	0	F	2	F	CR	LF
Hex	3A	30	33	30	36	34	31	37	38	30	30	30	46	32	46	0D	0A

The response is an echo of the request message.

Example 2:

Writing out of range value 0 to parameter **376** (0x0178) in data set 2 to the frequency inverter with address 3

Request: Master → Frequency Inverter

Field:	SoF	Adr		Fct.Code		DSet/Par-No.				Para-Value				LRC		EoF	
ASC	:	0	3	0	6	2	1	7	8	0	0	0	0	5	E	CR	LF
Hex	3A	30	33	30	36	32	31	37	38	30	30	30	30	35	45	0D	0A

Error Response: Frequency Inverter → Master

Field:	SoF	Adr		Fct.Code		Excep. Code		LRC		EoF	
ASC	:	0	3	8	6	0	4	7	3	CR	LF
Hex	3A	30	33	38	36	30	34	37	33	0D	0A

The sent exception code is hexadecimal value 0x04 = SLAVE DEVICE FAILURE

8.2.3 Function Code 100, Read 32-bit Parameter

Example 1:

Reading parameter *Fixed Frequency 2* **481** in data set 0 from the frequency inverter with address 1

Request: Master → Frequency Inverter

Field:	SoF	Adr		Fct.Code		DSet/Par-No.				LRC		EoF	
ASC	:	0	1	6	4	0	1	E	1	B	9	CR	LF
Hex	3A	30	31	36	34	30	31	45	31	42	39	0D	0A

Response: Frequency Inverter → Master

Field:	SoF	Adr		Fct.Code		Para-Value							LRC		EoF		
ASC	:	0	1	6	4	0	0	0	0	0	3	E	8	B	0	CR	LF
Hex	3A	30	31	36	34	30	30	30	30	30	33	45	38	42	30	0D	0A

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

Example 2:

Reading unknown parameter **1600** (0x0640) in data set 2 from the frequency inverter with address 1

Request: Master → Frequency Inverter

Field:	SoF	Adr		Fct.Code		DSet/Par-No.				LRC		EoF	
ASC	:	0	1	6	4	2	6	4	0	3	5	CR	LF
Hex	3A	30	31	36	34	32	36	34	30	33	35	0D	0A

Error Response: Frequency Inverter → Master

Field:	SoF	Adr		Fct.Code		Excep. Code		LRC		EoF	
ASC	:	0	1	E	4	0	2	1	9	CR	LF
Hex	3A	30	31	45	34	30	34	31	37	0D	0A

The exception code sent is hexadecimal value 0x04 = SLAVE DEVICE FAILURE.

8.2.4 Function Code 101, Write 32-bit Parameter

Example 1:

Writing parameter *Rated Frequency* **375** (0x0177) in data set 2 to frequency inverter with address 1

The rated frequency is to be set to 10.00Hz.

Parameter *Rated Frequency* **375** has two decimal places.

Therefore the value to be sent is 1000 = 0x03E8.

Request: Master → Frequency Inverter

Fld	SoF	Adr		Fct.Cd		DSet/Par-No.				Para-Value								LRC		EoF	
ASC	:	0	1	6	5	2	1	7	7	0	0	0	0	0	3	E	8	1	7	CR	LF
Hex	3A	30	31	36	35	32	31	37	37	30	30	30	30	30	33	45	38	31	37	0D	0A

Response: Frequency Inverter → Master

Fld	SoF	Adr		Fct.Cd		DSet/Par-No.				Para-Value								LRC		EoF	
ASC	:	0	1	6	5	2	1	7	7	0	0	0	0	0	3	E	8	1	7	CR	LF
Hex	3A	30	31	36	35	32	31	37	37	30	30	30	30	30	33	45	38	31	37	0D	0A

The response is an echo of the request message.

Example 2:

Writing out of range value to 9.00 Hz to parameter **375** (0x0177) in data set 2 from the frequency inverter with address 1

As **375** has 2 decimal places the value to be sent is 900 = 0x0384

Request: Master → Frequency Inverter

Fld	SoF	Adr		Fct.Cd		DSet/Par-No.				Para-Value								LRC		EoF	
ASC	:	0	1	6	5	2	1	7	7	0	0	0	0	0	3	8	4	7	B	CR	LF
Hex	3A	30	31	36	35	32	31	37	37	30	30	30	30	30	33	38	34	37	42	0D	0A

Error Response: Frequency Inverter → Master

Field	SoF	Adr		Fct.Code		Excep. Code		LRC		EoF	
ASC	:	0	1	E	5	0	4	1	6	CR	LF
Hex	3A	30	31	45	35	30	34	31	36	0D	0A

The exception code sent is hexadecimal value 0x04 = SLAVE DEVICE FAILURE.

8.2.5 Function Code 8, Diagnostics

Example 1a:

Clearing all Diagnostic Counters (Sub function 0x0A) in the frequency inverter with address 1

Request: Master → Frequency Inverter

Field:	SoF	Adr		Fct.Code		Subfunction				Data				LRC		EoF	
ASC	:	0	1	0	8	0	0	0	A	0	0	0	0	E	D	CR	LF
Hex	3A	30	31	30	38	30	30	30	41	30	30	30	30	45	44	0D	0A

Response: Frequency Inverter → Master

Field:	SoF	Adr		Fct.Code		DSet/ Para-No.				No. of Regs				LRC		EoF	
ASC	:	0	1	0	8	0	0	0	A	0	0	0	0	E	D	CR	LF
Hex	3A	30	31	30	38	30	30	30	41	30	30	30	30	45	44	0D	0A

The response is an echo of the request. All counters are now set to zero.

Example 1b:

With all counters set to zero, read Diagnostic Counter 4, "Slave Message Count" (Sub function 0x0E) from the frequency inverter with address 1

Field:	SoF	Adr		Fct.Code		Subfunction				Data				LRC		EoF	
ASC	:	0	1	0	8	0	0	0	E	0	0	0	0	E	9	CR	LF
Hex	3A	30	31	30	38	30	30	30	45	30	30	30	30	45	39	0D	0A

Response: Frequency Inverter → Master

Field:	SoF	Adr		Fct.Code		Subfunction				Data				LRC		EoF	
ASC	:	0	1	0	8	0	0	0	E	0	0	0	1	E	8	CR	LF
Hex	3A	30	31	30	38	30	30	30	45	30	30	30	31	45	38	0D	0A

Example 2:

Read unknown Diagnostic Counter 8 (Sub function 0x13) from frequency inverter with address 1

Request: Master → Frequency Inverter

Field:	SoF	Adr		Fct.Code		Subfunction				Data				LRC		EoF	
ASC	:	0	1	0	8	0	0	1	3	0	0	0	0	E	4	CR	LF
Hex	3A	30	31	30	38	30	30	31	33	30	30	30	30	45	34	0D	0A

Error Response: Frequency Inverter → Master

Field:	SoF	Adr		Fct.Code		Excep. Code		LRC		EoF	
ASC	:	0	1	8	8	0	1	7	6	CR	LF
Hex	3A	30	31	38	38	30	31	37	36	0D	0A

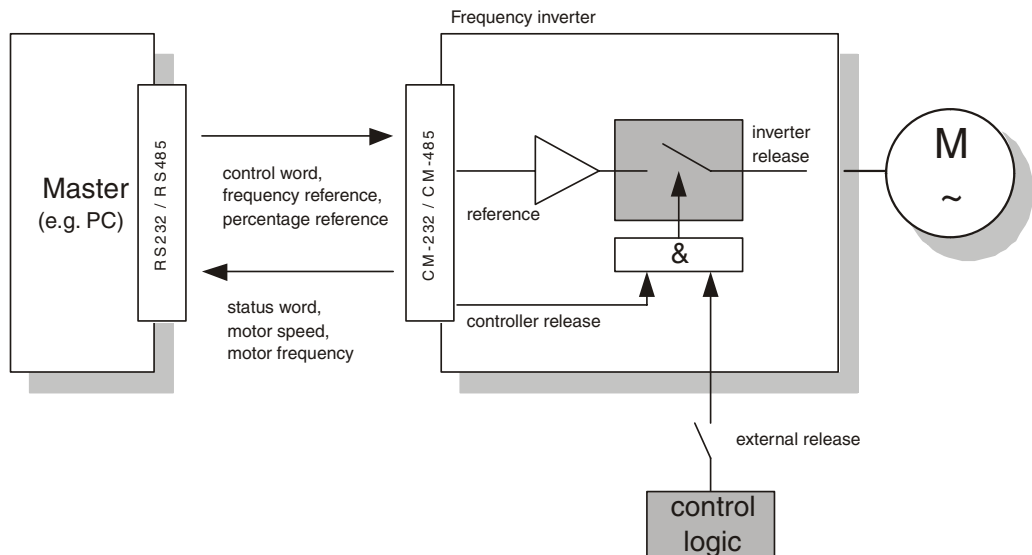
The exception code sent is hexadecimal value 0x01 = ILLEGAL FUNCTION.

9 ACT Inverter Control/Reference Value

The frequency inverter can be controlled completely via the serial interface. The following parameters and actual values are used for this:

Parameter		Settings			
No.	Name/Meaning	min.	max.	fact. sett.	type
410	Control Word	0x0000	0xFFFF	–	uInt
411	Status Word	0x0000	0xFFFF	–	uInt
484	Reference Frequency RAM [Hz]	-999.99	999.99	0.00	Long
524	Reference Percentage RAM [%]	-300.00	300.00	0.00	Long

With the *Control Word 410* (data type uInt), control commands are sent to the frequency inverter, with the *Reference Frequency RAM 484* (data type Long [Hz]) or *Reference Percentage RAM 524* (data type Long [%]), the reference line value is sent. Via the *Status Word 411* (data type uInt), the status of the frequency inverter is read out.



Note: *Control Word 410, Reference Frequency RAM 484 and Reference Percentage RAM 524* are stored in the RAM of the frequency inverter. This is generally addressed via data set 0.

Note: External release:

- With the ACT-inverter the external release is done with a high logic signal at the input S1IND.
- This digital input has the highest priority and has to be hardwired.

The frequency inverter can be controlled via three different operation modes. These operation modes set via parameter *Local/Remote* **412**.

<i>Local/Remote</i> 412		Supported Operation Modes
0 -	Control via Contacts	The Start and Stop commands as well as the direction of rotation are controlled via digital signals.
1 -	Control via State-machine	The Start and Stop commands as well as the direction of rotation are controlled via the DRIVECOM Statemachine ¹⁾ of the communication interface.
2 -	Control via Remote Contacts	The Start and Stop commands as well as the direction of rotation are controlled via virtual digital signals through the communication protocol.

Note: ¹⁾ Statemachine is a standardized software module within the controller of the frequency inverter. The Statemachine maps specified operating statuses and the controller within the frequency inverter.

Note:

- For operation via the serial interface, settings 0, 1 and 2 are relevant. Further possible operation modes *Local/Remote* **412** are described in the frequency inverter operating instructions. These relate to the control via the control unit KP500 and the control via digital signals.
- Parameter *Local/Remote* **412** is data set related, i.e. by selecting a data set, you can switch over between the different operation modes.

For example, it is possible to control the frequency inverter via the serial interface and to activate a local emergency operation mode if the controller fails. This switch-over is also visible via the status word in bit "Remote".

The data set switch-over can be effected via control contacts at the digital inputs of the frequency inverter or via the bus. For data set change-over via the bus, parameter *Data Set Selection* **414** is used.

Parameter		Settings		
No.	Name/Meaning	Min.	Max.	Fact. Set.
414	Data Set Selection	0	4	0

With the default setting *Data Set Selection* **414** = 0, the data set change-over is done via the digital inputs.

If *Data Set Selection* **414** is set to 1, 2, 3 or 4, the selected data set is activated via the bus. At the same time, data set change-over via the digital inputs is deactivated.

Via parameter *Active Data Set* **249**, the currently selected data set can be read out. This is independent of whether the data set change-over was done via the digital inputs or via *Data Set Selection* **414**.

9.1 Control

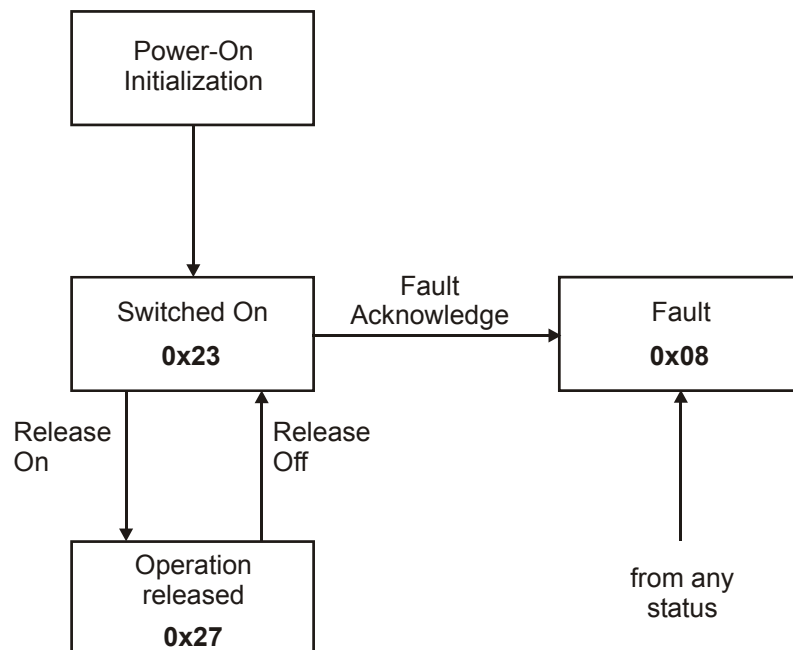
9.1.1 Control via Contacts

In the operation mode "Control via Contacts" (*Local/Remote* **412** = 0), the frequency inverter is addressed via the digital inputs S1IND ... S6IND, the multifunction input MFI1D as well as the additional inputs EM-S1IND ... EM-S3IND (optional expansion modules).

The function of these inputs is described in the frequency inverter operating instructions and the expansion module operating instructions.

Note: If the frequency inverter is addressed via digital inputs S1IND ... S6IND, addressing via the *Control Word* **410** is not used in this operation mode.

Sequence in Statemachine:



The numbers indicated in the individual operating statuses (e.g. **0x23**) signal the corresponding feedback (e.g. switched on) via the status word (bit 0...6).

The parameter *Status Word 411* has a length of 16 bits. The set bits have the following meaning:

<i>Status word 411</i>	
Bit no.	Function
0	Ready for being switched on
1	Switched on
2	Operation - released
3	Error
4	Voltage - disabled
5	Quick stop
6	Starting lock-out
7	Warning
8	–
9	Remote
10	Reference value reached
11	Limit value reached
12	–
13	–
14	–
15	Warning2

The status word reflects the operation state.

Status word	HEX ¹⁾	Bit 6	Bit 5	Bit 3	Bit 2	Bit 1	Bit 0
Switched on	0x23	0	1	0	0	1	1
Operation released	0x27	0	1	0	1	1	1
Error	0x08	0	X ²⁾	1	0	0	0

¹⁾ without consideration of bits 7 ... 15!

²⁾ "X" means any value ("0" or "1")

If a fault occurs, the fault status is activated.

Note: A fault can only be acknowledged 15 seconds after the occurrence of the fault, i.e. after the internal blocking time has elapsed.

If a fault has occurred, the cause of the fault can be read out via parameter *Current Error 260*.

Status Word Bit 7 to Bit 15

Bit 7, "Warning bit"

The **warning bit "7"** can signal an internal warning and results in the frequency inverter being switched off, depending on the cause.

The evaluation of the warning is done by reading out the warning status via parameter *Warnings* **270**.

Bit 9, "Remote"

The **remote bit** is always set to 0 in the case of the control via contacts.

Bit 10, "Reference value reached"

The bit **"Reference value 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 "Reference value 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 "Limit active"

The bit **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 result in the reference value being left or not reached.

Bit 15 "Warnung2"

The bit **"Warnung2"** extends bit 7 "Warning bit" by the following information:

Bit 15 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.

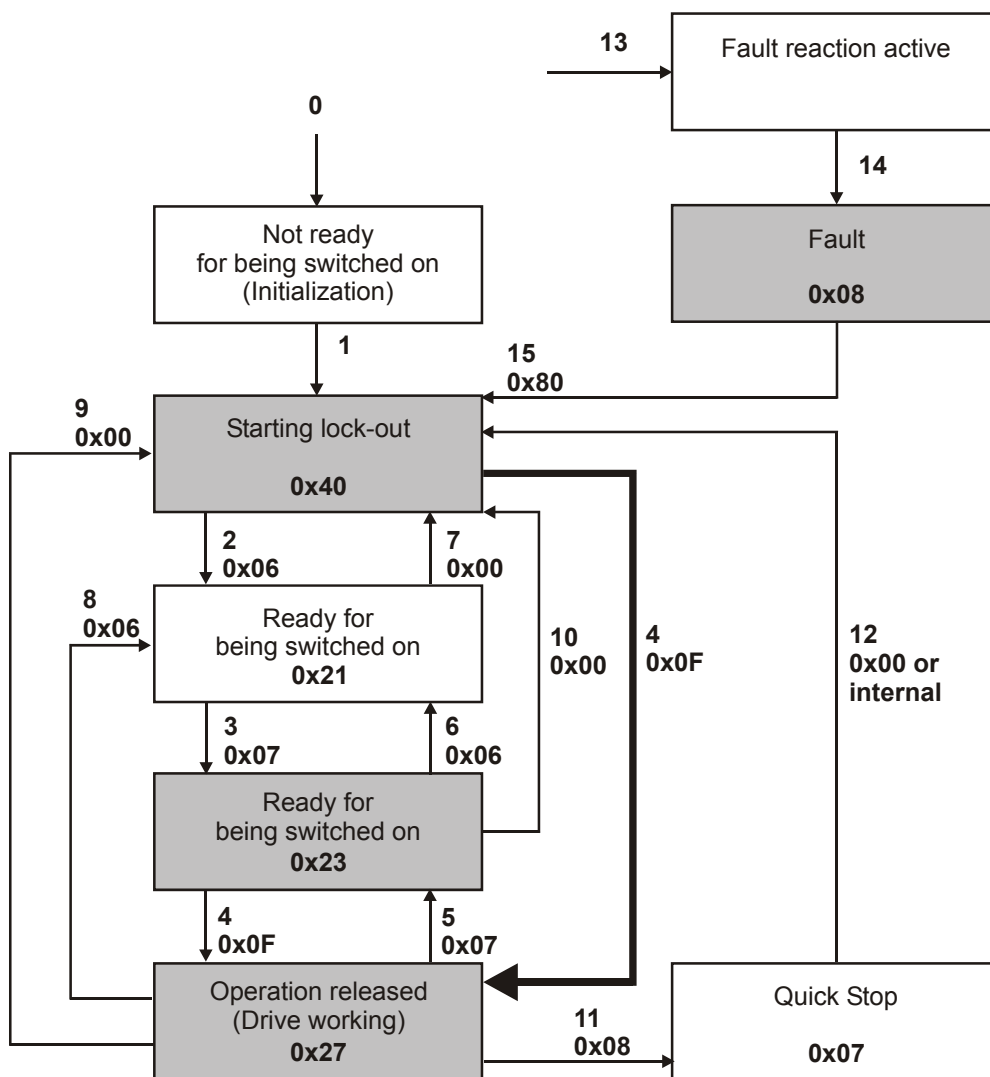
If **bit 15** is set, **bit 7** is set, too.

9.1.2 Control via Control Word of Statemachine

In this operation mode (*Local/Remote* **412** = 1), the frequency inverter is addressed via the **control word** of the Statemachine. The possible states and transitions are shown in the diagram.

The states and transitions are marked by squares and arrows, respectively. The numbers at the arrows identify the transitions between the states. The codes 0xnn at the transitions are the corresponding control word required (bit 0 ... 7). The codes 0xnn indicated in the states, indicated the content of the status word (bit 0 ... bit 7).

Sequence in Statemachine:



After mains on (Reset), the inverter is in the state "Starting lock-out" (0x40).
With transitions 4 and 5, there is a change between "Operation released" (0x27, output stages released, drive working) and "Switched on" (0x23, output stages disabled).

The release (transition 4) is only possible if the controller release signal and the corresponding control command are present at digital external release AND (S2IND OR S3IND). They can be firmly wired or also firmly linked to the logic states On or Off via the configuration of the digital inputs. If the control signal at the external release is withdrawn, the output stages can be disabled at any time. The drive then coasts to a standstill. In this case, there is a transition to "Switched on" (0x23, output stages disabled).

Note: External release has top priority for the controller release and is to be hard-wired.

The behavior **of** Transition 5 can be set via parameter *state-transition 5* **392**. Here, you can use coasting, shut-off via ramp (reversible) or DC braking (depending on the selected configuration, see Chapter 9.1.2.2, " Behavior in state-transition 5").

Parameter *Control Word* **410** has a length of 16 bits. The set bits have the following meaning:

<i>Control Word 410</i>	
Bit no.	Function / name
0	Switch on
1	Voltage - disable
2	Quick stop
3	Operation - released
4	–
5	–
6	–
7	Reset fault
8	–
9	–
10	–
11	–
12	–
13	–
14	–
15	–

Control Commands

The device control commands are triggered by the following bit combinations in parameter *Control Word* **410**:

Control Commands							
Command	Control word						Transition
	HEX	Bit 7	Bit 3	Bit 2	Bit 1	Bit 0	
Shutdown	0x06	X ¹⁾	X	1	1	0	2, 6, 8
Switch on	0x07	X	X	1	1	1	3
Voltage - disable	0x00	X	X	X	0	X	7, 9, 10
Quick stop	0x02	X	X	0	1	X	11
Operation - disable	0x07	X	0	1	1	1	5
Operation - released	0x0F	X	1	1	1	1	4
Reset fault	0x80	0 ⇒ 1	X	X	X	X	15

¹⁾ "X" means any value ("0" or "1")

In order to facilitate the operation of the device, an additional feature was implemented in the extension to the state machine defined under DRIVECOM. There is an additional transition 4 (0x0F) from "Starting lock-out" (0x040) to "Operation released" (0x27). Transition 4 is marked in the flow chart by a thick arrow.

The shaded areas show the commands relevant to the simplified Statemachine.

If a fault occurs, the "Fault" state is activated.

Note: If the command "Reset Fault" is executed, transition 15 takes place upon a positive edge of bit 7!

A fault can only be acknowledged 15 seconds after the occurrence of the fault, i.e. after the internal blocking time has elapsed.

The parameter *Status Word 411* has a length of 16 bits. The set bits have the following meaning:

<i>Status word 411</i>	
Bit no.	Function
0	Ready for being switched on
1	Switched on
2	Operation - released
3	Error
4	Voltage - disabled
5	Quick stop
6	Starting lock-out
7	Warning
8	–
9	Remote
10	Reference value reached
11	Limit value reached
12	–
13	–
14	–
15	Warning2

The status word reflects the operation state.

Status word	HEX¹⁾	Bit 6	Bit 5	Bit 3	Bit 2	Bit 1	Bit 0
Not ready for being switched on	0x00	0	X ²⁾	0	0	0	0
Starting lock-out	0x40	1	X	0	0	0	0
Ready for being switched on	0x21	0	1	0	0	0	1
Quick stop	0x07	0	0	0	1	1	1
Switched on	0x23	0	1	0	0	1	1
Operation released	0x27	0	1	0	1	1	1
Error	0x08	0	X	1	0	0	0
Fault reaction active	0x0F	0	X	1	1	1	1

¹⁾ without consideration of bits 7...15!

²⁾ "X" means any value ("0" or "1")

The shaded areas show the commands relevant to the simplified Statemachine.

Status Word Bit 7 to Bit 15

Bit 7, "Warning bit"

The **warning bit "7"** can come at any time. It signals an internal warning and results in the frequency inverter being switched off, depending on the cause.

The evaluation of the warning is done by reading out the warning status via parameter *Warnings* **270**.

Bit 9, "Remote"

The **remote bit** is set if the operation mode "Control via control word of State-machine" (*Local/Remote* **412** = 1) is set and the controller release signal is present at external release and the start command is present at digital input S2IND or S3IND.

Logic link:

external release **AND** (S2IND/"Start clockwise" **OR** S3IND/"Start anticlockwise")

Note: The frequency inverter can only be addressed via the control word if the hardware release is set and the remote bit *Local/Remote* **412** = 1 is set.

Bit 10, "Reference value reached"

The bit **"Reference value 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 "Reference value 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 "Limit active"

The bit **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 result in the reference value being left or not reached.

Bit 15 "Warning2"

The bit **"Warning2"** extends bit 7 "Warning bit" by the following information:

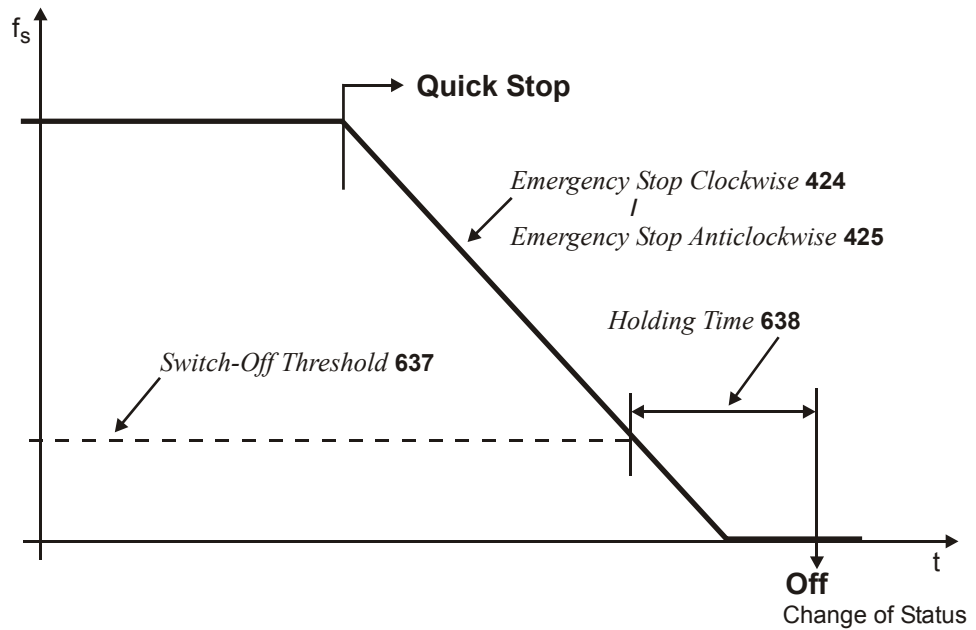
Bit 15 signals a critical operating state which will result in a fault switch-off of the frequency inverter within a short time. This bit is set if there is a delayed warning relating to the motor temperature, heat sink/inside temperature, Ixt monitoring or mains phase failure.

If **bit 15** is set, **bit 7** is set, too.

9.1.2.1 Behavior in Case of Quick Stop

In this case, the parameters *Switch-Off Threshold 637* (percentage of parameter *Maximum Frequency 419*) and *Holding Time 638* (holding time after the value drops below the switch-off limit) are relevant.

In a quick stop, the drive is brought to a standstill via the emergency stop ramps (*Emergency Stop Clockwise 424* or *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.

9.1.2.2 Behavior in state-transition 5 (from "Operation released" to "Switched on")

The behavior in transition 5 (from "Operation released" to "Switched on") can parameterized via parameter *state-transition 5 392*.

<i>state-transition 5 392</i>	function
0 – Coast to Stop	Immediate transition from "Operation released" 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 released" to "Switched on"
2 – Ramp	Transition at normal ramp, when the drive has come to a standstill, there is the change from "Operation released" to "Switched on"

Note: Setting 1 "DC-Brake" is only possible with applications with sensorless 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 DC-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.

The default value for *state-transition 5 392* is operation mode 2 (ramp). For configurations with torque control, the default value is 0 (coasting).

If the configuration is changed, the value set for *state-transition 5 392* is also changed, if necessary.

Note: If *state-transition 5 392* was triggered with value 1 "Direct current brake", a new control word will only be accepted after the transition process is complete. The change of state from "Operation released" to "Switched on" 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 0x0F again, while the drive is decelerating. In this way, the drive accelerates to its set reference value again and remains in the state "Operation released".

The change of state from "Operation released" 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 case, the parameters *Switch-Off Threshold 637* (percentage of parameter *Maximum Frequency 419*) and *Holding Time stop function 638* (holding time after the value drops below the switch-off limit) are relevant.

9.1.3 Control via Remote Contacts

In the operation mode Control via remote contacts (*Local/Remote* **412** = 2), the frequency inverter is addressed via parameter *Control Word* **410**.

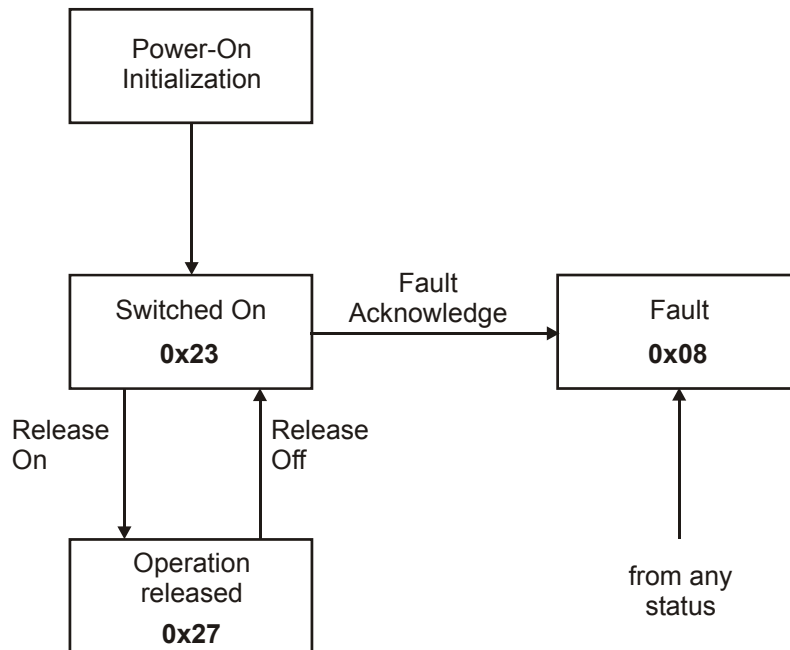
The digital inputs S1IND ... S6IND and the multifunction input MFI1D of the frequency inverter as well as inputs EM-S1IND ... EM-S3IND of the optional expansion modules are emulated through Bit 0 ... Bit 9 of parameter *Control Word* **410**.

If the remote contacts are used, the inverter behaves in the same way as in the case of addressing via the digital inputs. For the function and the parameterization of these inputs, refer to the frequency inverter operating instructions.

- Note:** A release is possible only if
- bit 0 of the control word is set to "1" **and**
 - the release via hardware is set to "1"

Controller release via the software alone is not possible.

Sequence in Statemachine:



The numbers indicated in the individual operating statuses (e.g. **0x23**) signal the corresponding feedback via the status word (bit 0...6).

- Note:** Inputs which are set via the control word can be monitored via the control unit KP500 or the control software VPlus by means of parameter *Digital Inputs* **250**.
Digital inputs are indicated as set only if the controller release signal is present **and** if bit 0 in the control word is set to "1".

- Note:** If data set change-over is used, make sure that the parameter *Local/Remote* **412** is set to "2" (control via remote contacts) in all assigned data sets.

Note: With the use of remote contacts the signal sources* are taken over from the control word 410. Signals at the hardware contacts (terminals) are not evaluated by the standard operation modes (e.g. 71 for S2IND). For the evaluation of terminal signals special operation modes are available. They are denoted with the additional term "(Hardware)" and numbered from 526 to 546.
 Exception: The controller release via the hardware contact S1IND (terminal X210A.3) and Bit 0 "S1IND" of the *controlword* must be set.
 It is not possible to release the controller only via software.

Signal sources are:

- S1IND ... S6IND,
- MFI1D,
- EM-S1IND ... EM-S3IND

Assignment of parameter *Control Word 410* and actual value *Status Word 411*:

<i>Control Word 410</i>	
Bit no.	Bit no.
0	S1IND
1	S2IND
2	S3IND
3	S4IND
4	S5IND
5	S6IND
6	MFI1D
7	EM-S1IND
8	EM-S2IND
9	EM-S3IND
10	–
11	–
12	–
13	–
14	–
15	–

<i>Status Word 411</i>	
Bit no.	Bit no.
0	Ready for being switched on
1	Switched on
2	Operation - released
3	Error
4	Voltage – disabled*
5	Quick stop
6	Starting lock-out
7	Warning
8	–
9	Remote
10	Reference value reached
11	Limit value reached
12	–
13	–
14	–
15	Warning2

* The logic state is "0" for ACT devices.

The status word reflects the operation state.

Status word	HEX ¹⁾	Bit 6	Bit 5	Bit 3	Bit 2	Bit 1	Bit 0
Switched on	0x23	0	1	0	0	1	1
Operation released	0x27	0	1	0	1	1	1
Error	0x08	0	X ²⁾	1	0	0	0

¹⁾ without consideration of bits 7 ... 15!

²⁾ "X" means any value ("0" or "1")

If a fault occurs, the fault status is activated.

Note: A fault can only be acknowledged 15 seconds after the occurrence of the fault, i.e. after the internal blocking time has elapsed.

If a fault has occurred, the cause of the fault can be read out via parameter *Current Error* **260**.

Status Word Bit 7 to Bit 15

Bit 7, "Warning bit"

The **warning bit "7"** can signal an internal warning and results in the frequency inverter being switched off, depending on the cause.

The evaluation of the warning is done by reading out the warning status via parameter *Warnings* **270**.

Bit 9, "Remote"

The **"Remotebit"** is set if the "Operation mode Control via remote contacts" is set (*Local/Remote* **412** = 2) **and** the external controller release is present. Only then can the frequency inverter be controlled via the control word.

Bit 10, "Reference value reached"

The bit **"Reference value 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 "Reference value 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 "Limit active"

The bit **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 result in the reference value being left or not reached.

Bit 15 "Warning2"

The bit **"Warning2"** extends bit 7 "Warning bit" by the following information:

Bit 15 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.

If **bit 15** is set, **bit 7** is set, too.

9.2 Reference Value

9.2.1 Reference Frequency

The following signal sources are available for determining the reference frequency:

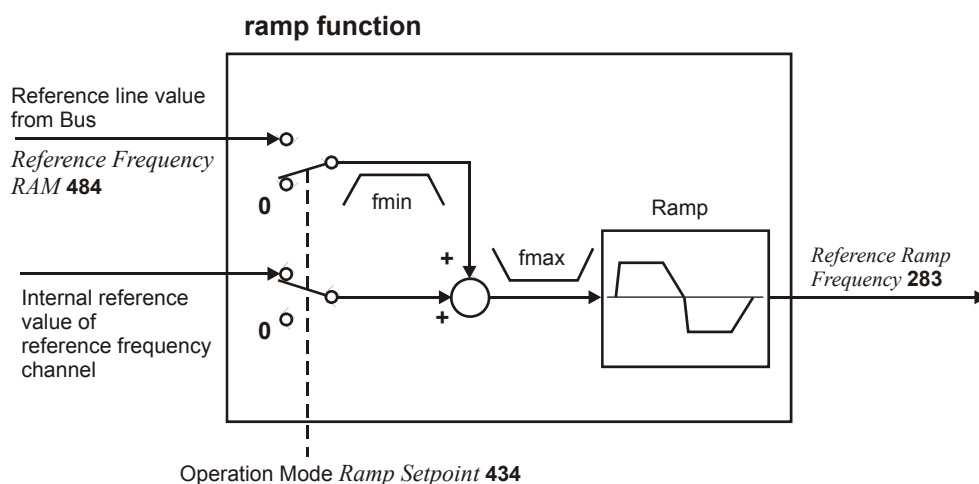
- External reference value as reference line value from bus
- Internal reference value from the reference frequency channel

The reference line value with the parameter name *Reference Frequency RAM 484* is sent to the frequency inverter via the bus.

The internal reference value reaches the frequency inverter via the reference frequency channel. The reference frequency channel is configured via parameter *Reference Frequency Source 475*.

The actual value can be read back via different parameters. The selection depends on the control method used and the application. The following parameters are possible, for example:

- *Stator Frequency 210* (data type long, Hz)
- *Encoder 1 Frequency 217* (data type long, Hz)
(Speed Sensor 1 Frequency)
- *Encoder 1 Speed 218* (data type int, rpm).
(Speed Sensor 1 Speed)



The internal reference value from the reference frequency channel and the reference line value (line setpoint) can be fed to the ramp individually or as an added variable. The result is available at the output of the ramp function as *Reference Ramp Frequency 283*.

The operation mode of the ramp function is set via the data set related parameter *Ramp Setpoint 434*.

For information on the reference frequency channel, refer to the frequency inverter operating instructions.

<i>Ramp Setpoint 434</i>	Function
1 – Internal Setpoint	The internal reference frequency is determined from the reference frequency channel.
2 – Line Setpoint	The reference value is supplied externally via the bus
3 – Internal + Line Setpoint	Addition (considering the sign) of internal reference frequency and reference line value

For *Ramp Setpoint* **434** = 3, the sign of the overall reference value is obtained from the addition of the reference frequency + the reference line value.

Note: If *Ramp Setpoint* **434** = 2 (reference line value only), this reference line value is limited to f_{min} .
In this case, consider that the sign in front of f_{min} with reference value = 0 is derived from the sign in front of the last reference line value which was not 0.
After Mains On, the reference line value is limited to $+f_{min}$ (motor clockwise).

The reference values can be controlled at the frequency inverter via the control unit KP500 or the control software VPlus via the following parameters:

- *Internal Reference Frequency* **228** = internal ref. value from ref. freq. channel
- *Reference Bus Frequency* **282** = reference line value from serial interface
- *Reference Ramp Frequency* **283** = sum of internal reference frequency + reference line value

Note: If the serial interface of the communication module CM-232 / CM-485 is connected to a PLC, for example, VPlus cannot access the frequency inverter via this interface directly.
In this case, the PC must be connected via the optional interface adapter KP232.

For information on the reference frequency channel, refer to the frequency inverter operating instructions.

9.2.2 Reference Percentage

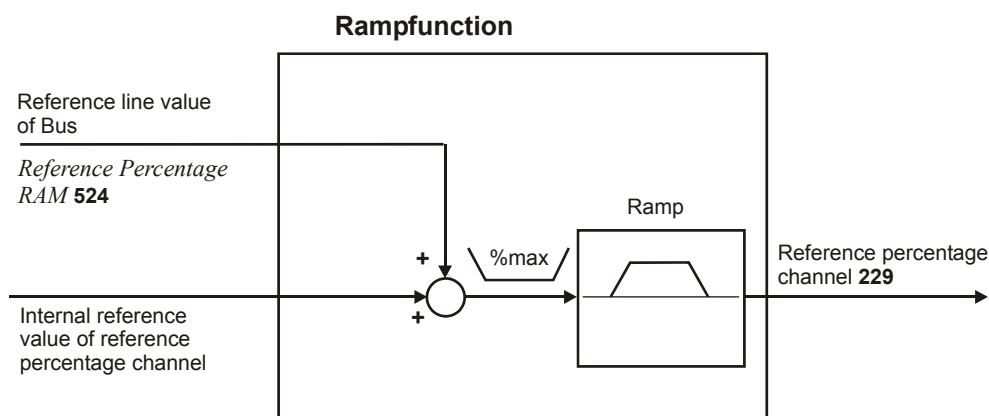
The following signal sources are available for determining the reference percentage:

- External reference value as reference line value from bus
- Internal reference value from the reference percentage channel

The reference line value with the parameter name *Reference Percentage RAM 524* is sent to the frequency inverter via the bus.

The internal reference value reaches the frequency inverter via the reference percentage channel. The reference percentage channel is configured via parameter *Reference Percentage Source 476*.

The parameter *Reference Percentage Value 229* can be read back as an actual value.



The internal reference value from the reference percentage channel and the reference line value are fed to the ramp as an added variable. The sum of the two variables has a positive or a negative sign according to the mathematical operation.

For information on the reference percentage channel, refer to the frequency inverter operating instructions.

- Note:**
- The actual value parameter *Reference percentage 229* can be checked at the frequency inverter via the control unit KP500 or the control software VPlus.
 - For example, the *Reference Percentage Value 229* is processed in the frequency inverter via the functions "Technology Controller" or "Torque Controller" (e.g. speed controller for torque limitation. For more information refer to the frequency inverter operating instructions.

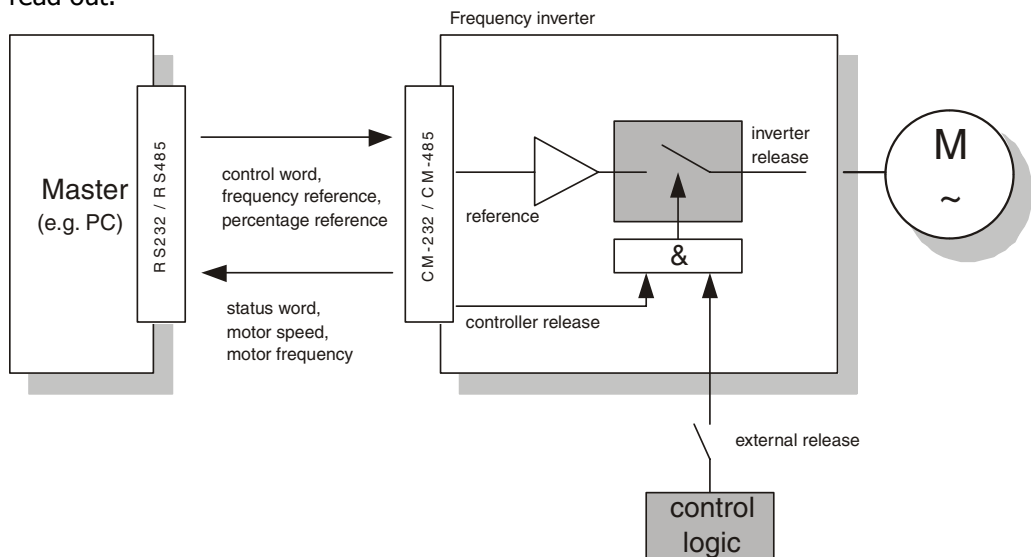
- Note:**
- If the serial interface of the module CM-232/CM-485 is connected to a PLC, for example, VPlus cannot access the frequency inverter via this interface directly. In this case, the PC must be connected via the optional interface adapter KP232.

10 ACU Inverter Control/Reference Value

The frequency inverter can be controlled completely via the serial interface. The following parameters and actual values are used for this:

Parameter		Settings			
No.	Name/Meaning	min.	max.	fact. sett.	type
410	Control Word	0x0000	0xFFFF	–	uInt
411	Status Word	0x0000	0xFFFF	–	uInt
484	Reference Frequency RAM [Hz]	-999.99	999.99	0.00	Long
524	Reference Percentage RAM [%]	-300.00	300.00	0.00	Long

With the *Control Word 410* (data type uInt), control commands are sent to the frequency inverter, with the *Reference Frequency RAM 484* (data type Long [Hz]) or *Reference Percentage RAM 524* (data type Long [%]), the reference line value is sent. Via the *Status Word 411* (data type uInt), the status of the frequency inverter is read out.



Note: *Control Word 410*, *Reference Frequency RAM 484* and *Reference Percentage RAM 524* are stored in the RAM of the frequency inverter. This is generally addressed via data set 0.

Note: **External release:**

- The ACU inverter inputs STOA (S1IND) and STOB (S7IND) must be enabled.
- These digital inputs have the highest priority and have to be hard-wired.

The control of the frequency inverter can be done in principle with three operation modes. They are set via the data set change-over capable parameter *Local/Remote* **412**.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
412	Local/Remote	0	44	44

For operation, only the settings 0, 1 and 2 are relevant. The further settings relate to the possibilities of control via the KP500 control unit.

Control mode	Function
0 - Control via digital inputs	The Start and Stop command as well as the statement of the direction of rotation are via digital input signals.
1 - Control via state machine	The inverter is controlled by the <i>controlword</i> . Only in this control mode the motion control functions are supported by <i>controlword</i> and <i>modes of operation</i> .
2 - Control via remote digital inputs	The Start and Stop command as well as the statement of the direction of rotation are via digital input signals emulated by the bits of the <i>controlword</i> .

Note: The parameter *Local/Remote* **412** is data set change-over capable. Thus, switching over between various control modes via the data set selection is possible.

The data set change-over can be done locally at the frequency inverter via digital inputs or via the bus. For the data set change-over via the bus, the parameter *Data set selection* **414** is used.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
414	Data set selection	0	4	0

With *Data set selection* **414** = 0, the data set switch-over via digital inputs is active. If *Data set selection* **414** has been set to 1, 2, 3, or 4, the data set selected in this way has been activated. The data set switch-over via the digital inputs is then disabled.

Via the parameter *Active data set* **249** the data set currently selected can be read out. *Active data set* **249** states the activated data set with the value 1, 2, 3 or 4. This is independent of whether the data set change-over has been done via digital inputs or via *Data set selection* **414**.

10.1 Control via contacts/remote contacts

In the operation mode control via digital inputs or remote digital inputs (parameter *Local/Remote* **412** = 0 or 2) the frequency inverter is controlled via the digital inputs S1IND, S2IND to S6IND directly or by digital input emulation with help of the single bits in the *controlword*. The meaning of these inputs can be seen from the operating instructions.

Controlword (Local/Remote 412= 2)		Stateword	
Bit No.	Name	Bit No.	Name
0	S1IND	0	Ready to switch on
1	S2IND	1	Switched on
2	S3IND	2	Operation enabled
3	S4IND	3	Fault
4	S5IND	4	Voltage enabled
5	S6IND	5	Quick stop
6	MFI1D	6	Switch on disabled
7	EM-S1IND	7	Warning
8	EM-S2IND	8	-
9	EM-S3IND	9	Remote
10	-	10	Target reached
11	-	11	Internal limit active
12	-	12	-
13	-	13	-
14	-	14	-
15	-	15	Warning 2

Note: When using the control mode "control via remote digital inputs" the controller release via STOA (terminal X210A.3) and STOB (terminal X210B.2) must be set AND bit 0 of *controlword* must be set to get the drive started.

The two control modes digital inputs and remote digital inputs facilitate the *mode of operation* "velocity mode" only.

Note: ACTIVE CUBE inverters support an external 24V supply for control logic. Even if the mains are not switched on the communication between PLC and inverter can be established.

The bit 4 "Voltage enabled" of the *statusword* displays the current state of the mains power supply.

Bit 4 "Voltage enabled" = 0 signals "no mains voltage" and the drive start is disabled.

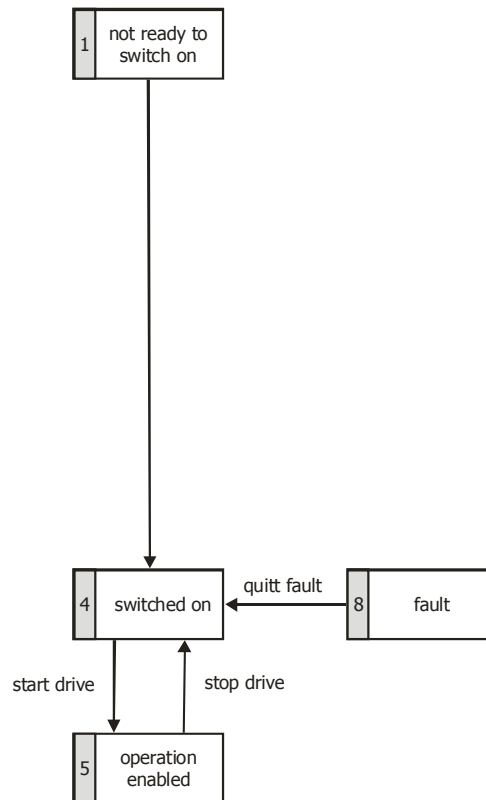
Bit 4 "Voltage enabled" = 1" signals "mains voltage switched on" and the drive is ready to start.

Note: With the use of remote contacts the signal sources* are taken over from the control word 410. Signals at the hardware contacts (terminals) are not evaluated by the standard operation modes (e.g. 71 for S2IND). For the evaluation of terminal signals special operation modes are available. They are denoted with the additional term "(Hardware)" and numbered from 526 to 546.
Exception: The controller release via the hardware contacts STOA (terminal X210A.3) and STOB (terminal X210B.2) must be set and Bit 0 "S1IND" of the *controlword* must be set.
It is not possible to release the controller only via software.

Signal sources are:

- S1IND ... S6IND,
- MFI1D,
- EM-S1IND ... EM-S3IND

State machine:



Stateword	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

Note: Bits marked "x" are don't care.

The **Warning bit "Bit No. 7"** can signal an internal warning and results in the frequency inverter being switched off, depending on the cause. The evaluation of the warning is done by reading out the warning status via parameter *Warnings 270*.

The bit **Target reached "Bit No. 10"** is set when the reference value specified has been reached. In the special case of power failure regulation, the bit is also set if the power failure regulation has reached the frequency 0 Hz (see operating instructions). For "Reference value reached" there is a hysteresis (tolerance range), which can be set via the parameter *max. Control deviation 549* (see operating instructions).

The bit **Internal limit active "Bit No. 11"** displays that an internal limit is active. This can, for example, be the present current limit, the torque limit or the over-voltage limit. All the functions lead to the reference value being quit or not reached.

The bit **Warning 2 "Bit No. 15"** reports a warning which leads to a fault switch-off of the frequency inverter within a short time. This bit is set if there is a warning for motor temperature, heat sink/inside temperature, Ixt monitoring or mains phase failure.

10.2 Control via state machine

In the operation mode "control via state machine" (parameter *Local/Remote* **412** = 1) the frequency inverter is controlled via *controlword*.

State transition 4 to state "Operation enabled" is only possible when:

Motion control configuration (*Configuration* **30** = **x40**):

→ controller release at STOA and STOB is set.

In other configurations (non motion control, *Configuration* **30** ≠ **x40**):

→ controller release at STOA and STOB is set AND (S2IND OR S3IND)
(S2IND = start clockwise/S3IND = start anticlockwise)

The behavior of transition 5 can be set via the parameter *State transition 5* **392**. Here, free stopping, shutdown via ramp (reversible) or DC braking (see Chapter "Behavior in transition 5") can be used.

<i>Control word 410</i>	
Bit	Meaning
0	Switch on
1	Enable voltage
2	Quick stop
3	Enable operation
4	<i>Operation mode specific</i>
5	<i>Operation mode specific</i>
6	<i>Operation mode specific</i>
7	Fault reset
8	<i>Halt</i>
9	<i>Operation mode specific</i>
10	<i>Reserved</i>
11	<i>Manufacturer specific</i>
12	<i>Manufacturer specific</i>
13	<i>Manufacturer specific</i>
14	<i>Manufacturer specific</i>
15	<i>Manufacturer specific</i>

Bits 9 ... 15 unused

<i>Status word 411</i>	
Bit	Meaning
0	Ready to switch on
1	Switched on
2	Operation enabled
3	Fault
4	Voltage enabled
5	Quick stop
6	Switch on disabled
7	Warning
8	Manufacturer specific
9	Remote
10	Target reached
11	Internal limit active
12	<i>Operation mode specific</i>
13	<i>Operation mode specific</i>
14	<i>Manufacturer specific</i>
15	<i>Manufacturer specific Warning2</i>

Bit 14 unused

Controlword bits 4, 5, 6 *operation mode specific* and bit 8 *halt* are used in motion control configurations (*Configuration* **30** = **x40**) only.

Statusword bits 12 + 13 *operation mode specific* are used in motion control configurations (*Configuration* **30** = **x40**) only.

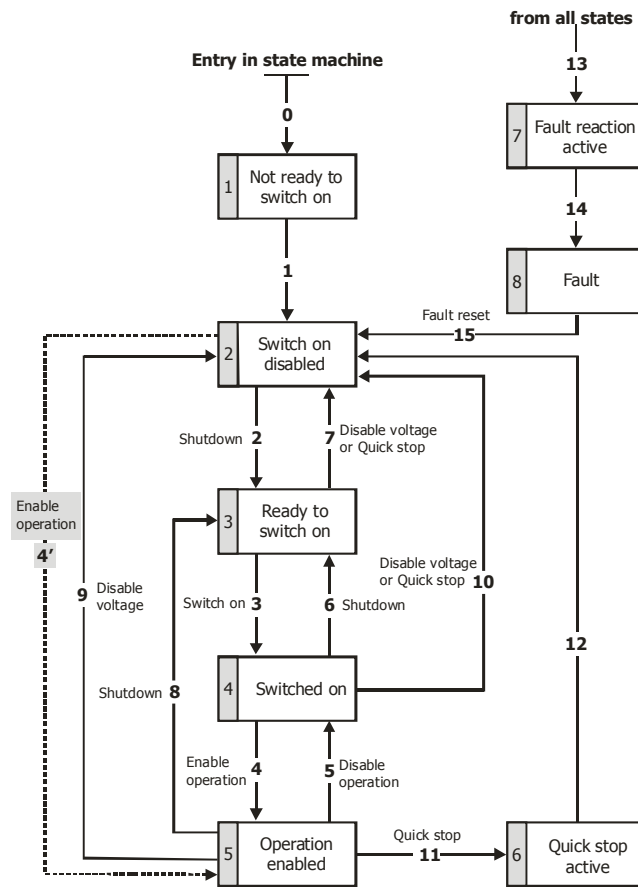
Note: ACTIVE CUBE inverters support an external 24V supply for control logic. Even if the mains are not switched on the communication between PLC and inverter can be established.

The bit 4 "**Voltage enabled**" of the *statusword* displays the current state of the mains power supply.

Bit 4 "**Voltage enabled**" = **0** signals "no mains voltage" and the state transition "Ready to switch on" → "Switched on" is **not possible**.

Bit 4 "**Voltage enabled**" = **1** signals "mains voltage switched on" and the state transition "Ready to switch on" → "Switched on" is **possible**.

State machine:



The device control commands are triggered by the following bit pattern in the *control-word*:

Controlword						
Command	Bit 7	Bit 3	Bit 2	Bit 1	Bit 0	Transitions
	Fault reset	Enable operation	Quick stop	Enable voltage	Switch on	
Shutdown	X	X	1	1	0	2, 6, 8
Switch-on	X	0	1	1	1	3
Switch on	X	1	1	1	1	3
Disable voltage	X	X	X	0	X	7, 9, 10, 12
Quick stop	X	X	0	1	X	7, 10, 11
Disable operation	X	0	1	1	1	5
Enable operation	X	1	1	1	1	4
Fault reset	0 ⇒ 1	x	x	x	x	15

Bits marked **X** are irrelevant

Note: The state transition 3 (command "Switch on") is processed only if bit no. 4 "Voltage enabled" of the *statusword* is set.

The state transition **4'** is only available for non motion control configurations (*Configuration 30* ≠ *x40*) and is processed only if bit no. 4 "Voltage enabled" of the *statusword* is set. This function is for downward compatibility to older software versions.

The *statusword* displays the operation state.

Statusword						
state	Bit 6	Bit 5	Bit 3	Bit 2	Bit 1	Bit 0
	Switch on disabled	Quick stop	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

Bits marked **X** are irrelevant

The **Warning bit "Bit No. 7"** can be set at any time. It displays a device-internal warning message. The evaluation of the warning reason is done by reading out the warning status with the parameter *Warnings 270*.

The **Remote bit "Bit No. 9"** is set if the operation mode control via state machine (*Local/Remote 412 = 1*) has been set **and** the hardware release is available.

Logic linking of the digital control signals:

STOA **AND** STOB **AND** (Start clockwise **OR** Start anticlockwise)

Only if the logic linking is true the inverter can be controlled via the. The logic inputs for Start clockwise / Start anticlockwise can be connected directly to *ON (Start Clockwise 68, Start Anticlockwise.69)*.

Note: For motion control configurations (*Configuration 30 = x40*) only the digital input S1IND must be set. Start clockwise and start anticlockwise have no function in motion control configurations.

The bit **Target reached reached "Bit No. 10"** is set when the reference value specified has been reached.

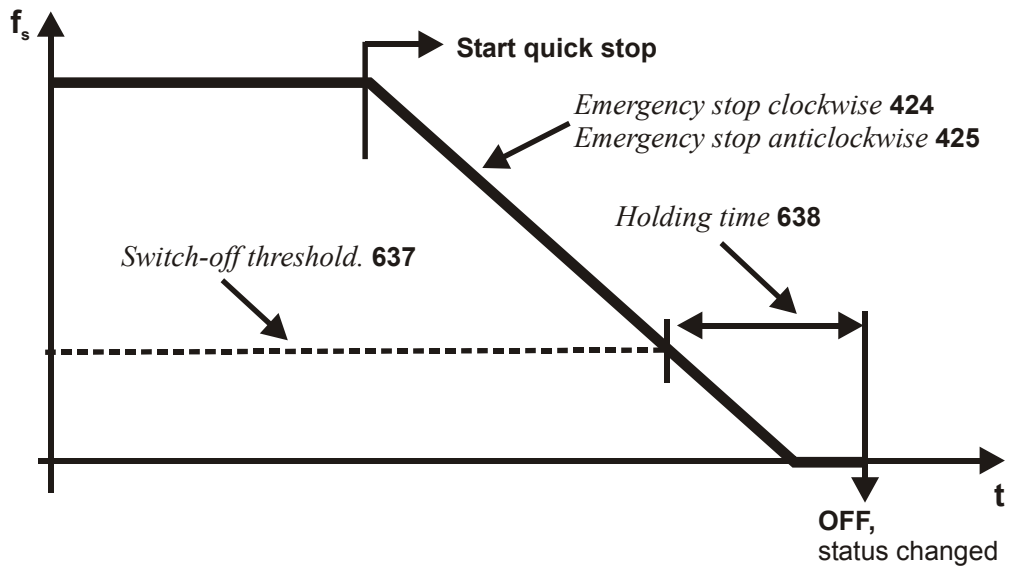
In non motion control configurations (*Configuration 30 ≠ x40*) target reached is related to the reference speed object 0x6042 *target velocity*. In the special case of power failure regulation, the bit is also set if the power failure regulation has reached the frequency 0 Hz (see operating instructions). For "Target reached" there is a hysteresis (tolerance range), which can be set via the parameter *max. Control deviation 549* (see operating instructions).

The bit **Internal limit active "Bit No. 11"** displays that an internal limit is active. This can, for example, be the present current limit, the torque limit or the over-voltage limit. All the functions lead to the reference value being quit or not reached.

The bit **Warning 2 "Bit No. 15"** reports a warning which leads to a fault switch-off of the frequency inverter within a short time. This bit is set if there is a warning for motor temperature, heat sink/inside temperature, Ixt monitoring or mains phase failure.

10.2.1 Behavior in quick stop

In this, the parameters *Switch-off threshold* **637** (percent of f_{max}) and *Holding time* **638** (holding time after falling short of the switch-off threshold) are relevant. In a quick stop, the drive is shutdown via the emergency stop ramps (*Emergency stop clockwise* **424** or *Emergency stop anticlockwise* **425**).



If frequency/speed zero has been reached during the holding time, the drive continues to be supplied with direct current until the switch-off time has expired. With this measure, there is an assurance that the drive is stationary in a change of state.

Note: The "behavior in quick stop" is only relevant for non motion control configurations (*Configuration* **30** \neq **x40**).

10.2.2 Behavior in transition 5

The behavior in transition 5 from "Operation enabled" to "Switched on" can be parameterized. The behavior is set via parameter *State transition 5* **392**.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
392	State transition 5	0	2	2

Operation mode	Function
0 - Coast to stop	immediate transition from "Operation enabled" to "Switched on", free stoppage of the drive
1 - DC brake	activation of DC brake, with the end of DC braking, there is the change from "Operation enabled" to "Switched on"
2 - Ramp	transmission with normal stop ramp, after reaching standstill, there is a change from "Operation enabled" to "Switched on"

Note: Setting operation mode "1 - DC brake" is only possible in applications with v/f characteristic (e.g. configuration 110), as other applications do not know such an operation mode.
If the frequency inverter is operated with a configuration which does not know the DC braking operation mode (e.g. configuration 210, field-orientation speed controlled), value "1" cannot be set. It is also not offered in the selection menus of the KP500 control unit or the VPlus program.

Note: The default value for the parameter *State transition 5* **392** is operation mode "2 - Ramp". For configurations with torque control, the default value is operation mode "0 - Coast to stop". In a switch-over of the configuration, the setting value for *State transition 5* **392** is also altered if necessary.

Note: The "behavior in transition 5" is only relevant for non motion control configurations (*Configuration* **30** ≠ **x40**).

If transition 5 has been triggered with *State transition 5* **392** = "1 - DC brake", a new control word is only accepted after the completion of the transition process. The change of state from "Operation enabled" to "Ready" is done after the expiry of the time *Braking time* **632** parameterized for the DC brake.

If the parameter *State transition 5* **392** = "2 - Ramp" has been set, the *controlword* can be set back to "Enable operation" during the stoppage of the drive. In this way, the drive runs back up to its set reference value and remains in the state "Operation enabled".

The change of state from "Operation enabled" to "Switched on" is done after the set switch-off threshold has been reached **and** expiry of the set holding time (equivalent to the behavior in a quick stop). In this, the parameters *Switch-off threshold* **637** (percent of fmax) and *Holding time* **638** (holding time after switch-off threshold reached) are relevant.

10.2.3 Reference value/actual value

The control (PLC) can set the frequency reference value for the frequency inverter via the parameter *Reference Frequency RAM* **484**.

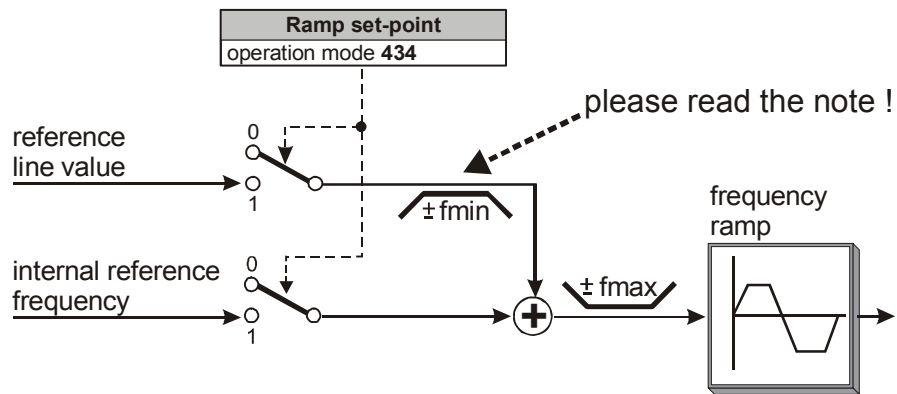
The control (PLC) can set the percentage reference value for the frequency inverter via the parameter *Reference Percentage RAM* **524**.

The value of the control will always be added to the local source value of *Reference Percentage Source* **476**.

Note: The Parameters *Reference Frequency RAM* **484** and *Reference Percentage RAM* **524** can only be written. Read access is not possible.

The use of the reference/actual value channel depends on the set configuration (control system). The actual value is generated from the correct source depending on the control system used.

The actual value can be read out via parameter *Actual Frequency* **241**. In addition, the internal reference frequencies can be read out.



The internal reference value from the reference frequency value channel and the reference line value can be fed to the ramp individually or as an added variable. Setting is done via the data set change-over capable parameter *Ramp set-point* **434**.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
434	Ramp set-point	1	3	3

Operation mode	Function
1 - Internal setpoint (reference frequency value)	Reference value from the sources of the percentage of reference frequency value channel
2 - Line setpoint (reference line value)	Reference value via a communication interface
3 - Internal + line setpoint	Sum of internal reference frequency value and reference line value

Note: This function is only relevant for non motion control configurations (*Configuration* **30** ≠ **x40**).

Note: If *Ramp set-point 434* = 2 (only reference line value), this reference line value is limited to fmin. Please consider that the sign in front of fmin at reference value = 0 is derived from the sign in front of the last reference line value $\neq 0$.
After Power On, the reference line value is limited to +fmin!

For *Ramp set-point 434* = 3, the sign in front of the overall reference value results from the sum of internal reference frequency value and reference line value.


The reference values can be read out on the frequency inverter with the help of the KP500 control unit or VPlus operating software.

Actual values		
Parameter	Contents	Format
<i>Internal reference frequency 228</i>	Internal reference value from frequency reference value channel	xxx.xx Hz
<i>Reference bus frequency 282</i>	Reference line value.	xxx.xx Hz
<i>Reference ramp frequency 283</i>	Sum of internal + reference line value	xxx.xx Hz

11 Parameter List

The following tables contain parameters which are relevant to the CM-232 and CM-485 communication modules. For the other parameters, refer to the frequency inverter parameters.

For better clarity, the parameters have been marked with pictograms:

-  The parameter is available in the four data sets.
- The parameter value is set by the SETUP routine.
- This parameter cannot be written when the frequency inverter is in operation.
- This parameter is not accessible via the control unit KP500 and the control software VPlus; it is only accessible via the communication channel.







I_{FUN} , U_{FUN} , P_{FUN} : rated values of the frequency inverter, \hat{u} : overload capacity of frequency inverter

11.1 Actual Value Menu (VAL)

Actual Values of the Frequency Inverter					
No.	Name/Meaning	Unit	Display range	Chapter	
228	Internal Reference Frequency	Hz	-1000.00 ... 1000.00	9.2.1, 10.2.3	
229	Reference Percentage Value	%	± 300.00	9.2.2	
249	Active Data Set	–	1 ... 4	9, 10	
250	Digital Inputs	–	0 ... 255	9.1.3	
<input checked="" type="checkbox"/>	260	Current Error	–	0 ... 0xFFFF	9.1; 12.2
<input checked="" type="checkbox"/>	270	Warnings	–	0 ... 0xFFFF (bit coded)	9.1; 12.1
282	Ref. Bus Frequency	Hz	-1000.00 ... 1000.00	9.2.1, 10.2.3	
283	Ref. Ramp Frequency	Hz	-1000.00 ... 1000.00	9.2.1, 10.2.3	
411	Status Word	–	0 ... 0xFFFF	9; 9.1	

11.2 Parameter Menu (PARA)

RS232 / RS485					
No.	Name/Meaning	Unit	Setting range	Chapter	
10	Baud Rate	–	1 ... 6	5.2, 5.3	
Inverter Data					
<input checked="" type="checkbox"/>	11	VABus SST Error Register	–	6.6	
<input checked="" type="checkbox"/>	34	Program(ming)	–	0 ... 9999	5.2, 5.3
Bus controller					
<input checked="" type="checkbox"/>	392	State-transition 5	–	0 ... 2	9.1.2.2, 10.2, 10.2.2
RS232 / RS485					
394	RS232/RS485 NodeID	–	1 ... 30	5.2, 5.3	
395	Protocol	–	0 ... 3	6	
Bus controller					
<input checked="" type="checkbox"/>	410	Control Word	–	0 ... 0xFFFF	9; 9.1
<input checked="" type="checkbox"/>	412	Local/Remote	–	0 ... 44	9; 9.1,10, 10.1

RS232 / RS485					
No.	Name/Meaning	Unit	Setting range	Chapter	
413	RS232/RS485 Watchdog Timer	s	0 ... 10000	6.8	
Data Set Change-Over					
414	Data Set Selection	-	0 ... 4	9, 10	
Frequency Ramps					
	424	Emergency Stop Clockwise	Hz/s	0.01 ... 9999.99	9.1.2.1, 10.2.1
	425	Emergency Stop Anticlockwise	Hz/s	0.01 ... 9999.99	9.1.2.1, 10.2.1
	434	Ramp Setpoint	-	1 ... 3	9.2.1, 10.2.3
Fixed Frequencies					
<input checked="" type="checkbox"/>	484	Reference Frequency RAM	Hz	-999.99 ... 999.99	9.2.1
Fixed Percentages					
<input checked="" type="checkbox"/>	524	Reference Percentage RAM	%	± 300.00	9.2.2
Digital Outputs					
	549	Max. Control Deviation	%	0.01 ... 20.00	9.1, 10.1
Direct current brake					
	632	Braking Time	s	0.0 ... 200.0	9.1.2.1, 9.1.2.2
Stopping Behavior					
	637	Switch-Off Threshold	%	0.0 ... 100.0	9.1.2.1, 9.1.2.2, 10.2.1
	638	Holding Time	s	0.0 ... 200.0	9.1.2.1, 9.1.2.2, 10.2.1, 10.2.2
Modbus					
	1375	Modbus Parity	-	0 ... 2	5.2.1, 5.3.1
	1376	Modbus Address	-	1 ... 247	5.2.2, 5.3.2

12 Annex

12.1 Warning Messages

The various control methods and the hardware of the frequency inverter include functions which continuously monitor the application. In addition to the messages documented in the frequency inverter operating instructions, further warning messages are activated by the RS232/RS485 communication modules CM-232/CM-485.

The bit-coded warning reports are issued via parameter *Warnings* **270** according to the following pattern:

Warning Messages			
Bit no.	Warning code	Description	
0	0x0001	Warning Ixt	1) 2)
1	0x0002	Warning Short-Term Ixt	1)
2	0x0004	Warning Long-Term Ixt	2)
3	0x0008	Warning Heat Sink Temperature Tk	
4	0x0010	Warning Inside Temperature Ti	
5	0x0020	Warning I-limit	
6	0x0040	Warning Init	
7	0x0080	Warning Motor Temperature	
8	0x0100	Warning Phase Failure	
9	0x0200	Warning Motor Protection Switch	
10	0x0400	Warning Fmax	
11	0x0800	Warning Analog Input MFI1A	
12	0x1000	Warning Analog Input A2 (EM-S1INA)	
13	0x2000	Warning System Bus Slave Failure	
14	0x4000	Warning Udc	
15	0x8000	Warning V-belt	

- 1) 2) Bit 0 "Warning Ixt" is always set
- if bit 1 "Warning Short-Term Ixt" **or**
 - if bit 2 "Warning Long-Term Ixt" is set.

Note: The individual warnings are described in detail in the frequency inverter operating instructions.

Note: In parameter *Warnings* **270** several warnings can be displayed at the same time.

Example:

Message	Warning code	Remarks
Warning Ixt	0x0001	Is set in Short-Term Ixt or Long-Term Ixt
Short-Term Ixt	0x0002	
Warning Limit Heat Sink Temperature	0x0008	
Warning Motor Temperature	0x0080	
Total	0x008B	

12.2 Error Messages

Fault messages can be read out via parameter *Current Error* **260**. The error code stored following a fault comprises the error group FXX (high-byte, hexadecimal) and the code YY (low-byte, hexadecimal).

General Fault Message		
Code		Meaning
F00	00	No fault has occurred.

Overload		
Code		Meaning
F01	00	Frequency inverter overloaded.
	02	Frequency inverter overloaded (60 sec), check load behavior.
	03	Short-term overload (1 sec), check motor and application parameters.

Heat Sink		
Code		Meaning
F02	00	Heat sink temperature too high, check cooling and fan.
	01	Temperature sensor defective or ambient temperature too low.

Inside		
Code		Meaning
F03	00	Inside temperature too high, check cooling and fan.
	01	Inside temperature too low, check electrical cabinet heating.

Motor Connection		
Code		Meaning
F04	00	Motor temperature too high or sensor defective, check connection S6IND.
	01	Motor circuit breaker tripped, check drive.
	02	The V-belt monitoring reports no load on the drive.
	03	Phase failure, check motor and wiring.

Output Current		
Code		Meaning
F05	00	Overloaded, check load situation and ramps.
	03	Short circuit or earth fault, check motor and wiring.
	04	Overloaded, check load situation and current value limit controller.
	05	Asymmetric motor current, check current and wiring.
	06	Motor phase current too high, check motor and wiring.
	07	Message from phase monitoring, check motor and wiring.

DC link voltage

Code		Meaning
F07	00	DC link voltage too high, check deceleration ramps and connected brake Resistor.
	01	DC link voltage too low, check mains voltage.
	02	Power failure, check mains voltage and circuit.
	03	Phase failure, check mains fuses and circuit.
	04	<i>Reference DC-Link Limitation 680</i> too low, check mains voltage.
	05	Brake chopper <i>Trigger Threshold 506</i> too low, check mains voltage.
	06	Motor chopper <i>Trigger Threshold 507</i> too low, check mains voltage.

Electronics voltage

Code		Meaning
F08	01	Electronics voltage 24 V too low, check control terminal.
	04	Electronics voltage too high, check wiring of control terminals.

Output frequency

Code		Meaning
F11	00	Output frequency too high, check control signals and settings.
	01	Max. frequency reached by control, check deceleration ramps and connected brake resistor.

Motor Connection

Code		Meaning
F13	00	Earth fault on output, check motor and wiring.
	01	Set <i>IDC Compensation Limit 415</i> reached, check motor and cabling, increase limit, if necessary.
	10	Minimum current monitoring, check motor and wiring.

Control Connection

Code		Meaning
F14	01	Reference value on multifunctional input 1 faulty, check signal.
	07	Overcurrent on multifunctional input 1, check signal.
	30	Speed sensor signal defective, check connections S4IND and S5IND.
	31	One track of the speed sensor signal is missing, check connections.
	32	Direction of rotation of speed sensor wrong, check connections.

Communication

Code		Meaning
F20	10	Communication watchdog RS232/RS485.

Note: In addition to fault messages mentioned, there are further fault messages. However these messages are only used for internal purposes and are not listed here. If you receive fault messages which are not listed here, please contact us !

12.3 ASCII Tabelle (0x00 – 0x7F)

Dec.	Hex.	Char.	Dec.	Hex.	Char.	Dec.	Hex.	Char.
0	00	NUL	43	2B	+	86	56	V
1	01		44	2C	,	87	57	W
2	02	STX	45	2D	-	88	58	X
3	03	ETX	46	2E	.	89	59	Y
4	04	EOT	47	2F	/	90	5A	Z
5	05	ENQ	48	30	0	91	5B	[
6	06	ACK	49	31	1	92	5C	\
7	07	BEL	50	32	2	93	5D]
8	08	BS	51	33	3	94	5E	^
9	09	TAB	52	34	4	95	5F	_
10	0A	LF	53	35	5	96	60	`
11	0B	VT	54	36	6	97	61	a
12	0C	FF	55	37	7	98	62	b
13	0D	CR	56	38	8	99	63	c
14	0E		57	39	9	100	64	d
15	0F		58	3A	:	101	65	e
16	10		59	3B	;	102	66	f
17	11		60	3C	<	103	67	g
18	12		61	3D	=	104	68	h
19	13		62	3E	>	105	69	i
20	14		63	3F	?	106	6A	j
21	15	NAK	64	40	@	107	6B	k
22	16		65	41	A	108	6C	l
23	17		66	42	B	109	6D	m
24	18		67	43	C	110	6E	n
25	19		68	44	D	111	6F	o
26	1A		69	45	E	112	70	p
27	1B	ESC	70	46	F	113	71	q
28	1C		71	47	G	114	72	r
29	1D		72	48	H	115	73	s
30	1E		73	49	I	116	74	t
31	1F		74	4A	J	117	75	u
32	20	SPACE	75	4B	K	118	76	v
33	21	!	76	4C	L	119	77	w
34	22	"	77	4D	M	120	78	x
35	23	#	78	4E	N	121	79	y
36	24	\$	79	4F	O	122	7A	z
37	25	%	80	50	P	123	7B	{
38	26	&	81	51	Q	124	7C	
39	27	'	82	52	R	125	7D	}
40	28	(83	53	S	126	7E	~
41	29)	84	54	T	127	7F	DEL
42	2A	*	85	55	U			

Note: Often used values are marked gray.



Bonfiglioli has been designing and developing innovative and reliable power transmission and control solutions for industry, mobile machinery and renewable energy applications since 1956.

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