THE HEART OF FRESHNESS

REFERENCE GUIDE

SG-160-1

Frequency Inverter for the CSVH and CSVW compressor
Original document

Frequency Inverters LFC-198 and LFC-289

Software version 1.7x

Electrical skilled installer

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1. Read this first!

The contents of this manual are subject to change without notice.

Lodam electronics a/s holds the copyright to this user's manual. The user must follow any instructions given in this user manual entirely and not only partly. Any disregard of this user manual result in exclusion of all warranties, guarantees, and liabilities.

Disposing of the parts of the Frequency Converter:

INFORMATION FOR USERS ON THE CORRECT HANDLING OF WASTE ELECTRICAL AND ELECTRONIC EQUIPMENT (WEEE)

In reference to European Union directives and the related national legislation, please note that:

1. WEEE cannot be disposed of as municipal waste and such waste must be collected and disposed of separately
2. The public or private waste collection systems defined by local legislation must be used. In addition, the equipment can be returned to the distributor at the end of its working life when buying new equipment
3. The equipment may contain hazardous substances: the improper use or incorrect disposal of such may have negative effects on human health and on the environment
4. The symbol (crossed-out wheeled bin) shown on the product or on the packaging and on the instruction sheet indicates that the equipment must be disposed of separately
5. In the event of illegal disposal of electrical and electronic waste, the penalties are specified by local waste disposal legislation.

Reading instructions
The following symbols are used to draw the reader's attention to different warning levels.

	Important information.
	Warning
	Danger!! Risk of personal injury or death!

1.1 Safety instructions

	**THIS EQUIPMENT IF USED INCORRECTLY IS POTENTIALLY DANGEROUS. THEREFORE, UNDER NO CIRCUMSTANCES SHOULD IT BE USED BEFORE THESE INSTRUCTIONS HAVE BEEN READ AND UNDERSTOOD BY THE END USER WHO SHOULD BE APPROPRIATELY QUALIFIED TO OPERATE THE EQUIPMENT.**

Installation of the LFC-198 or LFC-289 must be performed by authorized and skilled personnel only!

All warranties are excluded in case installation is performed by unauthorized personnel or in case the LFC-198 or LFC-289 has not been correctly installed according to this manual and national or local legislation.

Special care should be taken when installing and connecting external control equipment to the digital inputs, analogue inputs and communication ports.

	**The capacitors for the DC voltage are not discharged immediately after power has been disconnected! To avoid electrical shock, disconnect the mains before doing any maintenance and wait at least 5 minutes for the capacitors to discharge!**

	**The frequency converter contains dangerous voltage sources when it is connected to mains! Permanent earthing is mandatory on all models. The frequency converter can cause a dc current in the protective earthing conductor. Use a protective earthing conductor with same or higher current capabilities as the mains input conductors. Caution! Earth leakage current > 3,5 mA AC / 10 mA DC on all models**

	**Incorrect installation or operation of the frequency converter may cause damage to the equipment or lead to serious personal injury or death! Instructions in this manual must be observed!**

	**Circuit breakers used with VSDs and other similar equipment are not suitable for personnel protection. Use another means to provide personal safety. Refer to EN50178 / VDE0160 / EN60204-1**

1.2 General

The LFC-198 and LFC-289 are Lodam frequency converters designed to be incorporated with a BITZER CSV Screw Compressor. The LFC-198 and LFC-289 adds an electronic control to the compressor.

LFC-198 and LFC-289 are hereafter referred to as FC.

2. Definitions

AC	Alternating Current
AWG	American Wire Gauge
BEST	BITZER Electronics Service Tool
CB	Control Board
CE	European Conformity
Coast	Power to the compressor is switched off and the compressor will coast to a stop (freewheel)
CSA	Canadian Standards Association
CTW	Control Word
DC	Direct Current
FC	Frequency Converter – the LFC-198 and LFC-289
HW	Hardware/electronics.
ICC	Intelligent Compressor Control
ICP	Intelligent Compressor Protection
Inrush	The process of charging the capacitors at power-up of the FC
I/O	Input / Output
MCM	Thousand circular mils (kcmil). 1MCM = 0.5067 mm^2 ~AWG20
Modbus	Serial communication protocol originally by Modicon. An application-layer messaging protocol
PIB	Power Interface Board
PSU	Power Supply Unit
RMS	Root Mean Square, averaged readings
RS485	Hardware communication standard, physical layer. Aka TIA/EIA-485.
RTU	Remote Terminal Unit
STO	Safe Torque Off
STW	Status Word
SW	Software (also called firmware)
TBD	To Be Defined
THD	Total Harmonic Distortion
Trip	A fault condition is active and compressor outputs are switched off (coast)
UL	Underwriters Laboratories
XB	Extension Board

3. Technical data

3.1 Specifications

LFC-198:

Description	CSVH24-125Y-40A	CSVH25-160Y-40A	CSVH26-200Y-40A CSVH26-200MY-40M CSVW26-200MY-40M
Power supply	380 ~ 480 V AC; TN and TT network		
Maximum prospective short circuit current	100 kA RMS @ maximum 480 V input		
Rated input current 380 – 415 V line: 440 – 480 V line:	 220 A RMS 190 A RMS	 260 A RMS 225 A RMS	 340 A RMS 290 A RMS
Inrush time	Max. 10 sec.		
Mains imbalance(1)	Max 3 % of rated supply voltage		
Max fuse rating	Semiconductor fuse. Fuse characteristics aR or gR.		
	250 A	315 A	400 A
Line reactor 380 – 415 V line: 440 – 480 V line:	 100 µH - 130 µH 130 µH - 160 µH	 90 µH - 100 µH 90 µH - 130 µH	 70 µH - 90 µH 70 µH - 100 µH
Maximum number of power-ups per minute	1		
Power factor	> 0.9 at rated load (with line reactor mounted)		
Rated output current 380 V line: 400 – 480 V line:	 210 A RMS 200 A RMS	 270 A RMS 255 A RMS	 340 A RMS 330 A RMS
Output frequency	0 Hz – 267 Hz, dependent on the model		
Temperature range Operation(2) Storage	 -20 °C - +55 °C; max. average over 24 hours is 40 °C -25 °C - +70 °C		
Relative humidity	5 % - 95 % RH, non-condensing; EN60721-3-3 class 3K3 + 3C3 PCB's are coated		
Max altitude(3)	2000 m		
Environment (EN-60664-1)	Pollution degree 1		
Enclosure protection degree	IP54 with enclosure. Nema12 with enclosure IP00 without enclosure		
ELV limits	24 V		
Accessible SELV/PELV voltage	24 V (Conductors leading out of enclosure which are galvanically isolated from live parts)		
Software class	Safety Class B		
Communication	2 RS485 ports, COM1 galvanically isolated Half duplex, max 115 kbit/s Receiver Rin >= 12 kΩ		
Weight	34kg		
Dimensions	290 mm (w) * 260 mm (d) * 580 mm (l)		
Mounting	With bolts onto the compressor. The FC is an incorporated mounted control.		

LFC-289:

Description	CSVH37-240Y	CSVH38-290Y
Power supply	380 ~ 480 V AC; TN and TT network	
Maximum prospective short circuit current	100 kA RMS @ maximum 480 V input	
Rated input current 380 – 415 V line: 440 – 480 V line:	 420 A RMS 370 A RMS	 490 A RMS 430 A RMS
Inrush time	Max. 10 sec.	
Mains imbalance(1)	Max 3 % of rated supply voltage	
Max fuse rating	Semiconductor fuse. Fuse characteristics aR or gR.	
	600 A	600 A
Line reactor 380 – 415 V line: 440 – 480 V line:	 50 µH - 58 µH 50 µH - 70 µH	 40 µH - 50 µH 45 µH - 58 µH
Maximum number of power-ups per minute	1	
Power factor	> 0.9 at rated load (with line reactor mounted)	
Rated output current 380 V line: 400 – 480 V line:	 425 A RMS 425 A RMS	 530 A 530 A
Output frequency	0 Hz – 267 Hz, dependent on the model	
Temperature range Operation(2) Storage	 -20 °C - +55 °C; max. average over 24 hours is 40 °C -25 °C - +70 °C	
Relative humidity	5 % - 95 % RH, non-condensing; EN60721-3-3 class 3K3 + 3C3 PCB's are coated	
Max altitude(3)	2000 m	
Environment (EN-60664-1)	Pollution degree 1	
Enclosure protection degree	IP54 with enclosure. Nema12 with enclosure IP00 without enclosure	
ELV limits	24 V	
Accessible SELV/PELV voltage	24 V (Conductors leading out of enclosure which are galvanically isolated from live parts)	
Software class	Safety Class B	
Communication	2 RS485 ports, COM1 galvanically isolated Half duplex, max 115 kbit/s Receiver Rin >= 12 kΩ	
Weight	48kg	
Dimensions	430 mm (w) * 260 mm (d) * 617 mm (l)	
Mounting	With bolts onto the compressor. The FC is an incorporated mounted control.	

Note1: Imbalance above 3% between phases will lead to reduced lifetime due to increased load of the internal components.
Note2: The ambient temperature is defined as ambient for the FC enclosure.
Note3: By altitudes above 2000m, please contact BITZER regarding the internal isolation level.

The frequency converter uses 6-pulse rectifiers, and IGBTs for the output. The FC has an inrush limitation circuit to reduce the inrush current when the FC is powered up.

3.2 Directives/standards

Please see also the Declaration of Conformity for the FC.

3.2.1 The product is designed according to the following directives

2014/35/EU	Low Voltage Directive (LVD)
2014/30/EU	Electromagnetic Compatibility (EMC)
2011/65/EC	RoHS Directive
EC/1907/2006	REACH directive
2006/121/EC	REACH amending directive amending Council Directive 67/548/EEC
2006/42/EU	Machinery directive

3.2.2 The product is designed and tested according to the following harmonised standards

EN 61800-5-1:2007	Adjustable speed electrical power drive systems Part 5-1: Safety requirements – Electrical, thermal and energy
EN 61800-5-2:2007	Adjustable speed electrical power drive systems Part 5-2: Safety requirements – Functional
EN 61800-3:2004	Adjustable speed electrical power drive system – Part 3: EMC requirements and specific test methods
EN 61000-6-1:2007	Generic EMC Immunity. Residential, commercial and light-industrial environments
EN 61000-6-2:2005	Generic EMC Immunity. Industrial environments
EN 61000-6-4:2007	Generic EMC Emission. Industrial environments
EN61000-6-7:2015	Generic standards – Immunity requirements for equipment intended to perform functions in a safety related system (functional safety) in industrial locations
EN 50581:2012	Technical documentation for the assessment of electrical and electronic products with respect to the RoHS
EN ISO 13849-1:2015	Safety of machinery – Safety-related parts of control systems – Part 1: General principles of design

Other standards below have been used

UL/CSA 60730-1:2009	Standard for Automatic Electrical Controls for Household and Similar Use

3.3 Safe Torque Off – STO

This section provides general, original information about Safe Torque Off (STO).

It is the user's responsibility to:
1) Risk assess the refrigeration system.
2) Design, implement and assess an appropriate solution for each application to meet all relevant safety requirements.

3.3.1 STO functional description

As standard, the FC is equipped with the certified and safety-tested shut-off function, Safe Torque Off (STO).

- The STO function ensures that no torque-generating energy can act any more on the compressor. This will prevent an unexpected start according to EN 60204-1 Section 5.4.
- The STO function safely deletes all pulses of the drive. The drive is safely free of torque. This state is monitored inside the drive.
- The STO function allows the main contactor to the FC to be omitted. The STO, switched via the high-pressure cut out or other safety-relevant protective functions, can shut off the compressor directly.

	**Danger**! The STO function is not a galvanic isolation and may therefore not be used for maintenance or repair work on electrical dangerous parts of the refrigeration system! It is only an electronic protective function during normal operation of the FC. Prior to performing maintenance or repair work on electrical dangerous parts, the FC must be completely disconnected from the mains supply using a suitable electrical disconnecting device and proper insolation of all voltage connections must be checked! Switch off the main switch and secure it against being switched on again. Wait for at least 5 minutes until all capacitors have been discharged!

	The STO function is a factory built-in and tested function. Repairs on a FC equipped with STO function may only be carried out by authorized staff. Any unauthorized attempt to repair or dismantle the FC will void the guarantee and may impair the STO function. As soon as the FC detects an internal STO error, the cause of the error needs to be found and removed. It is not allowed to make any use of the system if an error is shown.

	Maximum line length to terminals X09/1, X09/2: 25 m! The STO input wires need to be installed separate to other cables/wires. A fault exclusion for short circuits to other wires/cables needs to be justified. See ISO 13849-2 Table D.4 for further information.

For high safety requirements, a STO control circuitry with redundant channels has been implemented in the hardware.
The STO circuit is designed such that upon occurrence of an error in part of the internal STO channel, the redundant hardware channel ensures that no inadvertent operation of the FC takes place.

The activated STO function overrides all attempts to start the FC. This means that if the STO function is switched by the STO control input, the FC will not start. This is also true if, for example, an internal software error should result in a start attempt.

3.3.2 Safety specification

As assessed to EN ISO13849-1 and EN61800-5-2 the FC has the following related safety values:

Criterion	Requirement
PFH according to EN 61508/61800-5-2/62061	4e-8/h
PFD according to EN 61508	2e-4 proof test interval 1 year 7e-4 proof test interval 3 years 2e-3 proof test interval 5 years
Classification EN ISO 13849-1:2015	Category 3, Performance Level d
SIL capability	2
$MTTF_D$	> 100 years
DC	≥ 60 %
Mission time	20 years
Fault reaction function	Latched STO

3.3.3 STO technical specification

Inputs specification

Low-level voltage (STO active)	-2.5V to +2.5V
High-level voltage (STO inactive)	+21.6V to +26.4V
Absolute maximum input voltage	-30V to +30V
Max input current @ 26.4V	12mA
Min input current @ 21.6V	6mA
Response time (time from STO activation to no torque on compressor)	<500ms
Maximum permissible test pulse time t_{TP} / test frequency: (Information for use with OSSD (Output Signal Switch Device))	2ms / 10Hz
Conditions in which the STO inputs are operative	All, i.e. STO cannot be disabled in any condition

	The STO signal must be SELV or PELV supplied

3.3.4 User Connections

The STO terminals are on the 2-pole terminal block X09. Terminal designations are

Terminal number	Terminal name	Description
X09/1	STO +	0 V or not connected: STO active and FC will not drive compressor 24 V: STO not active and FC is enabled to drive the compressor The input is galvanically isolated from other terminals except STO -
X09/2	STO -	0 V: Connect 0V potential with respect to STO+ signal to this terminal The input is galvanically isolated from other terminals except STO +

3.3.5 Commissioning

Start-up: Interrupt the signal path of the STO circuit. Try to make a start-up – either by analogue signal or via Modbus. The compressor must not start and the STO alarm signal must be active.
Establish the specified electrical STO signal path and maintain the speed signal. The compressor should start after Timed reset setting seconds.

Operation: Start the compressor and ramp up in speed – either by digital and analogue signal or via Modbus. Interrupt the signal path of the STO circuit; the power to the compressor should be interrupted immediately by the FC and the compressor must stop. The STO alarm must be set.

3.3.6 Automatic restart of STO application

The FC initiates an automatic restart when the STO signal changes from active to inactive.
Verify that the compressor starts after timeout of the Timed reset setting after the STO active signal has turned to inactive.

The signal to the STO input is from the high pressure switch and maybe other protection devices. The high pressure switch has a manual reset.

3.3.7 Service and maintenance

For EN 13849-1 and for high demand mode according to EN 61508 and for EN 62061 the test must always be performed every 12 months.

Only in operation according to low demand mode as defined in EN 61508, the interval can be lengthened to 36 months or 5 years. PFD values can be found in table in chapter 3.3.2 for different proof test intervals.

Operation: Start the compressor and ramp up in speed – either by analogue signal or via Modbus. Interrupt the signal path of the STO circuit; the power to the compressor should be interrupted immediately by the FC and the compressor must coast to a stop. The STO alarm should be set.

Start-up: Interrupt the signal path of the STO circuit. Try to make a start-up – either by analogue signal or via Modbus. The compressor must not start and the STO alarm signal must be active.

After the test the STO must be set and no STO failure alarms must be set.

Please see last page for contact information in case of a defective FC or other questions.

3.4 STO failure messages

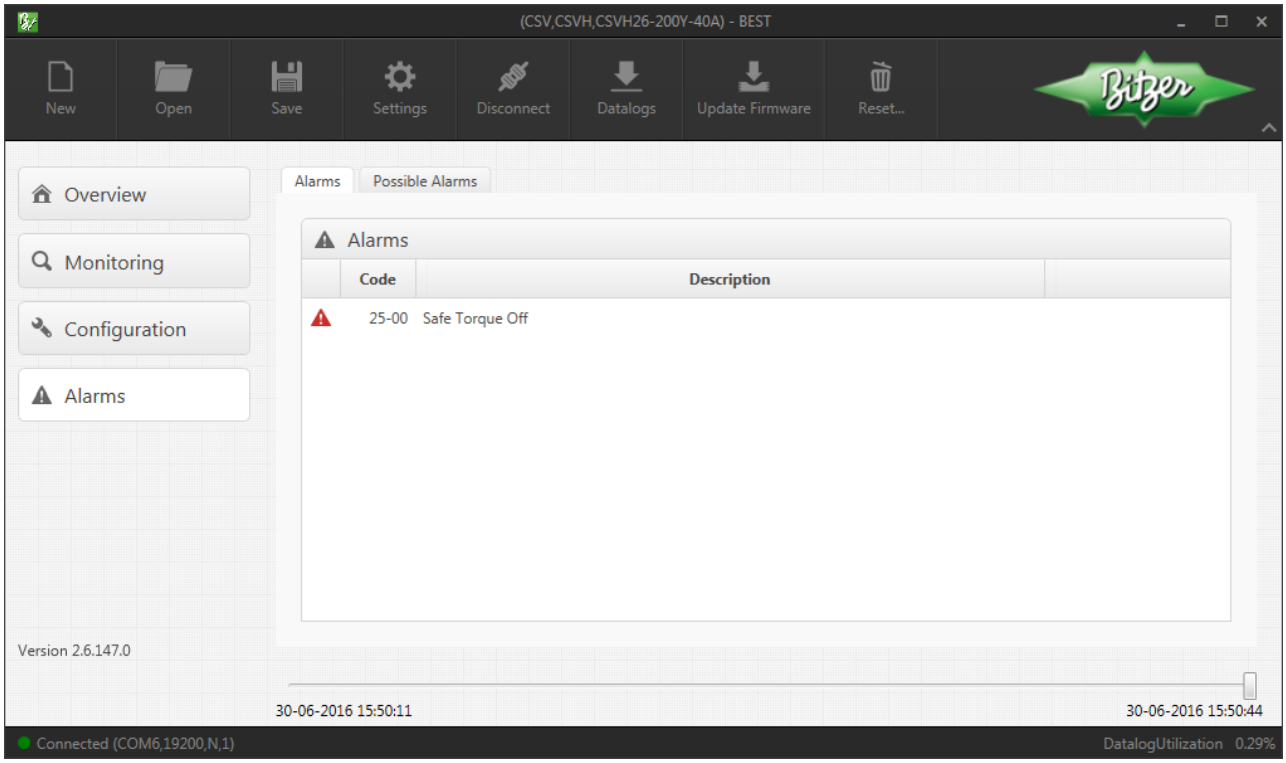
All STO failures are in the alarm Fault category and will stop the compressor.

3.4.1 STO activated

If the STO has been activated, alarm 25-00 Safe Torque Off is set.

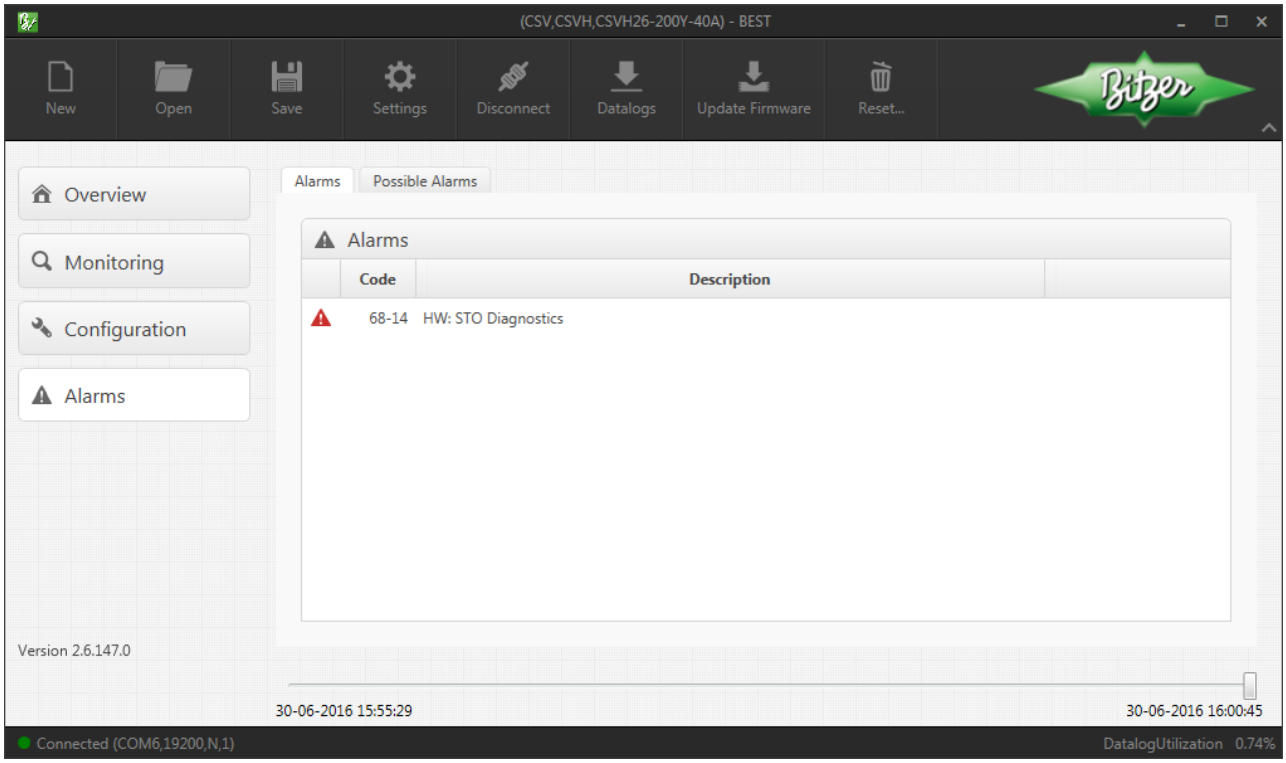
As soon as the STO is deactivated, alarm 25-00 becomes inactive and can be cleared. Operation can continue 60 s after deactivation of the STO.

In BEST the alarm will show like this



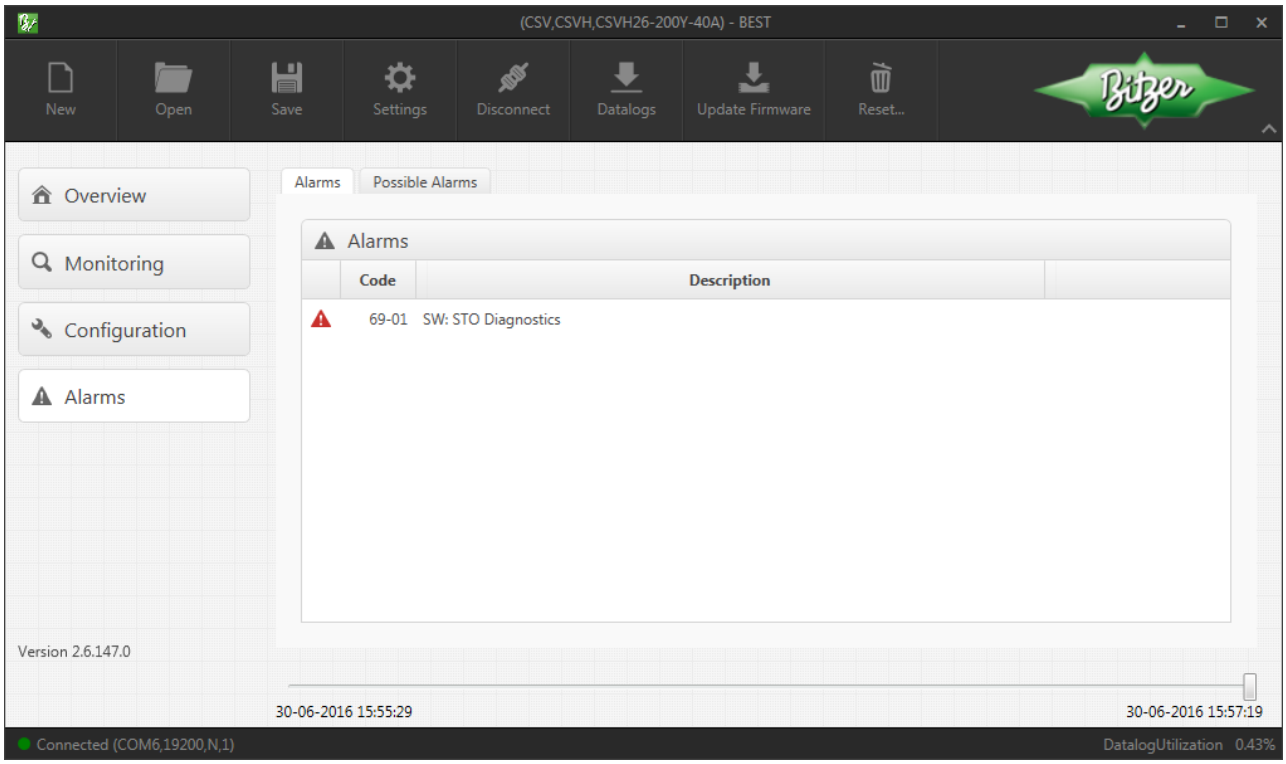
3.4.2 STO failure in redundant channel

If a failure in one of the redundant channels has been detected, alarm 68-14 HW: STO diagnostics is set. In BEST the alarm is shown as this



3.4.3 STO failure in case of malfunctioning diagnostic

In case of a defect in the diagnostic software, alarm 69-01 SW: STO Diagnostics is set.
BEST will show the alarm like this



4. Compressor functions in the FC

Control and status of the FC can be done via digital and analogue I/O, serial bus communication alone or a combination. The serial connection using Modbus (RTU) via RS485 or using BEST gives access to more detailed information of the FC.

The FC has several built-in functions to help control and protect the compressor thus eliminating the need for these functions in the system controller. This way the compressor becomes an intelligent compressor with factory installed sensors and factory configured application envelope.
The protection functions are specialized for the BITZER CSV compressor.

Intelligent Compressor Protection – ICP
The FC is equipped with an Intelligent Compressor Protection, ICP functionality. Using temperature sensors, pressure transmitters, voltage - and current measurement the compressor is protected against overload and operation outside the application envelope.

Intelligent Compressor Control - ICC
The FC has an integrated Intelligent Compressor Control, ICC. It controls the cooling of the compressor via liquid injection, handles Vi adaptation for volume index (ratio) control and control of the oil heater. It also controls cooling of the FC via liquid line.

Motor Control - MC
To protect the cooling installation against resonances some speeds can be avoided for continuous operation.

4.1 Intelligent Compressor Protection, ICP

4.1.1 Compressor overheat protection

The FC monitors the temperature in the motor windings and will stop the compressor if the compressor is overheated and signal a fault. This eliminates the need for extra protection devices.

The warning “Motor Temperature High” will be signalled if the temperature is above the warning limit.
“Motor Temperature High” fault will be signalled if the temperature is above the fault limit and the compressor will stop.

4.1.2 Oil level monitoring

Sufficient oil is crucial for the lifetime of the compressor. The FC monitors the oil level signal from the oil level sensor and stops the compressor if there is still insufficient oil after a specified time.

When an “Oil Level Low” is detected, a critical is signalled after 5 seconds. The compressor keeps running. If the critical is present more than 90 seconds, while the compressor is running, a fault is signalled and the compressor stops.
The fault must be reset by an external reset.

4.1.3 Oil temperature monitoring

If the oil temperature is too high, the compressor may be damaged. The FC monitors the oil temperature and stops the compressor if the temperature gets too high.

“Oil Temperature High” warning is signalled if the oil temperature is above 115 °C.
“Oil Temperature High” fault is signalled if the oil temperature is above 120 °C.
Below 105 °C the fault can be reset and operation can be continued.

4.1.4 Compressor Short Cycling – Start to start interval

A too high number of starts may reduce the lifetime of the compressor. The Start to start interval timer will delay a compressor start if the timer has not expired. If a start command is issued during this delay a

warning, “Compressor Short Cycling” is signalled. The warning signal is reset when the timer expires and a compressor start will follow immediately if the start request is still active.

4.1.5 High and Low Pressure cut-out

This function stops the compressor if the discharge pressure gets too high or the suction pressure gets too low.
For a better protection there is integrated a low- and high pressure cut-out functionality. Compared to the application envelope protection these limits are always active, also and especially during the first 2 minutes after a start where the application envelope protection is deactivated.
The purpose of the low pressure cut-out is to avoid running the compressor into vacuum, the purpose of the high pressure cut-out is to avoid that the maximum operating pressure of the compressor gets exceeded.

The default cut-out value of the low pressure switch is set to 0.8 bar(a), that corresponds to a temperature of -31.6 °C with R134a. The fault will be reset at 0.9 bar(a), respectively the equivalent saturated temperature of -29.0 °C.

The default cut-out value of the high pressure switch is set to 22 bar(a), respectively 21 bar over-pressure. That means a saturated temperature of 72.3 °C. The fault will be reset at an over-pressure of 20.5 bar, respectively an equivalent saturated temperature of 71.4 °C.

Cut-out values, reset values as well as type of fault can be configured by BEST Software.

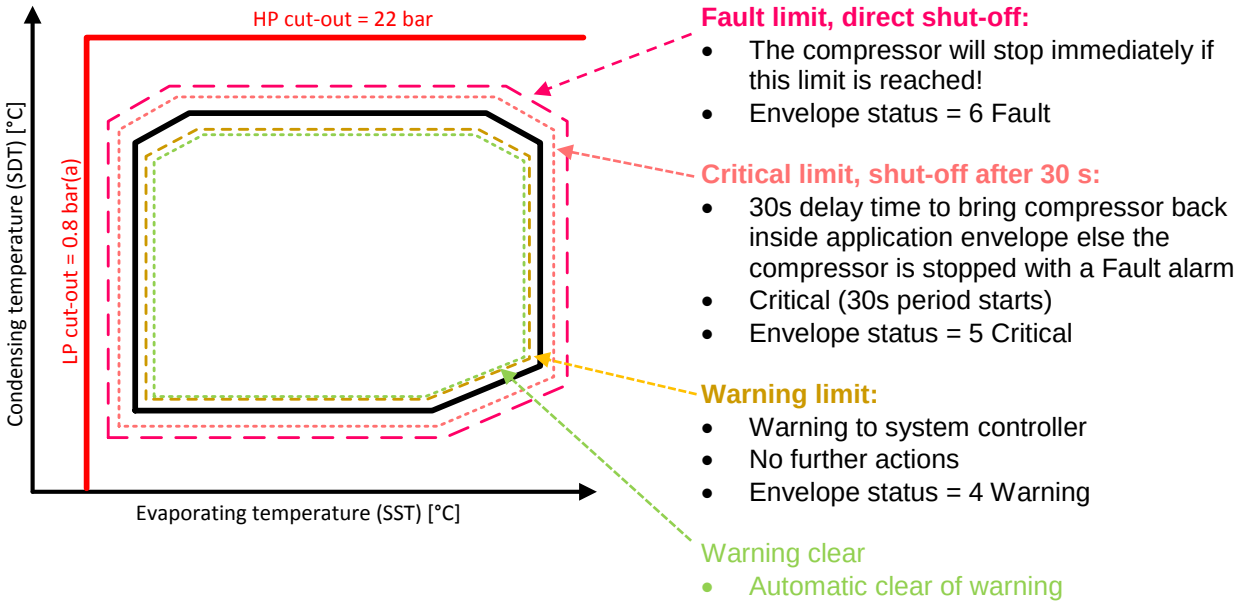
4.1.6 Application Envelope

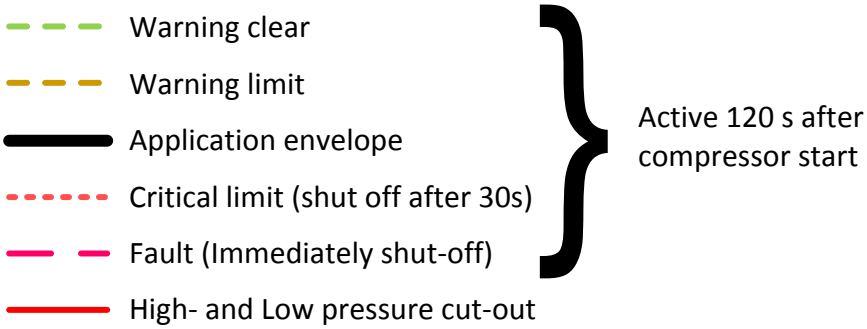
The application envelope function monitors if the operating conditions of the compressor is within the application limits – as shown in the BITZER software tool when doing compressor size calculations.
The BITZER software tool can be downloaded from BITZER’s homepage, www.bitzer.de.

The operating point is determined by the evaporating and condensing gas temperatures, which are calculated from the suction and discharge gas pressures based on the used refrigerant.

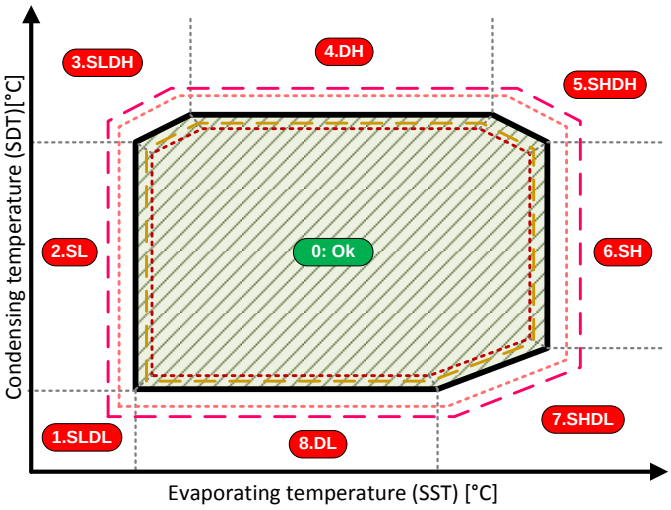
The figure below shows the multi-level monitoring of the application limits and behaviour when a limit is reached.

Active warning, critical and faults are set inactive when the operating point again is within the reset-limit.





There are nine zones in the application envelope as shown on the figure below.
Zone zero (the green-shaded area) is the normal, safe operation area within the application envelope.



Zone number, description and fault number:

Zone 1:	SST Low, SDT Low	3001
Zone 2:	SST Low	3002
Zone 3:	SST Low, SDT High	3003
Zone 4:	SDT High	3004
Zone 5:	SST High & SDT High	3005
Zone 6:	SST High	3006
Zone 7:	SST High & SDT Low	3007
Zone 8:	SDT Low	3008

Zone 0: Normal operation within application envelope and not a fault
SST = Evaporating temperature
SDT = Condensing temperature

A warning, critical or fault will be given if the warning level, critical level or fault level is reached.

Please also see envelope faults '**30-***' in section 8.3 Alarm list.

After a stop due to envelope fault, the fault can be reset when the operating point again is within the warning limit. If timed resets are enabled the FC will perform a timed reset otherwise an external reset is required. The FC will start again if the start command is active or when it is applied again.

Please observe:

	There is no Application Limits monitoring the first 120s after start of the compressor. Envelope status = **2** – Start up

Section 7.3.4 Compressor Status lists several compressor status parameters. There are however two parameters that relate to the application envelope:

- **Envelope Status** lists the status of the compressor and if there should be warnings related to the envelope:
  Envelope status **4** – warning means the operating point of the compressor is between the warning limit and the critical limit.
  Envelope status **5** – critical means the operating point of the compressor is between the critical limit and the fault limit and is only allowed to be there for 30 seconds from this warning became active.
  Envelope status **6** – fault means the compressor is stopped since the operating point of the compressor has been outside the critical limit for more than 30 seconds or has exceeded the fault limit.

- **Envelope Zone** shows in which zone the compressors operating point is right now or if a fault is active, in which zone the operating point was **when** the fault was set.
  The zones are listed above.
  The zone is zero if the operating point is within the warning limit and no envelope faults are active.

4.2 Intelligent Compressor Control, ICC

4.2.1 Oil heater

An oil heater function is provided in order to avoid too much refrigerant dissolved in the oil and to keep the oil temperature above a certain temperature.
The oil heater is turned on if the oil temperature is below a certain temperature. Power must be applied to the FC and 115 / 230 VAC to the control circuit for the oil heater to work.

4.2.2 Liquid injection – for oil cooling (Option)

Liquid Injection is used for oil cooling - controlled by the oil temperature.

The output is activated when the oil temperature, **Toil** exceeds 100 °C. The output is deactivated again when the oil temperature drops below 85 °C.

4.2.3 Vi slider control

The screw compressor has a slider for adjusting the Volume Index (internal volume ratio) for better adaption to the system operating conditions. The function provides automatic adjustment of the slider position based on the compressor operating conditions i.e. the ratio between suction pressure and discharge pressure. When the pressure ratio is exceeding the switchover threshold, the outputs for the slider position are changed. When the pressure ratio is below the threshold, the slider is changed back.

The first change is performed immediately, however all subsequent changes are activated after a delay of 30 s. A change also restarts the time delay to the next change.

4.2.4 Refrigerant cooled FC

The FC has a refrigerant cooled cold plate. The liquid line valve controls the flow of the refrigerant through the cold plate.

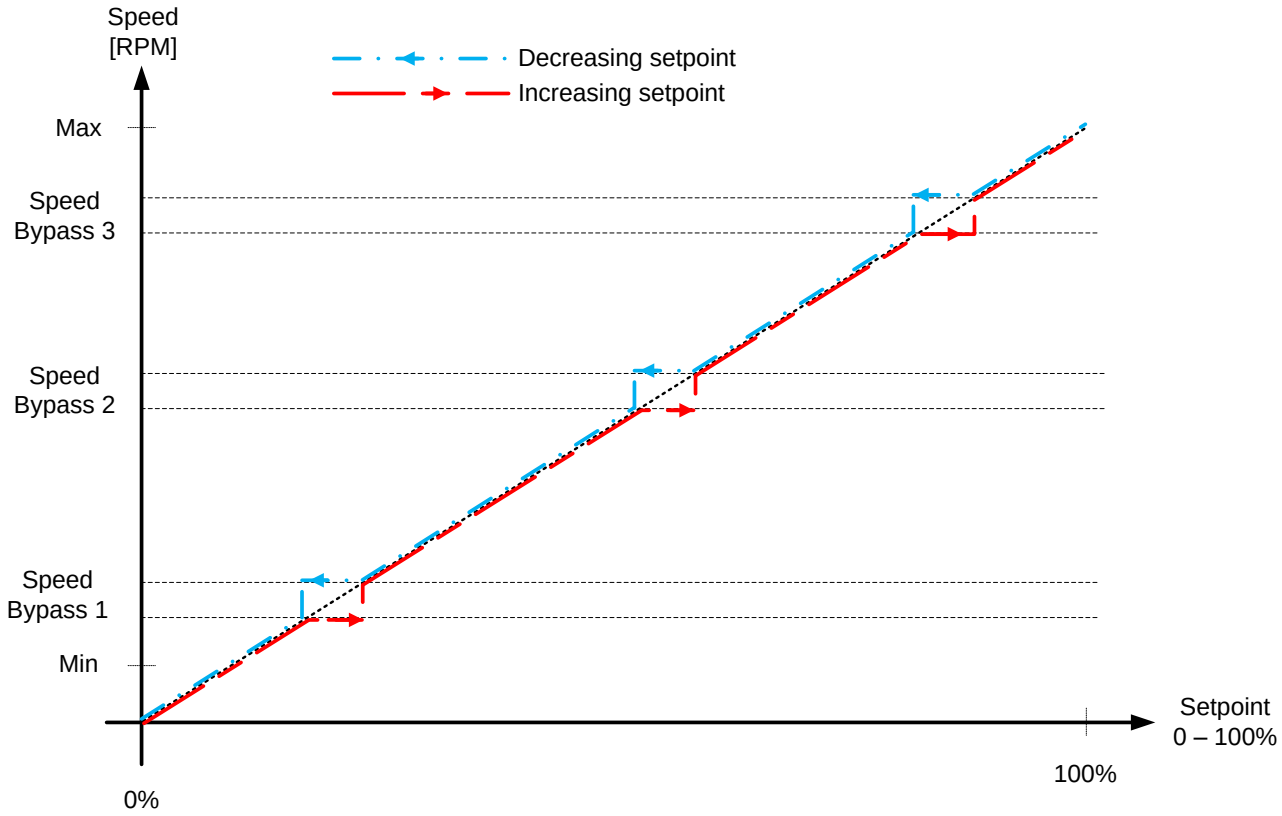
The liquid line valve is open during the Start Delay and when the compressor is running. When the compressor is stopped, the valve is closed.
The liquid line valve is not open during short cycling delay.

4.3 Motor control – MC

4.3.1 Compressor Speed Bypass

Some systems may have resonances at certain speeds. This function is meant for reducing the audible noise by avoiding continuous operation at certain speeds. This is done by limiting the speed setpoint.

This function can blend out three different speed ranges. There is a parameter for the Low speed and the High speed for each of the three separate speed ranges.



Whenever there is a difference between the setpoint and the actual speed, the parameter settings Ramp Time Up and Ramp Time Down are used for the speed change rate. Please see section 5.1.5 Operation examples.

If the Speed Bypass Low and the Speed Bypass High parameters are the same for a Speed Bypass range, the bypass function is disabled for this speed range.

4.4 Datalog

The FC has a built-in datalog that can be extracted using BEST.

The FC stores data in the datalog at regularly intervals as well as statistical data collected and summarized over time. The lifetime of the different data varies.

The datalog contains the following type of entries

- Alarms
- Events
- Parameter changes
- Datalog information
- Periodic data
- Statistics and counters

To increase serviceability the FC has further two internal volatile buffers, Compressor trace and FC trace. They are constantly kept updated during operation with measurements.
If a fault occurs, relevant content of one of these two buffers is then written to the datalog before the fault itself is written to the datalog. This way the service technician can see measurements made just before a fault occurred and get a better indication of what might have caused the fault.

4.4.1 Alarms

Information logged:

- Timestamp
- Alarm code and text
- Severity, can be Fault, Critical or Warning
- Set or Clear

Critical and warnings have Set and Clear entries. E.g.

23-11-2013 03:58	**5003: Under Voltage - Warning - Set**

…

23-11-2013 04:02	**5003: Under Voltage - Warning - Clear**

For faults only Set entries are found. E.g.:

07-11-2013 11:01	3300: High Oil Temperature - Fault - Set

When all faults are successfully reset and the FC is no longer in fault state, there is an entry like this:

02-12-2013 10:45	**0: No Fault - Fault - Clear**

Lifetime of alarm entries: 365 days.

4.4.2 Events

Possible events:

- Power Up – FC started up
- Power Down – FC recognized under voltage situation and ended power down action
- Power came back – only possible after Power Down event. Under voltage situation ended and operation is continued.
- Compressor Start – compressor has started turning
- Compressor Stop – compressor is at stand still

Lifetime of events: 30 days

4.4.3 Parameter changes

In case of parameters changes, which survive after power cycles, this information is logged:

- Timestamp
- Parameter name

- Previous value
- New value
- Channel – possible values: COM1 (i.e. Modbus), COM2 (i.e. BEST), internal
- Optional: “Set to default” – if parameter was commanded to be set to its default value.

Lifetime of parameter changes: 365 days

4.4.4 Datalog information

If bad sections are found in the datalog storage during download, an event is entered, telling that this has happened. If possible, information is added about the number of log entries that was lost.

4.4.5 Periodic data

The following data are stored on a regularly basis and “change of value”. If a value is changed more than a defined percentage the new value is stored. However, if there has been no change in the value after a fixed time of 5 min the values are stored anyhow to have values in the datalog.

	Pressure	Tempe-ratures	FC values	Compr Trace	FC trace
Log time	On change	On change	On change	On some faults	On some faults
Log interval	5s – 5min	5s – 5min	5s – 5min	2,5s	100ms
Lifetime	Some days	Some days	Some days	365 days	365 days
Delta_s				X	X
EvapTemp_SST	X			X	
CondTemp_SDT	X			X	
TempOil		X		X	
TempMotor		X		X	
TempColdPlt (3)		X		X	X
TempPwrMod (3)		X		X	X
SpdSet			X		X
SpdAct			X	X	X
OutputPower(3)			X		
UDC			X	X	X
Control.FC_CtrlWord			X	X	X
Control.FC_StatusWrd			X	X	X
IO_Status.DigInputs				X	X
AlarmStatus.FaultWord					X
AlarmStatus.CriticalWord					X
AlarmStatus.WarningWord					X
HW_Status.PuHwStatus1 (3)					X
HW_Status.PuHwStatus2 (3)					X

Compr. trace: Up to 20 records
FC trace: Up to 40 records
The Log interval is from minimum up to maximum logging interval.

4.4.6 Statistics and counters

Every midnight at 0:00 and at every Power Down a number of entries with counters or statistics are logged. Every one of these entries has a timestamp and some specific data as described below.

4.4.7 Accumulated operation counters

All accumulated since first power up
No of PowerUps
No of compressor Starts
FC Operating Hours
Compressor Operating Hours
No of Inrush

Lifetime: 365 days

4.4.8 Modbus Diagnostics Counters

- Modbus Packets Sent
- Modbus Packets Received
- Modbus Packets Received for me
- Modbus Timeouts Count
- Modbus CRC Errors Count
- Modbus Exceptions Sent

Lifetime: 30 days

4.4.9 Capacity Load

- Device Operating Time – number of minutes, that is basis for the next values
- Cap.Load 0 – percentage of the time, where the compressor was at standstill
- Cap.Load 1-10 – percentage of the time, where the compressor had a load in the range 1-10 %
- Cap.Load 11-20 – percentage of the time, where the compressor had a load in the range 11-20 %
- …
- Cap.Load 91-100 – percentage of the time, where the compressor had a load in the range 91-100 %

Lifetime: 365 days

4.4.10 Daily Counters

- Device Power Ups -- 0 or 1
- Compressor Starts
- Number of Faults
- Number of Criticals
- Number of Warnings
- Device Operating Time
- Compressor Runtime
- Fault Runtime – always zero size, CSV cannot run when fault is present
- Critical Runtime
- Warning Runtime
- Capacity Usage Rate
- Uniformity Degree (how consistent is the FC operation)
- Energy Consumption – currently zero, placeholder for next version

Lifetime: 365 days

4.4.11 Runtime Statistic

- Number of runs 0-4 min
- Number of runs 5-9 min
- Number of runs 10-19 min
- Number of runs 20-29 min
- Number of runs 30-59 min
- Number of runs 60-119 min
- Number of runs 120-299 min
- Number of runs >300 min

Lifetime: 365 days

4.4.12 Compressor Start Statistic

- starts/h
- 2-4 starts/h
- 5-9 starts/h
- 10-14 starts/h
- 15-19 starts/h
- >20 starts/h

Lifetime: 365 days

5. Control of the frequency converter

Control commands and setpoint can be given to the FC via different interfaces

Digital inputs:	Commands
Analogue input:	Setpoint
Serial control:	Commands and setpoint

The commands from the different interfaces are merged and the resulting “FC Control Word” can be read via the serial Interface.
The setpoint is limited between 0 % and 100 % even if the sum of the setpoints may be above 100%.

The serial protocol is Modbus (RTU). Modbus can be connected for example for monitoring only but still using the digital and analogue inputs for control of the FC. Most common is to monitor and control the FC via the Modbus interface.

5.1 Commands and setpoint

The basic operation of the FC is controlled by

- Commands: STO, Coast and Start
- Setpoint
- Setting of the parameters
  - "Ramp Time Up".
  - "Ramp Time Down".
  - "Speed Limit Low". Minimum speed is 1200 RPM
  - "Speed Limit High". Maximum speed depends on the compressor model
  - “Start-to-start interval”. Minimum value is 300 s.
  - “Setpoint Maximum”. The speed that corresponds to 100% setpoint.

  Note: See the above parameters in section 7.3.9 Application Config.
- Setting of serial control parameters
  - "Serial Control Source". See parameter in section 7.3.12 Serial Control Config.
- Internal parameters
  - "Ramp Time at Low Speed" – 1 s per 1000 RPM
  - “Start delay” – 10 s.

Commands and setpoint can be given via the digital and analogue inputs or by combining the digital and analogue inputs with values from the serial interface. See later in this section.

5.1.1 Command Coast

Whenever the Coast command is active, via digital input or serial communication, it will not be possible to start the compressor.
If the Coast command is set active when the compressor is running, output to the compressor will immediately stop and the compressor will coast to a stop (freewheel).
The purpose of a coast command is to stop the compressor immediately without ramping down like by removing the start command.

	**Use of the Coast command does not make it safe to operate on the power outputs to the compressor!** **Turn off the main switch before maintenance and wait at least 5 minutes before operating on the power output from the FC or the wires to the compressor thermistor!**

If the coast input is not needed, it can be permanently activated via a jumper wire or deactivated in BEST Software by changing the parameter “Input to use for the coast command” from “DI 2” to “None”.

5.1.2 Command Start

The Start command becomes active when

- A start signal is given
- The setpoint is higher than 1 %
- The start-to-start time interval has elapsed (Appl.Config – Start to start interval)

When the Start command becomes active, refrigerant injection will start and after expiration of the start delay (10 s) the compressor will start running.

The speed of the compressor will normally match the setpoint. Details are described below.
When the compressor is running and the start condition is removed (Start is set to inactive or Setpoint is set to 0%), the speed of the compressor is ramped down to 0 RPM and the compressor is stopped.

5.1.3 Setpoint – and speed changes

The setpoint is a value in the range 0 % to 100 %. The parameter Setpoint Maximum determines the compressor speed (in RPM) that a setpoint of 100 % is identical to.
The actual speed of the compressor will be ramped to the setpoint (in RPM) with the acceleration and deceleration rates defined by “Ramp Time Up” and Ramp Time Down” as seconds per 1000 RPM. Below 1200 RPM the speed change rate is 1000 RPM/s.
If the resulting setpoint is between 0 RPM and 1200 RPM, the compressor speed will be ramped to 1200 RPM (Low speed limit).
If the rate of setpoint change is slower than the ramp times, the compressor speed will follow the setpoint.

Please see section 7.3.12 Serial Control Config for the parameter to use for the setpoint.

5.1.4 Required signals to start the FC

Minimum signals required to start the FC.

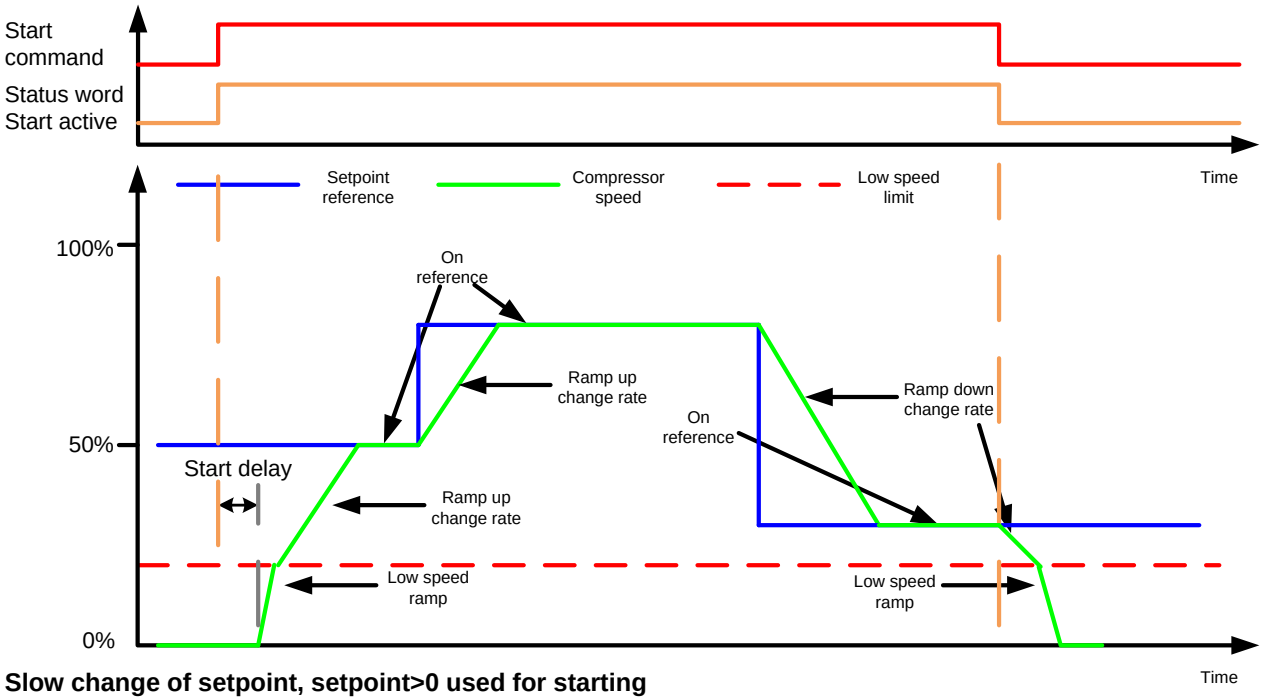
STO (Safe torque off)	Coast [1] command	Start command	Setpoint	FC state	Compressor State
On (active)	-	-	-	Fault	Stopped
Off (inactive)	On	–	-	Coast	Stopped
Off (inactive)	Off	Off	-	Stopped	Stopped
Off (inactive)	Off	On	0 %	Stopped	Stopped
Off (inactive)	Off	On	>1 %	Ramping	Running/ Ramping[2]

Note1: Coast can be disabled via BEST software by setting coast input to None
Note2: Please observe start-to-start delay

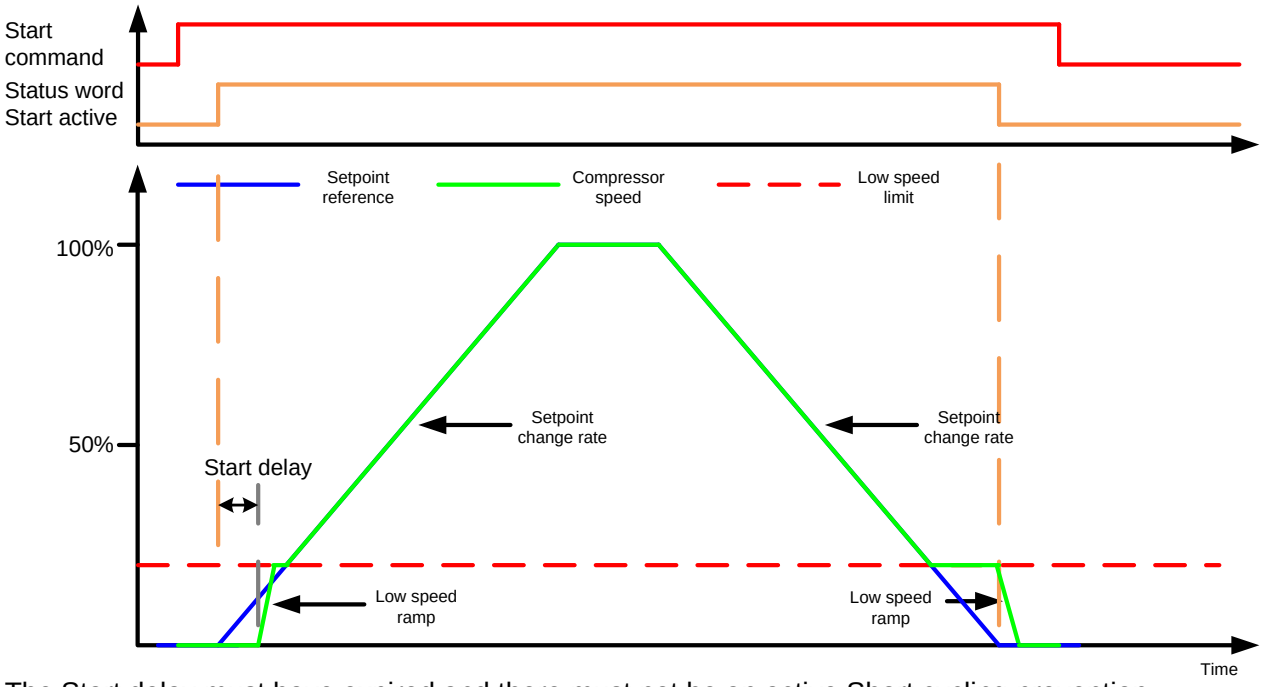
Please see also section 3.3 Safe Torque Off – STO and section 3.4 STO failure messages.

5.1.5 Operation examples

Fast change of setpoint, start command used for starting



Slow change of setpoint, setpoint>0 used for starting



The Start delay must have expired and there must not be an active Short cycling prevention.
The compressor is following setpoint when setpoint is above Low speed limit.
If the setpoint is above zero but below Low speed limit, the Low speed limit is used as setpoint.
After removal of the start command the setpoint is not used.

The Start delay is used for cooling of the FC before start of the compressor.
Starting and stopping a compressor too often may reduce the lifetime of the compressor. Short cycling – start-to-start delay is used for preventing this by setting a minimum time between starts. There is a warning when the start-to-start interval timer is active at a start request.

5.2 Digital commands and analogue setpoint

Digital input number	Function name	Description
1	Start[1]	When this signal is low the start command can be controlled from the serial Modbus interface. When this signal is high the start command is active. Please see section 5.1.2 Command Start.
2	Coast	When the signal is low, the coast command is active and start is blocked. When the signal is high, the coast command is inactive and it is possible to start the compressor via the Start command. Please see section 5.1.1 Command Coast.
3	Reset	This signal is **rising edge** triggered. The reset function is used for resetting alarms. If e.g. the “Over Voltage fault” has been triggered it may be possible to reset that fault by using this command.

Note 1: The Start delay and Start-to-start interval must have expired before the compressor starts. The Start delay is 10s. The default Start-to-start interval is 300s.

Coast signal	Start signal	FC *State*
Low	–	Coast
High	Low	Stopped
High	High	Run

Analogue input number	Function name	Description
1	Setpoint	0 – 10V DC: 0 – 100% setpoint

5.2.1 Using digital and analogue control only

1. Set the digital input Coast to High. Setting the Coast command to Low will immediately deactivate the output to the compressor.
2. Set the digital input Start Low to start the FC.
3. Apply the required setpoint to the analogue input.

If the serial interface should be disabled, please see section 5.3.6 Disable serial control.
The serial interface may prevent the compressor start if it has the coast command active. The setpoint may also be affected by the serial interface if it is active and the setpoint is not set to 0%.

5.3 Serial control (Modbus)

Control commands can be given to the FC via the Serial Control Word. The bit definitions are shown in the table below.
The protocol used is Modbus (RTU). Modbus register definitions are listed in section 7.3 Parameters.

5.3.1 Control Word bit definitions

Bit	Function	Description
0-2	Reserved	Must be set to 1
3	Coast	Coast command is active when bit = 0
4	Reserved	Must be set to 1
5	Reserved	Must be set to 1
6	Start	Start command is active when bit = 1
7	Reset	Positive edge triggered. Reset command is active when bit is set from 0 to 1
8-9	Reserved	
10	Data valid	The serial control word and the serial setpoint are valid for use. The resulting control word will always have this set. Please see section 7.3.1 Control.
11-15	Reserved	

The data valid bit must be set in order to update the serial control word and the serial setpoint.

5.3.2 Data valid bit

The data valid bit must be set to “1” for setpoint and commands to be accepted from the serial control interface.

When the data valid bit is set to “0” all other bits in the control word and the setpoint are ignored. This means that if the start command was active just before the data valid bit is set to “0” the command remains active until the data valid bit is set to “1” and the start bit is set to “0”.
Please see also section 5.3.6 Disable serial control.

5.3.3 Examples of Serial Control Word setups:

Command	Hexadecimal value	Decimal value	Binary							
			Reserved	Data valid	Reserved	Reset	Start	Reserved	Coast	Reserved
No cmd	43F	1087	0000 0	1	00	0	0	11	1	111
Start	47F	1151	0000 0	1	00	0	1	11	1	111
Reset	4BF	1215	0000 0	1	00	1	0	11	1	111
Coast	437	1079	0000 0	1	00	0	0	11	0	111

‘No cmd’ is the neutral value allowing digital control.
The neutral value of the control word is 43F hex (= 1087 dec = 10000111111 binary)
To start the compressor, the control word must be 47F hex (= 1151 dec = 10001111111 binary)
To disable this interface: Please see section 5.3.6 Disable serial control.
In the FC status word, the actual status of the inverter can be seen.
Please see section 7.3.1 Control for specific access to the FC Status Word.

5.3.4 Status Word bit definitions

FC Status Word

Bit	Function	Description
0	Control ready	The control is ready for operation 0: Control not operational 1: The control is ready for operation
1	FC Ready	The FC is ready for operation 0: Power not ready 1: The FC is ready for operation
2	Operation enabled	0: Compressor is coasted (the FC does not apply power to the compressor). 1: Compressor is not coasted. FC controls the compressor
3	Fault	0: No fault present 1: A fault is present. The compressor is coasted (outputs are turned off).
4	Reserved	
5	Reserved	
6	Start disabled	0: Start is enabled. 1: Start is disabled.
7	Warning	0: No warning present 1: A warning is present. The FC continues operation, but attention may be required
8	On Setpoint	0: The compressor is ramping or not running 1: The compressor is operating at setpoint. No ramping active
9	Reserved	
10	Reserved	
11	Running	0: Compressor is not running 1: The compressor is running. Ramping may be active
12	Start active	0: Start command is not given OR start is prohibited (e.g. Coast command active) 1: Start command is given (e.g. start signal is given, setpoint > 0 %, not prevented by start-to-start interval) and Operation is enabled
13	Critical	0: No critical present 1: A critical is present. The FC is close at its limits and may soon coast to protect itself
14-15	Reserved	

Important combinations

Fault	Warning	Running	Start active	State
0	0	0	0	Compressor is stopped
0	1	0	0	Compressor is stopped. Warning is present. Start might be prevented by start-to-start interval
0	X	0	1	FC in start delay period
0	X	1	1	Compressor is Running
0	X	1	0	Compressor is ramping to stop since no start command given
1	X	0	0	Compressor is stopped (coasted) since fault is present

5.3.5 Setting the setpoint

Procedure to limit setpoint adjustment only to be via the Serial interface:

- The setpoint is set via the parameter Serial Setpoint
  Please see sections 7.3.12 Serial Control Config and 7.3.1 Control.

The setpoint is set via the Modbus holding register 111:

Name	Possible values	Default	Description	Modbus type & addr
Serial Setpoint (Control.SerSetpoint)	-200.00 % - 200.00 % scale 100 sint16	0.00 %	Serial setpoint	HR 111

The serial setpoint is a percentage value with 2 decimals. E.g. writing 5000 to the serial setpoint register will set the serial setpoint to 50.00%.

5.3.6 Disable serial control

The serial control is active by default.

To disable serial control:
Set parameter “Serial Control Source” to 0 (= None).
To re-enable the serial control set the parameter to 1 (“COM1”).

5.3.7 Serial Control Timeout Function

If the communication is interrupted, the FC can be configured for different reactions to this interrupt. Default function is to let the FC continue without any changes.

The timeout for activation and the different reactions of the Serial Control Timeout Function can be adjusted. Every update of the Serial control word resets the timeout function.
Please see section 7.3.12 Serial Control Config for further information.

5.4 Combination of digital and serial control

In some installations, it makes sense to use the digital inputs for Start and Coast signals and set the setpoint via the Modbus interface. Digital input Coast is always active and a digital signal must be applied.

The digital signals are used as described in section 5.4.1 Using serial control only:

Coast signal	Start signal	FC state
Low	–	Coast
High	Low	Inactive
High	High	Run

If status of the FC is needed, the FC status word can be read via the Modbus interface:

FC Status Word (Control.FC_Status Wrd)	unit None scale 1 uint16	-	Readout of the status word.	IR 103

- Bit 1, FC ready, must be 1
- Bit 2, Operation enabled must be 1
- Bit 6, Start disabled should be 0

Then the FC is ready for the setpoint setting via Modbus.

5.4.1 Using serial control only

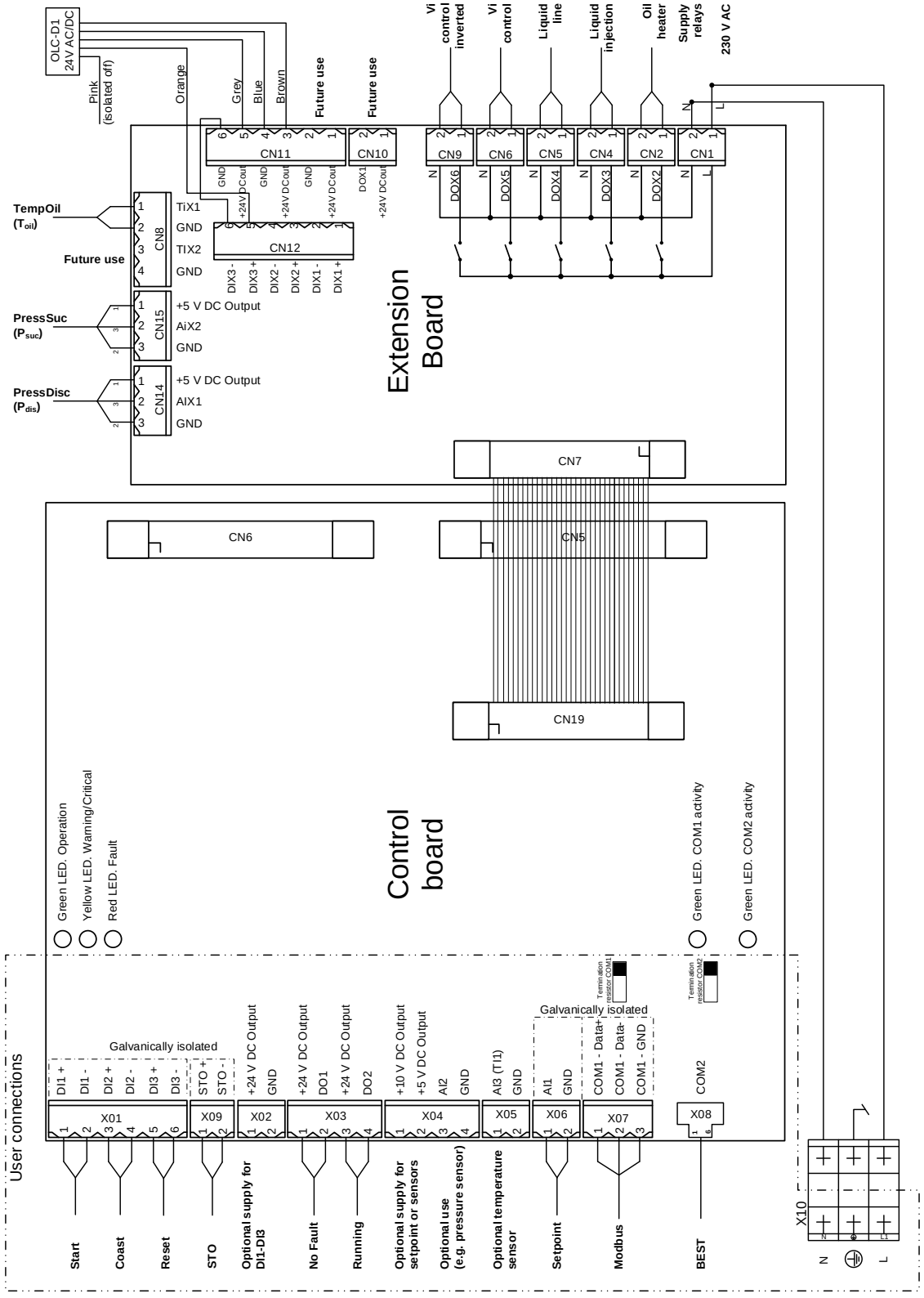
1. Wire the digital input Coast permanently to High. Setting the Coast command to Low will immediately deactivate the output to the compressor.
2. Wire the digital input Start permanently to Low.
3. Apply the required setpoint via the serial interface.

6. Electrical installation

6.1 Recommended guidelines for cable routing

- Signal, control and communication cables should be shielded with braided shielding and the shield connected to the earth connections on the FC
- Signal, control and communication cables should be routed so the influence from the power cables is minimized
- Signal and power cables that run in parallel should be separated by the largest possible appropriate clearance distance, approx. 20 – 25 cm. A grounded shield plate or grounded metal duct can be used instead
- The cable shielding must not be interrupted
- The cables should be kept as short as possible
- Route cables using grounded, metal cable trays or cable ducts. Sections of cable tray or ducts must be connected together with as large areas as possible
- Digital signal cables should have the shield connected at both ends
- Communication cables should be twisted pair for the data wires

6.2 Control connections



Note1: COM2/X08 is for use with BEST and the BEST converter and only for non-permanent use. The outputs of equipment connected to COM2/X08 must comply with PELV or SELV.

Note2: Termination resistors are off when the switches are in the shown (default) position.

6.3 Control cables

Cable/connection dimensions.

Control cables mm²	0.25 – 2.5 mm²
Control cables AWG	24 – 12 AWG

Use 75 °C (Cu) copper cables or higher temperature rated cables. The control cables should be shielded and twisted-pair.
Max cable length for control and signal cables for the Control board is 10m. For Modbus on COM1 the cable length can be up to 100 m.

6.4 User connections – Control Board

The Control Board contains all control cable connections for the users.

Function	Input / output	Connection	Type	Range
Start	In[1]	X01:1 – DI1+ X01:2 – DI1-	Digital	0 / 24 V DC 24 V = Start max source 5 mA Rin typ. 5 kΩ galvanically isolated
Coast	In[1]	X01:3 – DI2+ X01:4 – DI2-	Digital	0 / 24 V DC 0V = Coast max source 5 mA Rin typ. 5 kΩ galvanically isolated
Reset	In[1]	X01:5 – DI3+ X01:6 – DI3-	Digital	0 / 24 V DC 24 V = Reset max source 5 mA Rin typ. 5 kΩ galvanically isolated
STO (Safe Torque Off)	In	X09:1 – STO + X09:2 – STO -	Digital	0 / 24 V DC max source 12 mA Rin typ. 2.7 kΩ galvanically isolated
Optional supply for D1- D4	Out	X02:1 – +24 V DC Output X02:2 – GND	Supply GND	0 / 24 V DC output e.g. for digital inputs in X01.
No Fault	Out[2]	X03:1 – 24 V DC X03:2 – DO1	Digital Open collector	0 / 24 V DC Output active = 0 V max 3W per output
Running	Out[2]	X03:3 – 24 V DC X03:4 – DO2	Digital Open collector	0 / 24 V DC Output active = 0 V max 3W per output
Optional supply for setpoint or sensors to AI1 or AI2 AI2 – future use	Out	X04:1 – +10 V DC Output X04:2 - +5 V DC Output X04:3 – AI2 X04:4 – GND	Supply Supply Analogue GND	0 / 10 V DC output Max output 10 mA. 0 / 5 V DC output Max output 5 mA. Analogue input – for future use
AI3 – future use	In	X05:1 – AI3 (Ti1) X05:2 – GND	Temp.	Temperature input for future use (NTC)
Speed setpoint	In	X06:1 – AI1 X06:2 – GND	Analogue	0 – 10 V DC: 0 – 100 % setpoint Accuracy ±0.5 % of full scale; max source 1 mA; Rin typ. 10 kΩ;

Function	Input / output	Connection	Type	Range
				galvanically isolated
COM1 - Modbus	In/Out	X07:1 – Data+ X07:2 – Data- X07:3 - GND	Serial	Use RS 485 cable for serial communication. Half duplex, max. 100m twisted pair cable, grounded shield, shunt capacitance < 50pF/m, <100 Ω resistance, 2 * 120 Ω termination. Rin typ. >= 12 kΩ. Galvanically isolated.
COM2 - BEST	In/Out	X08	Serial	Use service adapter cable for serial communication. 2 * 120 Ω termination. Rin typ. >= 12 kΩ
230V AC supply	In	X10:N – Neutral X10: ⏚ – Earth X10:L – 230 V AC	Supply Relays 230 V AC	230 V AC Power Supply for relays DOX2 – DOX6

Note1: Digital input can be wired both as PNP and NPN input.
Note2: DO1 and DO2 in X03 are Open collector type and cannot share the same wire for grounding.
Note3: COM2/X08 is for use with BEST and the BEST converter and only for non-permanent use. The outputs of equipment connected to COM2/X08 must comply with PELV or SELV.

6.5 Digital Input/Output Extension Board

The extension board is only for factory connections of the CSV compressor.

Function	Input / output	Connection	Type	Range
Future use	In[1]	CN12:1 – DIX1 + CN12:2 – DIX1 -	Digital	0 / 24 V DC
Future use	In[1]	CN12:3 – DIX2 + CN12:4 – DIX2 -	Digital	0 / 24 V DC
Low Oil level	In[1]	CN12:5 – DIX3 + CN12:6 – DIX3 -	Digital	0 / 24 V DC 0V = Oil level low
Oil heater	Out	CN2:1 – DOX2 CN2:2 – N	Digital	0 / 230 V AC Oil heater on = 230 V Max 2A/230VAC
Liquid injection	Out	CN4:1 – DOX3 CN4:2 – N	Digital	0 / 230 V AC Liquid injection = 230 V Max 2 A/230 V AC
Liquid line	Out	CN5:1 – DOX4 CN5:2 – N	Digital	0 / 230 V AC Liquid line = 230 V Max 2A/230 V AC
Vi control	Out	CN6:1 – DOX5 CN6:2 – N	Digital	0 / 230 V AC Vi control = 230 V Max 2 A/230 V AC
Vi control inverted	Out	CN9:1 – DOX6 CN9:2 – N	Digital	0 / 230 V AC Vi control inverted = 230 V Max 2 A/230 V AC

Future use	Out	CN10:1 – DOX1 CN10:2 – N	Digital	0 / 230 V AC Max 2 A/230 V AC

Note1: Digital input can be wired both as PNP and NPN input.
Note2: Other digital inputs/outputs are reserved for future use.
Note3: The board is factory wired.

6.6 Analogue Input Extension Board

Function	Input / Output	Connection	Type	Range
Oil Temperature, Toil	In	CN8:1 – TIX1 CN8:2 – Gnd	NTC	NTC sensor input Oil temperature Accuracy ±1 °C
TiX2 – future use	In	CN8:3 – TIX2 CN8:4 – Gnd	NTC	NTC sensor input Accuracy ±1 °C
Suction pressure, Psuc	In	CN15:1 – 5 V DC CN15:2 – AIX2 CN15:3 – Gnd	Analogue	0 – 5 V DC; max 5 mA Suction pressure Accuracy better than ±1.5 % of full scale including sensor = ± 0,21 Bar
Discharge pressure, Pdis	In	CN14:1 – 5 V DC CN14:2 – AIX1 CN14:3 – Gnd	Analogue	0 – 5 V DC; max 5 mA Discharge pressure Accuracy better than ±1.5 % of full scale including sensor = ± 0,52 Bar

Note: The board is factory wired.

6.7 Current ratings for control signals

Connector	Recommended rating [mA]
X02	50
X03	2 times 150
X04-1	30
X04-2	10
CN10	150
CN11	Total 50
CN14 **CN15**	Total 100

6.8 Communication and wiring

Communication with the FC is via RS485 using Modbus (RTU).
The FC is connected using a 3-wire connector on COM1 communication port.
Please see section 7.2 Serial communication for more details regarding the protocol definitions.

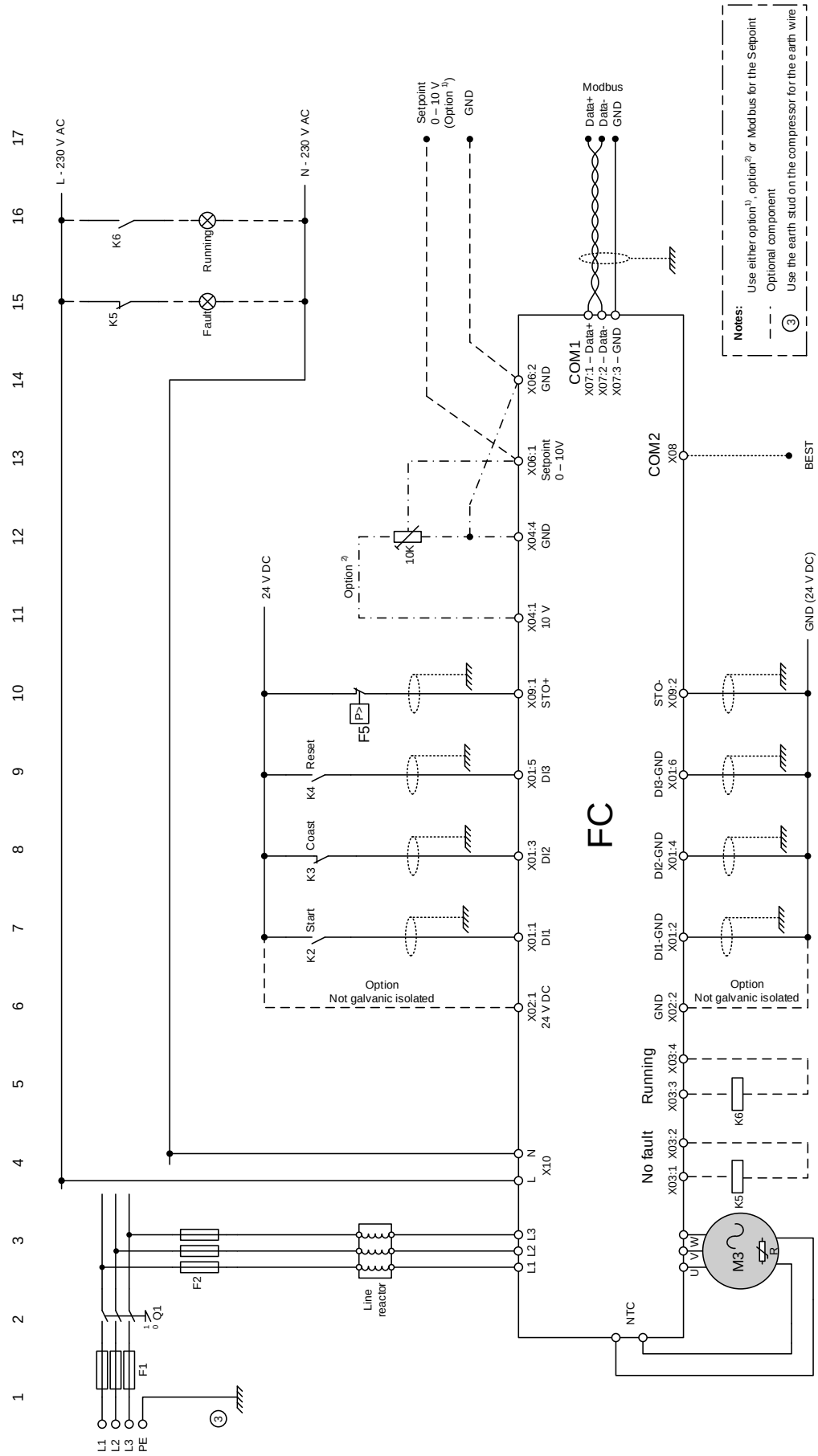
The termination resistors shown in in section 6.2 Control connections are for COM1 and COM2. If the FC is the last unit on the communication line, the termination resistor should be set in the On position.

The BEST Software can be used during commissioning and maintenance using COM2.

BEST Software gives access to most of the parameters marked in section 7 for both reading and modification.

BEST Software is available for free download at the BITZER homepage, www.bitzer.de.

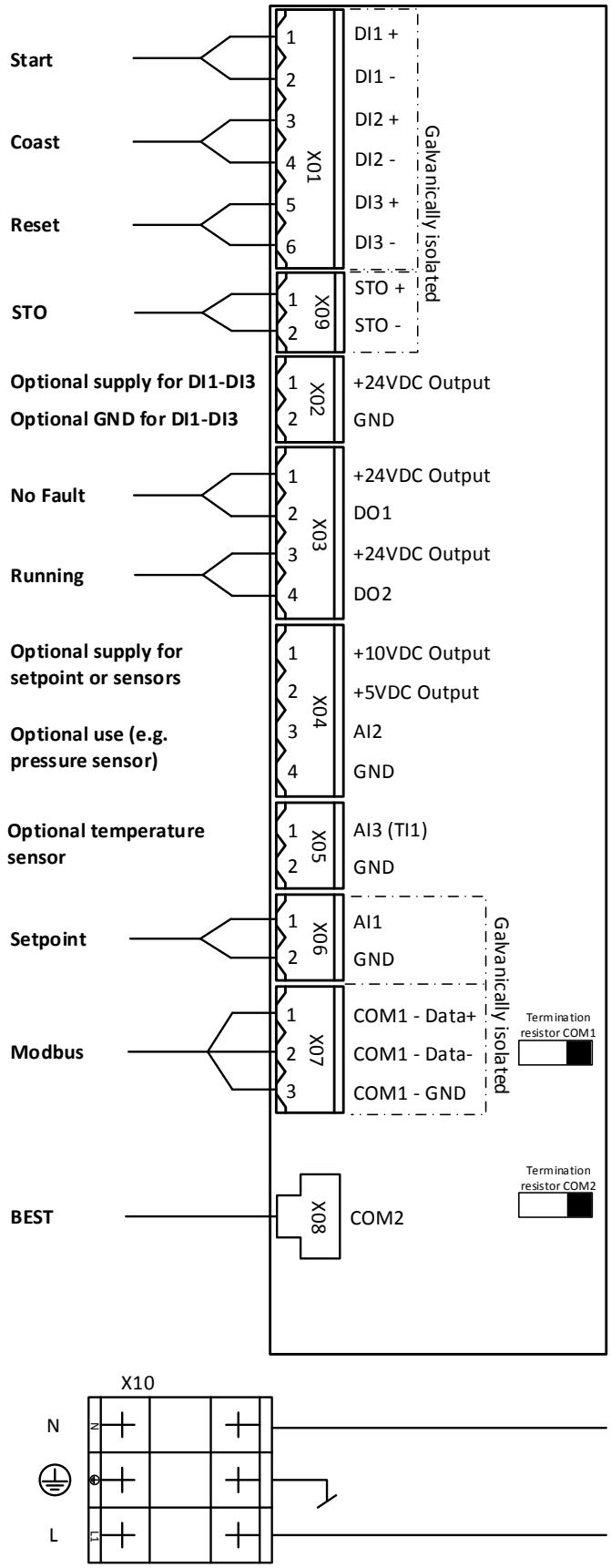
6.9 Connection example – external FC connections



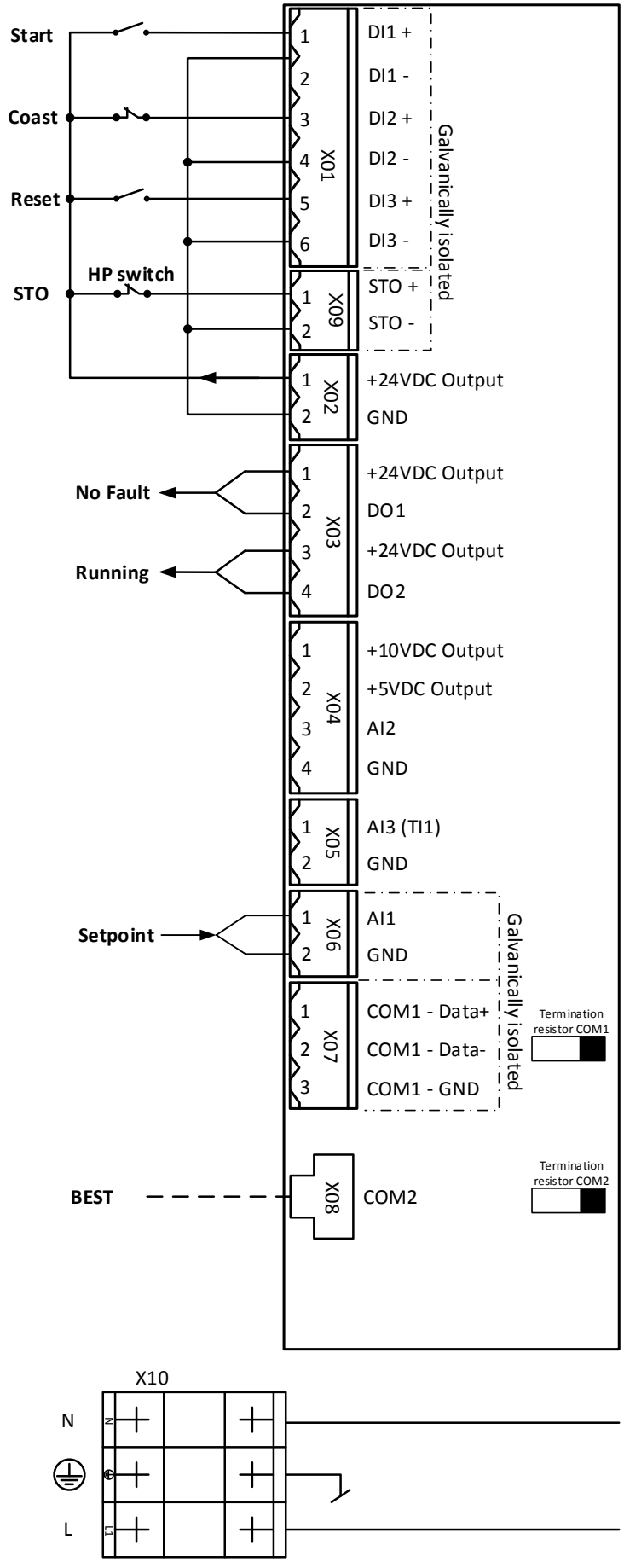
Note: Only sample diagram

6.10 All user connections

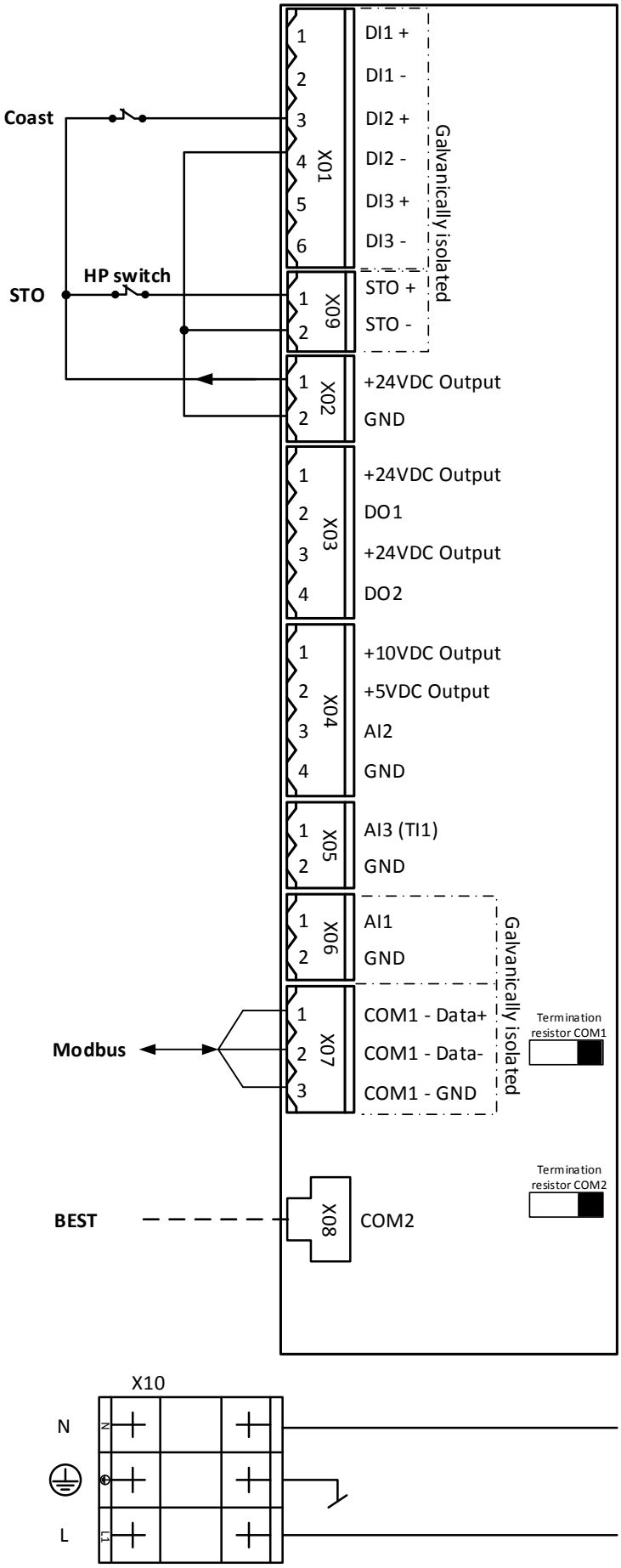
User connections



6.11 User connections – analogue and digital control



6.12 User connections – Modbus control



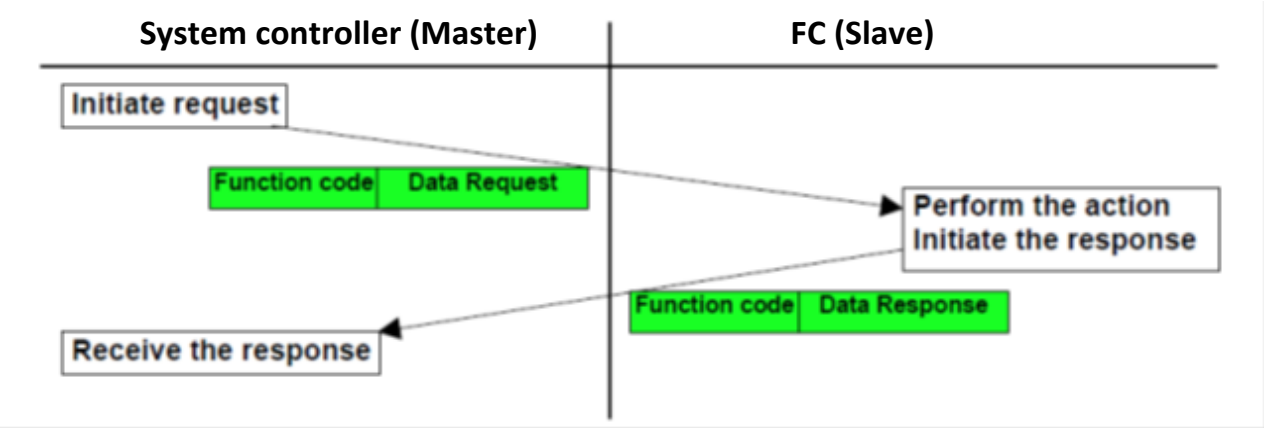
7. Programming and monitoring

7.1 Introduction

Even though the FC is preconfigured for the compressor it is mounted on, there may be a need to adjust some settings or read the status and operation data.

7.2 Serial communication

Communication with the FC is via Modbus (RTU). Configuration and reading of status from the FC is described in the following sections.



7.2.1 Modbus (RTU) configuration

Specification of the protocol:

Protocol:	Modbus (RTU mode). See http://www.modbus.org/specs.php
Modbus address:	FC uses default address 32.
Baud rate:	Default 19200; 4800, 9600, 19200, 38400 and 115200 are selectable.
Number of data bits:	8
Parity:	Default Even; None and Odd are selectable
Number of stop bits:	1; 2 (2 only if Parity is None)

Setup of communication configuration is done via Modbus or BEST Software using the COM1 parameters. Please see section 7.3.18 COM1 Config for the configuration telegram.

Setting of the parameters via BEST or Modbus: Address, Baud rate and Parity will not result in immediate changes of the communication. The setting will be pending (this is indicated by COM1 Config Status showing the value 1 = CfgDirty). Pending values are made active by setting "COM1 Command" to 2 = Program or by cycling power to the FC.

COM1 parameters can be set back to the default values by setting "COM1 Command" to
5 = ResetComm To Factory. This command is a pending change that can be further modified and made active as described above.

7.2.2 Data values, scaling and data types

Following is a description of used scaling and data types.

Scale 1, 10 and 100 refers to where the decimal point is implied, as a decimal value can't be transmitted via Modbus.

Scale 1: The value is the exact value
Scale 10: To transmit a value it must be multiplied by 10; i.e. 12.3 -> 123
A received value must be divided by 10; i.e. 123 -> 12.3
Scale 100: To transmit a value it must be multiplied by 100; i.e. 1.23 -> 123
A received value must be divided by 100; i.e. 123 -> 1.23

uint8: unsigned 8-bit integer
uint16: unsigned 16-bit integer
sint16: signed 16-bit integer
uint32: unsigned 32-bit integer
sint32 signed 32-bit integer

7.2.3 Reading and writing 32-bit values via Modbus

32-bit values must be read as two consecutive Modbus registers.
For example, if the fault word in the input registers 11000-11001 should be read.

B3	B2	B1	B0
MSB			LSB

	Register A		Register A+1	
Transmitted	First			Last
Default	B1	B0 (LSB)	B3 (MSB)	B2

Function code 10hex write multiple registers should be used.

7.2.4 Reading string values via Modbus

A string type is transferred as a number of consecutive registers.
Here the text 'ABCD' is used as a sample.
Line termination, LT=0.
Character order, CO=BACD with MSB (most significant byte) transferred first.

	Register A		Register A+1		Register A+2		Register A+3	
Transmitted	first							last
CO=BADC;	'B'	'A'	'D'	'C'	LT	x	x	x

7.2.5 Modbus function codes

The following function codes have been implemented from the standard Modbus protocol:

Function	Code (hexadecimal)	Code (decimal)	Remarks
Read Holding Registers	03	03	
Read Input Register	04	04	
Write Single Register	06	06	
Diagnostics	08	08	Sub-functions(1) 0, 10-18, 20 (decimal) 0, 0A-12, 14 (hexadecimal)
Get Comm Event counter	0B	11	
Write Multiple Registers	10	16	
Read/Write Multiple Registers	17	23	

Note1: Not all sub-functions return a value.

7.2.6 Modbus exception codes

Code	Name	Meaning
01	Illegal function	The function code is not valid.
02	Illegal data address	The specified register is not valid
03	Illegal data value	The value is not allowed
04	Slave device failure	Unrecoverable error in slave.

Check also parameter COM1 Error Code in case of exception codes. Please see section 7.3.18 COM1 Config.

7.2.7 Modbus communication when using Siemens S7 and some other PLCs

Siemens S7 PLCs and some other PLCs too cannot use the full Modbus address range for Input Registers. Therefore, an alternative set of Input Register addresses can be selected. This alternative set is selected, by setting the parameter Modbus Register Selection (ProtocolCfg.ModbusSelect) to the value 1.

The alternative Input Register addresses can be found inside the parenthesis in the Modbus column of the parameter tables in section 7.3 Parameters.
Please note that the parameter tables contain the zero-based register addresses, but Siemens S7 uses the one-based register numbers. Therefore, add one (1) to the register addresses when entering them in the PLC program.
Input registers must be specified with the 5-digit format 3xxxx. Example: The parameter Setpoint (Control.RO_Setpoint) (IR 100) must be entered as 30101.

The full Modbus address range for Holding Registers can be handled by the Siemens S7 PLCs, when using the 6-digit address format 4xxxxx. One (1) must be added to convert from the zero-based register addresses to the one-based register numbers. Example: The parameter Serial Setpoint (Control.SerSetpoint) HR 110 must be entered as 400111.

7.3 Parameters

The parameters are separated into logical groups.

Name column:	Parameter name. The name in parenthesis is the BEST Software field name.
Possible values:	Parameter unit, scale and range for some parameters.
Default:	The default settings of the parameters.
Description:	Description of the parameter and specific settings for some parameters marked with italics.
Modbus type & addr.:	Modbus register address and type of register. Please observe that register addresses are used in this manual! IR is an Input register (Read Only), (IR xxx) is notation to use with Siemens S7 PLC's and other controllers/PLCs with limited input register address range. Modbus Register Selection must be enabled in section 7.3.16 Protocol Config. HR is a Holding register (Read and write)

The comment ***NotWhileRunning*** means the parameter cannot be changed while the compressor is running.

If a parameter with ***NotWhileRunning*** is being written to while the compressor is running, the return code is set to 3 = "Not writeable in this state".
In section 7.3.18 COM1 Config are listed error codes.

7.3.1 Control

This group contains parameters related to control of the compressor.

Name	Possible values	Default	Description	Modbus type & addr
Setpoint (Control.RO_Setpoint)	unit % scale 100 sint16	-	Readout of the resulting setpoint in percent.	IR 100 (IR 100)
Actual Value (Control.ActualValue)	unit % scale 100 sint16	-	Readout of the actual value in percent. This is comparable to the Setpoint.	IR 101 (IR 101)
FC Control Word (Control.FC_CtrlWord)	unit None scale 1 uint16	-	Readout of the resulting control word.	IR 102 (IR 102)
FC Status Word (Control.FC_StatusWrd)	unit None scale 1 uint16	-	Readout of the status word.	IR 103 (IR 103)
Serial Control Word (Control.SerCtrlWord)	0 - 65535 scale 1 uint16	0x043F	Actual serial control word.	HR 110
Serial Setpoint (Control.SerSetpoint)	-200.00 % - 200.00 % scale 100 sint16	0.00 %	Actual serial setpoint.	HR 111

Please see section 5.3 Serial control (Modbus).

7.3.2 Application Status

This group contains application status parameters.

Name	Possible values	Default	Description	Modbus type & addr
Speed Setpoint (ApplStatus.SpdSetpoint)	unit RPM scale 1 uint16	-	Readout of the speed setpoint. Maximum (SpeedSetpointMax) is compressor dependent.	IR 10000 (IR 1000)
Motor Speed (ApplStatus.MotorSpeed)	unit RPM scale 1 uint16	-	Readout of the actual motor speed. This value is estimated based on rated slip.	IR 10001 (IR 1001)

7.3.3 Alarm Status

This group contains information about current state of alarms.

Name	Possible values	Default	Description	Modbus type & addr
Fault Word (AlarmStatus.FaultWord)	unit None scale 1 uint32	-	Readout of the active faults.	IR 11000-11001 (IR 1100-1101)
Critical Word (AlarmStatus.CriticalWord)	unit None scale 1 uint32	-	Readout of the active criticals.	IR 11002-11003 (IR 1102-1103)
Warning Word (AlarmStatus.WarningWord)	unit None scale 1 uint32	-	Readout of the active warnings.	IR 11004-11005 (IR 1104-1105)

Please see definitions for Warning word, Critical word and Fault Word in section 8.1 Alarm severity types for further information.

7.3.4 Compressor Status

This group contains status values for the compressor.

Name	Possible values	Default	Description	Modbus type & addr
Oil Temperature (CompStatus.TempOil)	unit °C scale 10 sint16	-	Readout of compressor oil temperature.	IR 12000 (IR 1200)
Suction Pressure (CompStatus.PressSuc)	unit bar(a) scale 100 uint16	-	Readout of the suction pressure.	IR 12001 (IR 1201)
Discharge Pressure (CompStatus.PressDisc)	unit bar(a) scale 100 uint16	-	Readout of the discharge pressure.	IR 12002 (IR 1202)

Name	Possible values	Default	Description	Modbus type & addr
Evaporating Temperature (SST) (CompStatus.SatTempSuc)	unit °C scale 10 sint16	-	Readout of the calculated evaporating temperature (saturated suction temperature).	IR 12003 (IR 1203)
Condensing Temperature (SDT) (CompStatus.SatTempDis)	unit °C scale 10 sint16	-	Readout of the calculated condensing temperature (saturated discharge temperature).	IR 12004 (IR 1204)
Envelope Status (CompStatus.EnvelopeStat)	unit None scale 1 uint8	-	Readout of the envelope operating status. *0: stopped, 1: starting, 2: running, 3: stopping, 4: warning (inside envelope), 5: critical (outside envelope), 6: fault (0=Stopped, 1=Starting, 2=Running, 3=Stopping, 4=Warning - inside envelope, 5=Critical - outside envelope, 6=Fault, 7=Defrosting)*	IR 12005 (IR 1205)
Envelope Zone (CompStatus.EnvelopeZone)	unit None scale 1 uint8	-	Readout of the envelope operating zone. *Zone number where a fault happened, if the status is Fault, otherwise number of actual zone (0=Inside, 1=SST Low, SDT Low, 2=SST Low, 3=SST Low, SDT High, 4=SDT High, 5=SST High, SDT High, 6=SST High, 7=SST High, SDT Low, 8=SDT Low)*	IR 12006 (IR 1206)
Short Cycling Remaining Time (CompStatus.ShCycRemain)	unit s scale 1 uint16	-	Remaining time for short cycling protection, i.e. time until a start command will result in a start of the compressor.	IR 12007 (IR 1207)
Start Delay Remaining Time (CompStatus.StDlyRemain)	unit s scale 1 uint16	-	Remaining time for start delay, i.e. the time from a start command is accepted until the compressor will start.	IR 12008 (IR 1208)
Capacity Load (CompStatus.CapacityLoad)	unit % scale 1 sint8	-	Readout of the compressor's capacity load.	IR 12009 (IR 1209)
AI2 Pressure (CompStatus.AI2Pressure)	unit bar(a) scale 100 uint16	-	Readout of AI2 as pressure.	IR 12020 (IR 1220)

Name	Possible values	Default	Description	Modbus type & addr
AI2 Temperature (ST) (CompStatus.AI2SatTemp)	unit °C scale 10 sint16	-	Readout of the calculated temperature (saturated temperature).	IR 12021 (IR 1221)

Please see section 4.1.6 Application Envelope regarding Envelope Status and Envelope Zone and section 5.1 Commands and setpoint for more information about the specific parameters.

7.3.5 Motor Status

This group contains status values for the motor.

Name	Possible values	Default	Description	Modbus type & addr
Motor Temperature (MotorStatus.TempMotor)	unit °C scale 10 sint16	-	Readout of the motor temperature.	IR 13000 (IR 1300)

7.3.6 FC Status

This group contains status values for the FC.

Name	Possible values	Default	Description	Modbus type & addr
Status-Command (FC_Status.StatusCmd)	unit None scale 1 uint8	-	Readout of the command to the FC. *(1=DC, 2=Coast, 3=Q-Stop, 4=Stop, 5=Freeze, 6=Start, 7=NoCmd, 8=Setpoint=0)*	IR 14001 (IR 1401)
Status-State (FC_Status.StatusState)	unit None scale 1 uint8	-	Readout of the state of the FC. *(1=Power Not Ready, 2=Stopped, 3=Short Cycling, 4=Start Delay, 5=Freeze, 6=Running, 7=DC-Inj, 8=Stopping, 9=Locked, 10=Fault, 11=Service)*	IR 14002 (IR 1402)
Status String (FC_Status.StatusString)	char[16]	-	The first part describes the command, second part is the state: 'Command - State'. *Command: Start, NoCmd, Setp=0, Stop, Coast, Fault. State: ShortCyc, StDelay, Running, Stopping, Stopped, Locked*	IR 14030-14037 (IR 1430-1437)
Output Power (FC_Status.OutputPower)	unit kW scale 10 sint16	-	Readout of the calculated output power.	IR 14022 (IR 1422)
DC-link Voltage (FC_Status.UDC)	unit V scale 1 sint16	-	Readout of the DC-link voltage.	IR 14010 (IR 1410)

7.3.7 HW Status

This group contains status values for the hardware in the FC.

Name	Possible values	Default	Description	Modbus type & addr
IGBT Temperature (HW_Status.TempPwrMod)	unit °C scale 10 sint16	-	Readout of the IGBT temperature.	IR 14100 (IR 1500)
Cold Plate Temperature (HW_Status.TempColdPlt)	unit °C scale 10 sint16	-	Readout of the Cold Plate temperature.	IR 14101 (IR 1501)

7.3.8 Input / Output Status

This group contains status values of the inputs and outputs.

Name	Possible values	Default	Description	Modbus type & addr
Analog Input 1 V (IO_Status.AnalogIn1)	unit V scale 100 sint16	-	Readout of voltage on analogue input 1.	IR 15100 (IR 1600)
Analog Input 2 V (IO_Status.AnalogIn2)	unit V scale 100 sint16	-	Readout of voltage on analogue input 2.	IR 15101 (IR 1601)
Analog Input 3 T (IO_Status.AnalogIn3T)	unit °C scale 10 sint16	-	Readout of analogue input 3 temperature (CB TI1).	IR 15112 (IR 1612)
Analog Input 4 T (IO_Status.AnalogIn4T)	unit °C scale 10 sint16	-	Readout of analogue input 4 temperature (XB TIX2).	IR 15113 (IR 1613)
Digital Inputs (IO_Status.DigInputs)	unit None scale 1 uint16	-	Readout of digital input levels. *Bit 0 = DI1, bit 1 = DI2, bit 2 = DI3, bit 3 = DI4, bit 6 = LowOilLevel*	IR 15120 (IR 1620)
Digital Outputs (IO_Status.DigOutputs)	unit None scale 1 uint16	-	Readout of digital output levels. *Bit 0 = DO1, bit 1 = DO2 etc.*	IR 15130 (IR 1630)

7.3.9 Application Config

This group contains configuration parameters related to the application.

Name	Possible values	Default	Description	Modbus type & addr
Ramp Time Up (ApplConfig.RampTimeUp)	0.2 s - 1000.0 s	Compressor	Set the acceleration time per 1000 rpm.	HR 20000

Name	Possible values	Default	Description	Modbus type & addr
	scale 10 uint16	dependent		
Ramp Time Down (ApplConfig.RampTimeDown)	0.2 s - 1000.0 s scale 10 uint16	Compressor dependent	Set the deceleration time per 1000 rpm.	HR 20001
Speed Limit Low (ApplConfig.SpeedLimLow)	0 RPM - 10000 RPM scale 1 uint16	Compressor dependent	Set the lower speed limit below which continuous operation is not allowed. **NotWhileRunning**	HR 20002
Speed Limit High (ApplConfig.SpeedLimHigh)	0 RPM - 10000 RPM scale 1 uint16	Compressor dependent	Set the upper speed limit above which operation is not allowed. **NotWhileRunning**	HR 20003
Short Cycling - Start to Start Interval (ApplConfig.StartToStart)	0 s - 600 s scale 1 uint16	Compressor dependent	Set the minimum time between two starts.	HR 20004
Speed Bypass 1 Low (ApplConfig.Bypass1Low)	0 RPM - 8000 RPM scale 1 uint16	0 RPM	Set the low speed of bypass area 1.	HR 20010
Speed Bypass 1 High (ApplConfig.Bypass1High)	0 RPM - 8000 RPM scale 1 uint16	0 RPM	Set the high speed of bypass area 1.	HR 20011
Speed Bypass 2 Low (ApplConfig.Bypass2Low)	0 RPM - 8000 RPM scale 1 uint16	0 RPM	Set the low speed of bypass area 2.	HR 20012
Speed Bypass 2 High (ApplConfig.Bypass2High)	0 RPM - 8000 RPM scale 1 uint16	0 RPM	Set the high speed of bypass area 2.	HR 20013
Speed Bypass 3 Low (ApplConfig.Bypass3Low)	0 RPM - 8000 RPM scale 1 uint16	0 RPM	Set the low speed of bypass area 3.	HR 20014
Speed Bypass 3 High (ApplConfig.Bypass3High)	0 RPM - 8000 RPM scale 1 uint16	0 RPM	Set the high speed of bypass area 3.	HR 20015
Suction Pressure Low (ApplConfig.SucPresLow)	0.00 bar(a) - 20.00 bar(a) scale 100 uint16	Compressor dependent	Set the low pressure cut out limit.	HR 20020

Name	Possible values	Default	Description	Modbus type & addr
Suction Pressure Low Difference (ApplConfig.SucPresLowD)	0.10 bar - 5.00 bar scale 100 uint16	Compressor dependent	Set the low pressure difference for reset.	HR 20021
Discharge Pressure High (ApplConfig.DisPresHigh)	0.00 bar(a) - 40.00 bar(a) scale 100 uint16	Compressor dependent	Set the high pressure cut out limit.	HR 20022
Discharge Pressure High Difference (ApplConfig.DisPresHighD)	0.50 bar - 10.00 bar scale 100 uint16	Compressor dependent	Set the high pressure difference for reset.	HR 20023

Please see description of how to use the Speed Bypass in section 4.3.1 Compressor Speed Bypass.

7.3.10 Date and Time

This group contains parameters for setting and reading the built-in real time clock. Used for e.g. Fault Log.

Name	Possible values	Default	Description	Modbus type & addr
Date (DateAndTime.Date)	2012-01-01 - 2037-12-31 scale 1 uint32	2012-01-01	Set and readout of current date.	-
Time (DateAndTime.Time)	00:00:00 - 23:59:59 scale 1 uint32	00:00:00	Set and readout of current time.	-
Year	2012 y - 2037 y scale 1 uint16	0 y	Set and readout of current year.	HR 20100
Month and Day	257 - 3103 scale 1 uint16	0	Set and readout of current month and day. *Bit 8-15: month, bit 0-7: day of month*	HR 20101
Hour and Minute	0 - 5947 scale 1 uint16	0	Set and readout of current hour and minute. *Bit 8-15: hour, bit 0-7: minute*	HR 20102
Millisecond	0 ms - 59999 ms scale 1 uint16	0 ms	Set and readout of current milliseconds.	HR 20103

7.3.11 Setpoint Config

This group contains parameters related to configuration of the setpoint.

Name	Possible values	Default	Description	Modbus type & addr
Setpoint Maximum (SetpointCfg.SetpointMax)	1 RPM - 10000 RPM scale 1 uint16	Compressor dependent	Set the scaling of the analogue/serial input to setpoint. This value corresponds to 100% input.	HR 20201
Analogue Setpoint Source (SetpointCfg.AnSetpSource)	0 - 2 scale 1 uint8	1	Select the input to use for analogue setpoint. *(0=None, 1=AI1, 2=AI2)* **NotWhileRunning**	HR 20210

7.3.12 Serial Control Config

This group contains parameters for configuration of serial control.

Name	Possible values	Default	Description	Modbus type & addr
Serial Control Source (SerialCtlCfg.SerCtrlSrc)	0 - 2 scale 1 uint8	1	Select the source for updating the serial control word and setpoint. Set to 'None' for disabling serial control. *(0=None, 1=COM1, 2=COM2)*	HR 20300
Serial Control Timeout Function (SerialCtlCfg.TimeoutFnct)	0 - 2 scale 1 uint8	0	Select the function wanted if serial control is lost, i.e. serial control word is not updated within the specified time. *(0=None, 1=Stop, 2=Fault)*	HR 20301
Serial Control Timeout Time (SerialCtlCfg.TimeoutTm)	1 s - 600 s scale 1 uint16	60 s	Set the timeout value for activating the Serial Control Timeout Function.	HR 20302

7.3.13 Reset Type Config

This group contains parameters for configuration of reset type of faults.

Name	Possible values	Default	Description	Modbus type & addr
Pressure Limits (ResetTypeCfg.PressLimits)	2 - 3 scale 1 uint16	2	Select the reset type for pressure limit faults. *(2=Timed reset, 3=External reset)*	HR 21050
Safe Torque Off Reset Type (ResetTypeCfg.STO)	1 - 3 scale 1 uint16	2	Select the fault reset type for safe torque off. *(1=Auto reset, 2=Timed reset, 3=External reset)*	HR 21051

7.3.14 Timed Reset Config

This group contains parameters for configuration of timed reset of faults.

Name	Possible values	Default	Description	Modbus type & addr
Timed Reset Function (TimedRsetCfg.Enabled)	0 - 1 scale 1 uint16	1	Select whether the timed reset of faults while a fault is present should be off or on. *(0=Off, 1=On)*	HR 21100
Timed Reset Interval (TimedRsetCfg.Interval)	1 s - 300 s scale 1 uint16	60 s	Set the interval between timed reset attempts.	HR 21101

Please see section 8 Trouble shooting and alarms for fault handling.

7.3.15 Compressor Config

This group contains parameters for configuration of compressor speed limits, frequency limit, start delay, compressor pressure sensors etc.

Name	Possible values	Default	Description	Modbus type & addr
Ramp Time at Low Speed (CompConfig.RampTmLowSpd)	0.1 s - 1000.0 s scale 10 uint16	Compressor dependent	The accel/decel time per 1000 rpm below 'Speed Limit Low'	IR 22000 (IR 2200)
Speed Minimum (CompConfig.SpeedMin)	0 RPM - 8000 RPM scale 1 uint16	Compressor dependent	The minimum and default value for the lower speed limit. **NotWhileRunning**	IR 22001 (IR 2201)
Speed Maximum (CompConfig.SpeedMax)	1 RPM - 8500 RPM scale 1 uint16	Compressor dependent	The maximum and default value for the upper speed limit. **NotWhileRunning**	IR 22002 (IR 2202)
AI2 Pressure Minimum (CompConfig.AI2PressMin)	0.000 bar(a) - 40.000 bar(a) scale 1000 uint16	Compressor dependent	Set the minimum value of AI2 as pressure input according to the used pressure sensor. This value corresponds to input low value. *0 or 1.0 bar(a)* **NotWhileRunning**	-
AI2 Pressure Maximum (CompConfig.AI2PressMax)	0.001 bar(a) - 40.000 bar(a) scale 1000 uint16	Compressor dependent	Set the maximum value of AI2 as pressure input according to the used pressure sensor. This value corresponds to input high value. *13.8 or 35.5 bar(a)* **NotWhileRunning**	-

7.3.16 Protocol Config

This group contains configuration of communication protocols.

Name	Possible values	Default	Description	Modbus type & addr
Modbus Register Mapping (ProtocolCfg.ModbusSelect)	0 - 1 scale 1 uint8	0	Selection of Modbus Register Mapping. 0: use the full register address range, 1: use a limited input register address range from 0-9998 used by some controllers (e.g. Siemens S7) *(0=Normal, 1=Limited IR addr. range)*	HR 24000

7.3.17 Input / Output Config

This group contains parameters for configuration of inputs and outputs.

Name	Possible values	Default	Description	Modbus type & addr
AI1 Low Value V (IO_Config.AI1LowValue)	0.00 V - 10.00 V scale 100 sint16	0.10 V	Set the input voltage that corresponds to 0% input.	HR 25000
AI1 High Value V (IO_Config.AI1HighValue)	0.00 V - 11.00 V scale 100 sint16	10.00 V	Set the input voltage that corresponds to 100% input.	HR 25001
AI2 Mode (IO_Config.AI2Mode)	2 - 4 scale 1 uint8	2	Select the input mode for analogue input 2. *(2=Voltage, 3=Temperature, 4=Pressure)*	HR 25019
AI2 Low Value V (IO_Config.AI2LowValue)	0.00 V - 10.00 V scale 100 sint16	0.10 V	Set the input voltage that corresponds to 0% input.	HR 25010
AI2 High Value V (IO_Config.AI2HighValue)	0.00 V - 11.00 V scale 100 sint16	10.00 V	Set the input voltage that corresponds to 100% input.	HR 25011
AI3Sensor_T (IO_Config.AI3Sensor_T)	0 - 6 scale 1 uint8	0	Select the temperature sensor for analogue input 3 (CB). *(0=None, 6=DC95F103V)*	HR 25024
AI4Sensor_T (IO_Config.AI4Sensor_T)	0 - 6 scale 1 uint8	0	Select the temperature sensor for analogue input 4 (XB). *Set value to 5 for special*	HR 25034

Name	Possible values	Default	Description	Modbus type & addr
			sensor (0=None, 6=DC95F103V)	
DigCommand Coast Input (IO_Config.DigCmdCoast)	0 - 3 scale 1 uint8	2	Select the input to use for the coast command. *(0=None, 1=DI1, 2=DI2, 3=DI3)* **NotWhileRunning**	HR 25101
Digital Output 1 (IO_Config.DigOutput1)	0 - 3 scale 1 uint8	1	Select the function to use for digital output 1. *(0=None, 1=No Fault, 2=Warning, 3=Running)* **NotWhileRunning**	HR 25200
Digital Output 2 (IO_Config.DigOutput2)	0 - 3 scale 1 uint8	3	Select the function to use for digital output 2. *(0=None, 1=No Fault, 2=Warning, 3=Running)* **NotWhileRunning**	HR 25201
AI2 Description (IO_Config.AI2Descript)	char[16]	AI2	Set descriptive text for AI2	-
AI3 Description (IO_Config.AI3Descript)	char[16]	AI3	Set descriptive text for AI3	-
AI4 Description (IO_Config.AI4Descript)	char[16]	AI4	Set descriptive text for AI4	-

7.3.18 COM1 Config

This group contains parameters for configuration of the COM1 port.

Name	Possible values	Default	Description	Modbus type & addr
COM1 Address (COM_Config.Address)	1 - 247 scale 1 uint8	32	Set the address for the port. *Modbus RTU: 1-247*	HR 65409
COM1 Baudrate (COM_Config.Baudrate)	1 bps - 132 bps scale 1 uint8	2 bps	Set the data rate for the port. *(1=9600, 2=19200, 3=115200, 131=4800, 132=38400)*	HR 65410
COM1 Parity (COM_Config.Parity)	0 - 2 scale 1 uint8	1	Set the parity for the port. *(0=None, 1=Even, 2=Odd)*	HR 65412
COM1 Stop Bits (COM_Config.StopBits)	1 - 2 scale 1 uint8	1	Set the number of stop bits for the port (value only used if parity is None).	HR 65411
COM1 Command (COM_Config.Cmd)	0 - 5 scale 1 uint8	0	Select action for changing port settings. The value returns to 0 'Ready' after change. *Note: Command 3 and 4 is*	HR 65408

Name	Possible values	Default	Description	Modbus type & addr
			not supported. (0=Ready, 1=Clear CmdReply, 2=Program, 5=Reset COM1 to factory)	
COM1 Command Reply (COM_Config.CmdReply)	unit None scale 1 uint8	-	Status of action set in 'Cmd'. *Note: 3,131,4,132=NotSupported , 143=CmdNotSupported (0=None, 2=ConfigProgDone, 3=N/A, 4=N/A, 130=ConfigProgError, 131=N/A, 132=N/A, 143=N/A)*	IR 65287 (IR 9987)
COM1 Config Status (COM_Config.CfgStatus)	unit None scale 1 uint8	-	Status of port settings. Dirty means the settings has not been activated. *(0=Config OK, 1=Config Dirty)*	IR 65288 (IR 9988)
COM1 Error Code (COM_Config.ErrorCode)	unit None scale 1 uint16	-	Readout of parameter access error code. This value is updated after each parameter access. *(0=OK, 1=Unknown parameter, 2=Read-only parameter, 3=Not writeable in this state, 4=Invalid data type, 5=Value out of range)*	IR 2 (IR 2)

7.3.19 Operation Data

This group contains counters about the operation of the FC and the compressor.

Name	Possible values	Default	Description	Modbus type & addr
FC Operating Hours (OperatioData.FC_OprHrs)	unit h scale 1 uint32	-	Number of hours the FC has been powered up. *Hours*	IR 30000-30001 (IR 3000-3001)
Compressor Running Hours (OperatioData.MotorOprHrs)	unit h scale 1 uint32	-	Number of hours the compressor has been running. *Hours*	IR 30010-30011 (IR 3010-3011)
Number of Starts (OperatioData.NoOfStarts)	unit None scale 1 uint32	-	Number of compressor starts. *Counter*	IR 30012-30013 (IR 3012-3013)
Number of FC Power Ups (OperatioData.NoOfPwrUp)	unit None scale 1 uint32	-	Number of FC power ups/on *Counter*	IR 30020-30021 (IR 3020-3021)

Name	Possible values	Default	Description	Modbus type & addr
Number of Inrush (OperatioData.NoOfInrush)	unit None scale 1 uint32	-	Number of inrush *Counter*	IR 30022-30023 (IR 3022-3023)

7.3.20 Modbus Diagnostics Counters

This group contains Modbus Diagnostics (function 08) counters. Function and subfunction numbers are in hexadecimal. The counters start counting from reset (function 08/subfunction 0A) or power-up of the compressor. See the Modbus protocol specification for further information.

Name	Possible values	Default	Description	Modbus type & addr
Total Message Count (ModbusDiag.PcksRecvd)	unit None scale 1 uint32	-	The number of messages detected on the communications system. Modbus function 08 subfunction 0B.	IR 35104-35105 (IR 3304-3305)
Slave Message Count (ModbusDiag.PcksRecvdMe)	unit None scale 1 uint32	-	The number of messages addressed or broadcasted to this device. Modbus function 08 subfunction 0E.	IR 35106-35107 (IR 3306-3307)
Sent Message Count (ModbusDiag.PcksSent)	unit None scale 1 uint32	-	The number of messages sent from this device. This is not a Modbus Diagnostics subfunction.	IR 35100-35101 (IR 3310-3311)
Modbus Timeouts Count (ModbusDiag.TimeoutsCnt)	unit None scale 1 uint32	-	The number of timeouts for this device. This is not a Modbus Diagnostics subfunction.	IR 35102-35103 (IR 3302-3303)
CRC Error Count (ModbusDiag.ChecksumErrs)	unit None scale 1 uint32	-	The number of CRC errors encountered by this device. Modbus function 08 subfunction 0C.	IR 35108-35109 (IR 3308-3309)
Exception Error Count (ModbusDiag.ExceptSent)	unit None scale 1 uint32	-	The number of exception responses from this device. Modbus function 08 subfunction 0D.	IR 35110-35111 (IR 3300-3301)

Use the listed special Modbus function codes to read the counters.

7.3.21 Compressor Information

This group contains information about the compressor.

Name	Possible values	Default	Description	Modbus type & addr
Compressor Model (CompInfo.CompName)	char[20]	-	Readout of the compressor model.	IR 42000-42009 (IR 4200-4209)

Name	Possible values	Default	Description	Modbus type & addr
Compressor Serial Number (CompInfo.Product_SN)	char[16]	-	Readout of the compressor serial number.	IR 42020-42027 (IR 4220-4227)

7.3.22 Version Info SW

This group contains version information of software in the FC.

Name	Possible values	Default	Description	Modbus type & addr
FC Type (VerInfoSW.FCtype)	char[16]	-	Value for indication of the FC type.	-
SW Version (VerInfoSW.SW_Version)	unit None scale 100 uint16	-	Readout of the control software version.	IR 44020 (IR 4420)
PIB SW Version (VerInfoSW.PIB_SW_Ver)	unit None scale 100 uint16	-	Readout of the power software version.	IR 44030 (IR 4430)
PIB SW Class B Version (VerInfoSW.PIB_SW_B_Ver)	unit None scale 100 uint16	-	Readout of the power software version SW Class B.	IR 44050 (IR 4450)
PIB SW Class B Identification (VerInfoSW.PIB_SW_B_Id)	unit None scale 1 uint32	-	Readout of the power software SW Class B identifier.	IR 44060-44061 (IR 4460-4461)

7.3.23 Version Info File

This group contains version information of data in the FC.

Name	Possible values	Default	Description	Modbus type & addr
Compressor Data (VerInfoFile.Product)	char[32]	-	Readout of version, CRC etc. of compressor data file.	IR 45000-45015 (IR 4900-4915)
Envelope Data (VerInfoFile.Envelope)	char[32]	-	Readout of version, CRC etc. of envelope data file.	IR 45016-45031 (IR 4916-4931)
Motor Data (VerInfoFile.Motor)	char[32]	-	Readout of version, CRC etc. of motor data file.	IR 45032-45047 (IR 4932-4947)
Motor Data SW Class B (VerInfoFile.MotorB)	char[32]	-	Readout of version, CRC etc. of motor SW class B data file.	IR 45048-45063 (IR 4948-4963)

Name	Possible values	Default	Description	Modbus type & addr
FC Functions Data (VerInfoFile.FcFunctions)	char[32]	-	Readout of version, CRC etc. of FC functions data file.	IR 45144-45159 (IR 5044-5059)
Power Unit Data (VerInfoFile.PowerUnit)	char[32]	-	Readout of version, CRC etc. of power unit data file.	IR 45064-45079 (IR 4964-4979)
Power Unit Data SW Class B (VerInfoFile.PowerUnitB)	char[32]	-	Readout of version, CRC etc. of power unit data SW class B file.	IR 45080-45095 (IR 4980-4995)
CB Data (VerInfoFile.CB)	char[32]	-	Readout of version, CRC etc. of CB data file.	IR 45096-45111 (IR 4996-5011)
PIB Data (VerInfoFile.PIB)	char[32]	-	Readout of version, CRC etc. of PIB data file.	IR 45112-45127 (IR 5012-5027)
PSU Data SW Class B (VerInfoFile.PSU_B)	char[32]	-	Readout of version, CRC etc. of PSU data SW Class B file.	IR 45128-45143 (IR 5028-5043)

Example of retrieved data ‘I:116 V:5.2 C:F4EA7FDC’.
I:xx is file ID.
V:x.x is file data version
C:xxxxxxxx is CRC for the file.

7.3.24 Version Info HW

This group contains version information of hardware in the FC.

Name	Possible values	Default	Description	Modbus type & addr
FC Part Number (VerInfoHW.LFC_PN)	char[12]	-	Readout of FC part number.	IR 44400-44405 (IR 4800-4805)
FC Serial Number (VerInfoHW.LFC_SN)	char[16]	-	Readout of FC serial number.	IR 44300-44307 (IR 4700-4707)

Please note that the part numbers are for internal use and not available as BITZER part numbers.

7.4 Compressor dependent parameters

The following list contains default settings of compressor dependent values. In parenthesis is listed if the value also applies to the minimum (min) or the maximum (max) value of the parameter.

Parameter	CSVH24-125Y-40A	CSVH25-160Y-40A	CSVH26-200Y-40A CSVH26-200MY-40M CSVW26-200MY-40M
Ramp time up (min)	10	10	10
Ramp time down (min)	5	5	5
Speed Limit Low (min)	1200	1200	1200
Speed Limit High (max)	5120	6400	8000
Start to start interval (min)	300	300	300
Setpoint Maximum	5120	6400	8000

Parameter	CSVH37-240Y-40A	CSVH38-290Y-40A
Ramp time up (min)	10	10
Ramp time down (min)	5	5
Speed Limit Low (min)	1200	1200
Speed Limit High (max)	5310	6400
Start to start interval (min)	300	300
Setpoint Maximum	5310	6400

7.5 List with the commonly used Modbus parameters

The following Modbus parameters cover most applications for reading information from the inverter. Please see more information listed in section 7.3 Parameters.

Name	Possible values	Default	Description	Modbus type & addr
Speed Setpoint (ApplStatus.SpdSetpoint)	unit RPM scale 1 uint16	-	Readout of the speed setpoint. Maximum (SpeedSetpointMax) is compressor dependent.	IR 10000 (IR 1000)
Motor Speed (ApplStatus.MotorSpeed)	unit RPM scale 1 uint16	-	Readout of the actual compressor speed. This value is estimated based on rated slip.	IR 10001 (IR 1001)
Oil Temperature (CompStatus.TempOil)	unit °C scale 10 sint16	-	Readout of compressor oil temperature.	IR 12000 (IR 1200)
Suction Pressure (CompStatus.PressSuc)	unit Bar scale 100 uint16	-	Readout of the suction pressure (bar a).	IR 12001 (IR 1201)
Discharge Pressure (CompStatus.PressDisc)	unit Bar scale 100 uint16	-	Readout of the discharge pressure (bar a).	IR 12002 (IR 1202)
Evaporating Temperature (SST) (CompStatus.SatTempSuc)	unit °C scale 10 sint16	-	Readout of the calculated evaporating temperature (saturated suction temperature).	IR 12003 (IR 1203)
Condensing Temperature (SDT) (CompStatus.SatTempDis)	unit °C scale 10 sint16	-	Readout of the calculated condensing temperature (saturated discharge temperature).	IR 12004 (IR 1204)

Name	Possible values	Default	Description	Modbus type & addr
Envelope Status (CompStatus.EnvelopeStat)	unit None scale 1 uint8	-	Readout of the envelope operating status. *0: stopped, 1: starting, 2: running, 3: stopping, 4: warning (inside envelope), 5: critical (outside envelope), 6: fault*	IR 12005 (IR 1205)
Envelope Zone (CompStatus.EnvelopeZone)	unit None scale 1 uint8	-	Readout of the envelope operating zone. *Zone number where a fault happened, if the status is Fault, otherwise number of actual zone (0=Inside, 1=SST Low, SDT Low, 2=SST Low, 3=SST Low, SDT High, 4=SDT High, 5=SST High, SDT High, 6=SST High, 7=SST High, SDT Low, 8=SDT Low)*	IR 12006 (IR 1206)
Short Cycling Remaining Time (CompStatus.ShCycRemain)	unit s scale 1 uint16	-	Remaining time for short cycling protection, i.e. time until a start command will result in a start of the compressor.	IR 12007 (IR 1207)
Start Delay Remaining Time (CompStatus.StDlyRemain)	unit s scale 1 uint16	-	Remaining time for start delay, i.e. the time from a start command is accepted until the compressor will start.	IR 12008 (IR 1208)
Motor Temperature (MotorStatus.TempMotor)	unit °C scale 10 sint16	-	Readout of the motor temperature.	IR 13000 (IR 1300)
IGBT Temperature (HW_Status.TempPwrMod)	unit °C scale 10 sint16	-	Readout of the IGBT temperature.	IR 14100 (IR 1500)
Cold Plate Temperature (HW_Status.TempColdPlt)	unit °C scale 10 sint16	-	Readout of the Cold Plate temperature.	IR 14101 (IR 1501)

Alarm status of the inverter can be monitored using the following parameters

Name	Possible values	Default	Description	Modbus type & addr
Fault Word (AlarmStatus.FaultWord)	unit None scale 1 uint32	-	Readout of the active faults.	IR 11000-11001 (IR 1100-1101)
Critical Word (AlarmStatus.CriticalWord)	unit None scale 1 uint32	-	Readout of the active criticals.	IR 11002-11003

Name	Possible values	Default	Description	Modbus type & addr
				(IR 1102-1103)
Warning Word (AlarmStatus.WarningWord)	unit None scale 1 uint32	-	Readout of the active warnings.	IR 11004-11005 (IR 1104-1105)

Please observe that the above parameters are 32 bit. In section 7.2.3 Reading and writing 32-bit values via Modbus is listed how to read these values.

7.6 Fault log

The FC's fault log has a history depth of 10 levels.
The FC stores the 10 latest detected different faults. A fault condition can be detected several times and the number of faults is stored.
Please see a list of fault codes and description in section 8 Trouble shooting and alarms.

7.6.1 Fault Log 1 to 10

The Fault Log group contains information about alarm code of the fault, number of times the specific fault has occurred and date and time for the last occurrence of the fault.

Fault Log 1 to 10 represents 10 different Faults, each with its own counter and time and date for last occurrence.
Fault Log 1 to 10 have the same layout, however the Modbus registers increases by 10 from one Fault Log entry to the next Fault Log entry.

Fault Log 1

Name	Possible values	Default	Description	Modbus type & addr
Alarm Code (FaultLog1.AlarmCode)	unit None scale 1 uint16	-	Alarm number of the fault.	IR 31000 (IR 3100)
Fault Count (FaultLog1.FaultCount)	unit None scale 1 uint16	-	Number of times the fault has occurred.	IR 31002 (IR 3102)
Date (FaultLog1.Date)	unit None scale 1 uint32	-	Date of last fault occurrence.	-
Time (FaultLog1.Time)	unit None scale 1 uint32	-	Time of last fault occurrence.	-
Year	unit None scale 1 uint16	-	Year of last fault occurrence.	IR 31003 (IR 3103)
Month and Day	unit None scale 1 uint16	-	Month and day of last fault occurrence. *Bit 8-15: month, bit 0-7: day of month*	IR 31004 (IR 3104)

Name	Possible values	Default	Description	Modbus type & addr
Hour and Minute	unit None scale 1 uint16	-	Hour and minute of last fault occurrence. *Bit 8-15: hour, bit 0-7: minute*	IR 31005 (IR 3105)
Milliseconds (FaultLog1.MilliSec)	unit ms scale 1 uint16	-	Milliseconds of last fault occurrence.	IR 31006 (IR 3106)

7.7 Firmware update

The firmware is updated using the BEST Software. Only communication port COM2 can be used for a firmware update.

	A firmware update cannot be performed while the compressor is running!

8. Trouble shooting and alarms

Installation, service and electrical troubleshooting of the FC must be performed by authorized and skilled personnel only!

	**The capacitors for the DC voltage are not discharged immediately after power has been disconnected!** **To avoid electrical shock, disconnect the mains before doing any maintenance and wait at least 5 minutes for the capacitors to discharge!**

	**Incorrect installation or operation of the frequency converter may cause damage to the equipment or lead to serious personal injury or death!** **Instructions in this manual must be observed!**

8.1 Alarm severity types

There are the following alarm severity types:

Fault:

- If a fault-level alarm condition is detected, the FC will coast (turn off outputs to the compressor) and the compressor will stop running (freewheel).
- The bit number corresponding to the fault condition is set in the Fault word according to the table in the next section.
- A fault is logged in the fault log.

Critical:

- If a critical-level alarm condition is detected, operation may continue but for a limited time or with reduced performance.
- The bit number corresponding to the critical condition is set in the Critical Word according to the table in the next section.

Warning:

- A warning is signalled when a condition occurs which may require attention but is not severe enough to stop operation of the FC. The compressor keeps running.
- The bit number corresponding to the warning condition is set in the Warning word according to the table in the next section.

Warnings, Criticals and Faults can be active at the same time as they may have separate alarm limits.

8.2 Fault reset types

Below are listed the different methods to reset faults.
A reset will dismiss faults where the fault condition has disappeared.
An external reset can reset both externally and timed resettable alarms; a timed reset however, can only reset timed resettable alarms.

Restart: Cleared by a power cycle of the FC.

External reset: The fault is cleared when the reset command is received and the fault condition has disappeared.

	**Continuous automatic external reset of a fault may lead to breakdown of the FC if the cause is not resolved!** **Please consider if automatically initiated external reset is needed!**

Timed reset: Timed reset is an automatic, repetitive, timed reset.
Timed reset is enabled in the Timed Reset parameter.
Please see section 7.3.14 Timed Reset Config for details.
Timed resets will be issued with an interval of ”Timed Reset Timeout” time as long as a timed resettable fault is present.

Auto: Automatic reset of faults when the fault condition disappears.

8.2.1 Monitoring of faults of timed resets type

Some faults will be reset after a certain time after the failure has disappeared. These faults are “Timed resets”. Please see section 7.3.14 Timed Reset Config for more information.

To avoid infinite repetitive starts due to “Timed Resets”, the following rules are applied:

- If the same timed resettable fault occurs 5 times within 24 hours, the fault “1000 Too many identical timed reset faults in 24 hours” will be set
- If any or the same timed resettable fault occurs 5 times within 1 hour, the fault “1001 Too many timed reset faults in 1 hour” will be set
- Both fault 1000 and 1001 requires an “External reset” or a “Restart” to be cleared
- The faults are counted when a timed resettable fault brings the FC to a fault state from a non-fault state.
  Both the 1 hour and the 24 hour fault counters are cleared whenever an “External reset” is applied to the FC

8.3 Alarm list

The Bit number column in the table below refers to the 32-bit Warning word, 32-bit Critical word and 32-bit Fault word.

Bit31	Bit16	Bit15	Bit0
MSB			LSB

No.	Text	Warning	Critical	Fault	Fault type	Bit number	Fault trace
10-*	System - Operation						
1000	Too many identical timed reset faults in 24 hours	No	No	Yes	External	0	None
1001	Too many timed reset faults in 1 hour	No	No	Yes	External	0	None
11-*	System - Communication						
1100	Serial Control Timeout	Yes	No	Yes	Timed	0	None
12-*	System - Supply						
1200	Mains Failure	No	No	Yes	Timed	1	None
25-*	Application - Other Input						
2500	Safe Torque Off	No	No	Yes	STO	0	Compr
30-*	Compressor - Operation						
3001	Envelope: SST Low, SDT Low	Yes	Yes	Yes	Timed	2	Compr
3002	Envelope: SST Low	Yes	Yes	Yes	Timed	2	Compr
3003	Envelope: SST Low, SDT High	Yes	Yes	Yes	Timed	2	Compr
3004	Envelope: SDT High	Yes	Yes	Yes	Timed	2	Compr
3005	Envelope: SST High, SDT High	Yes	Yes	Yes	Timed	2	Compr
3006	Envelope: SST High	Yes	Yes	Yes	Timed	2	Compr
3007	Envelope: SST High, SDT Low	Yes	Yes	Yes	Timed	2	Compr
3008	Envelope: SDT Low	Yes	Yes	Yes	Timed	2	Compr
3010	Envelope: Startup Timeout	No	No	Yes	Timed	3	Compr
3011	Envelope: Configuration Failure	No	No	Yes	Restart	3	Compr
3020	Compressor Short Cycling	Yes	No	No	N/A	4	None
33-*	Compressor - Temperature						
3300	Oil Temperature High	Yes	No	Yes	Timed	5	Compr
34-*	Compressor - Pressure						
3400	Suction Pressure Low	No	No	Yes	Pressure Limit	22	Compr

No.	Text	Warning	Critical	Fault	Fault type	Bit number	Fault trace
3411	Discharge Pressure High	No	No	Yes	Pressure Limit	22	Compr
35-*	Compressor - Other Input						
3500	Oil Level Low	No	Yes	Yes	External	6	Compr
40-*	Motor - Operation						
4000	Motor Overload	No	No	Yes	External	8	FC
43-*	Motor - Temperature						
4301	Motor Temperature High	Yes	Yes	Yes	Timed	10	Compr
50-*	FC - Operation						
5000	Inverter Output[1]	No	Yes	Yes	External	11	FC
5001	Over Current	Yes	No	Yes	External	12	FC
5002	Over Voltage	Yes	No	Yes	External	13	FC
5003	Under Voltage	Yes	Yes	Yes	Timed	14	FC
5004	FC Overload	Yes	Yes	Yes	External	11	FC
53-*	FC - Temperature						
5300	Over Temp: Power Module	Yes	Yes	Yes	Timed	15	FC
5301	Over Temp: Cold Plate	Yes	No	Yes	Timed	15	Compr
5302	Over Temp: Power I. Board	Yes	No	Yes	Timed	15	Compr
56-*	FC - HW Configuration						
5600	HW Config: Power not Supported	No	No	Yes	Restart	16	None
5601	HW Config: Gate Drive Missing	No	No	Yes	Restart	16	None
57-*	FC - SW Configuration						
5700	Config Data: Power Data	No	No	Yes	Restart	17	None
5701	Config Data: Prod Data	No	No	Yes	Restart	17	None
5710	Parameter Config: Motor Data	No	No	Yes	Auto	18	None
58-*	FC - Electronics Fault						
5801	HW: Power MCU	No	No	Yes	Restart	19	None
5802	HW: Inrush	No	No	Yes	Auto	19	FC
5803	HW: Inrush Supply	No	Yes	Yes	Restart	19	None

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Continuous automatic external reset of an External Reset may lead to breakdown of the FC if the cause is not resolved!

No.	Text	Warning	Critical	Fault	Fault type	Bit number	Fault trace
5810	HW: Gate Drive U	No	No	Yes	External	19	FC
5811	HW: Gate Drive V	No	No	Yes	External	19	FC
5812	HW: Gate Drive W	No	No	Yes	External	19	FC
5820	HW: Fan1 Speed Low	Yes	No	No	N/A	19	None
5821	HW: Fan2 Speed Low	Yes	No	No	N/A	19	None
5851	HW: 24V	No	No	Yes	External	19	FC
5852	HW: 15V	No	No	Yes	External	19	FC
5853	HW: N15V	No	No	Yes	External	19	FC
5854	HW: PIB 3.3V	No	No	Yes	Restart	19	FC
63-*	Device - Temperature						
6303	Over Temp: Control Board	Yes	No	Yes	Timed	15	Compr
66-*	Device - HW Configuration						
6601	HW Config: Control Not Supported	No	No	Yes	Restart	16	None
6602	HW Config: No XB	No	No	Yes	Restart	16	None
67-*	Device - SW Configuration						
6700	Config Data: No File	No	No	Yes	Restart	17	None
6701	Config Data: CRC Error	No	No	Yes	Restart	17	None
6702	Config Data: Wrong Version	No	No	Yes	Restart	17	None
6703	Config Data: Read Only	No	No	Yes	Restart	17	None
68-*	Device - Electronics Fault						
6801	HW: Control MCU	No	No	Yes	Restart	19	None
6810	HW: 3.3V	No	No	Yes	Restart	19	FC
6811	HW: User 5V	No	No	Yes	Restart	19	FC
6812	HW: Compr. 5V	No	No	Yes	Restart	19	FC
6814	HW: STO Diagnostics	No	No	Yes	Restart	0	FC
6850	HW: Power MCU Comm	No	Yes	Yes	External	19	FC
69-*	Device - Other						
6900	Datalog error	Yes	No	No	N/A	23	None
6901	SW: STO Diagnostics	No	No	Yes	External	0	None
73-*	Sensor - Temperature						
7300	Sensor: Power Module	No	No	Yes	Timed	21	FC

No.	Text	Warning	Critical	Fault	Fault type	Bit number	Fault trace
7301	Sensor: Cold Plate	No	No	Yes	Timed	21	Compr
7302	Sensor: Power I. Board	No	No	Yes	Timed	21	Compr
7303	Sensor: Control Board	No	No	Yes	Timed	21	Compr
7304	Sensor: Motor Thermistor	No	Yes	Yes	Timed	21	Compr
7305	Sensor: Oil Temperature	No	No	Yes	Timed	21	Compr
74-*	Sensor - Pressure						
7403	Sensor: Suction Pressure Signal Low	No	No	Yes	Timed	22	None
7404	Sensor: Suction Pressure Signal High	No	No	Yes	Timed	22	None
7405	Sensor: Discharge Pressure Signal Low	No	No	Yes	Timed	22	None
7406	Sensor: Discharge Pressure Signal High	No	No	Yes	Timed	22	None

8.4 General trouble shooting

	**Incorrect installation or service of the frequency converter may cause damage to the equipment or lead to serious personal injury or death! Instructions in this manual must be observed! Only certified electricians are allowed to do the following troubleshooting on the power connections!**

- Over voltage: Mains voltage level too high.
  - Check mains voltage level with a multi meter
- Under voltage: Mains voltage level too low.
  - Check mains voltage with a multi meter
  - Check mains fuses
- Mains failure: Missing a phase or severe mains imbalance
  - Check mains voltage with a multi meter
  - Check mains fuses
- Low oil level fault:
  - Check oil level
  - Check oil level sensor and cable
  - Check 230 V AC external supply with a multi meter
  - Check fuse for 230 V AC external supply (X09)
- Over temperature in the FC:
  - Check valve for liquid line and cable
  - Check refrigerant charge
- Temperature faults
  - Check temperature sensor T_{oil} and cable
  - Check temperature sensor T_{motor} and cable
  - Check 230 V AC external supply (X09)

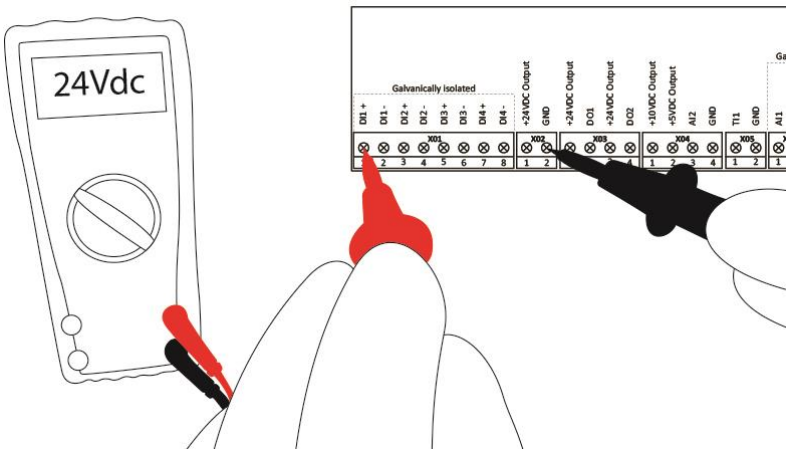
8.5 Control signals

	The capacitors for the DC voltage are not discharged immediately after power has been disconnected! **To avoid electrical shock, disconnect the mains before doing any maintenance and wait at least 5 minutes for the capacitors to discharge!**

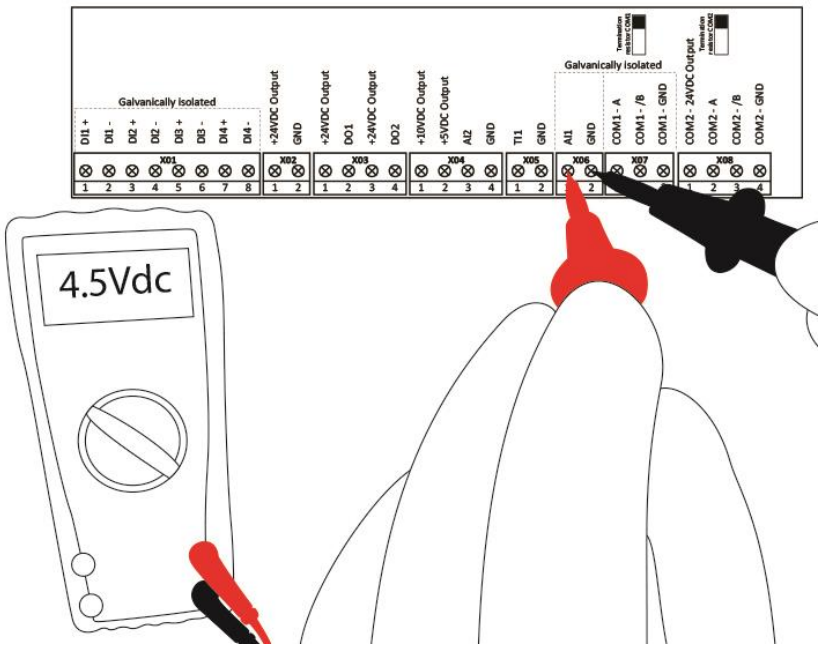
The compressor does not start:

- Check control signal levels

Digital input	Low	High	Max voltage
	<5 Vdc	>12 Vdc	30 Vdc



Analogue input	Low	High	Max voltage
	0 Vdc	10 Vdc	11 Vdc



8.6 Communications trouble shooting

- Check the communication cables for correct wiring
- Check if the communication address setting matches the selected.
  Note: Address 0 is not allowed! Default address is 32
- Check if the communication speed matches the selected.
  Use BEST Software to read the settings
- Check if communication is active
- Please observe that all registers in the parameters are index based, meaning they start with no. 1 and not with zero

Use BEST for viewing Modbus communication status. The data can be seen and monitored in section 7.3.20 Modbus Diagnostics Counters.

Return codes from Modbus communication if a telegram is not accepted by the FC can be seen in section 7.2.6 Modbus exception codes.

Check warning, critical and fault messages via Modbus or BEST.

8.7 Service and CE approvals

There are no user serviceable parts inside the enclosure.

8.8 Cooling

The FC is cooled by refrigerant in the cold plate and internal fans. The FC controls a liquid line valve to inject liquid refrigerant into the cold plate. The fans ensure low temperatures of key components.

The cooling system requires no maintenance.

9. Modbus example telegram

The following example reads the Serial Setpoint (speed request). It is in the Serial Control parameter group.

Name	Possible values	Default	Description	Modbus type & addr
Setpoint (Control.RO_Setpoint)	unit % scale 100 sint16	-	Readout of the resulting setpoint in percent.	IR 100
FC Control Word (Control.FC_CtrlWord)	unit None scale 1 uint16	-	Readout of the resulting control word	IR 102
FC Status Word (Control.FC_StatusWrd)	unit None scale 1 uint16	-	Readout of the status word	IR 103
Serial Control Word (Control.SerCtrlWord)	0 - 65535 scale 1 uint16	0x043F	Serial control word	HR 110
Serial Setpoint (Control.SerSetpoint)	-200.00 % - 200.00 % scale 100 sint16	0.00 %	Serial setpoint	HR 111

Request: 2003006F0001B2A6
Response: 20030200000443

Request (Holding register)

0x20	Slave address	1 byte
0x03	Function code	1 byte
0x006F	Start address (111)	2 bytes
0x0001	Quantity	2 bytes
0xB2A6	CRC	2 bytes

Response

0x20	Address	1 byte
0x03	Function code	1 byte
0x02	NB bytes of data	1 byte
0x0000	Value (setpoint = 0)	2 bytes
0x0443	CRC	2 bytes

10. Notes

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Subject to change

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