

REFERENCE GUIDE

CG-110-1

Compressor protection module SE-i1
Original document
Preliminary v. 1.0A

SE-i1

Electrical skilled installer

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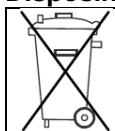
1. Read this first!

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

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Disposing of the parts of the controller:



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

In reference to European Union directive **2012/19/EU** 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



Danger!! General danger



Danger!! High voltage. Danger of electrical current or voltage

1.1 Reference guide



Before installation, the user should be thoroughly familiarized with this reference guide, especially with purposes, installation and operation.

Special care should be taken when installing and connecting external equipment (PTC sensor, high voltage etc.) and handling the modules correctly according to protection against ESD (Electro Static Discharge).



Installation of the SE-i1 must be performed by authorized personnel only. All warranties are excluded in case installation is performed by unauthorized personnel or in case the SE-i1 has not been correctly installed.

1.2 Safety



The SE-i1 is a protection device and not a safety component according to the Machinery Directive and cannot be used in “medical” or “life support” equipment

Before plant commissioning, the service technician shall ensure that personal safety requirements are met in conformity with the Machinery Directive based on safety estimations.



Electrical plant failures are to be immediately solved, even though no immediate danger exists; the SE-i1 and motor must be without power.



Before soldering or welding on the compressor, all connections on the SE-i1 must be secured against overvoltage!

2. Definitions

BEST	BEST Software
ESD	Electro Static Discharge
HW	Hardware/electronics.
I/O	Input / Output (electrical signals in and out of a unit)
NC	Normally Closed (relay).
NO	Normally Open (relay).
NTC	Negative Temperature Coefficient (sensor element).
PTC	Positive Temperature Coefficient (sensor element).
SW	Software

3. Functions

The SE-i1 compressor protection module has a number of built-in functions to protect, diagnose and control the compressor.

The SE-i1 has several functions which are listed in the following and further described.

No.	Group	Name	Stopped	Start-up	Running	Action
1	Motor (protection)	Phase sequence		X		L
2		Phase loss		X	X	A L
4		Overheat	X	X	X	L
5	Application (limits)	Oil fault		X	X	L
6		Compressor start		X		A L
7		Envelope			X	W A L
8		Discharge temperature		X	X	W A L

W: Warning, A: Alarm, L: Lock-out

If the SE-i1 is locked, an external reset must be performed by either powering off the device for minimum 5 seconds or sending a reset command on the serial bus. If a BEST converter is connected, it must be removed during the power-off as the converter will supply power to the module.

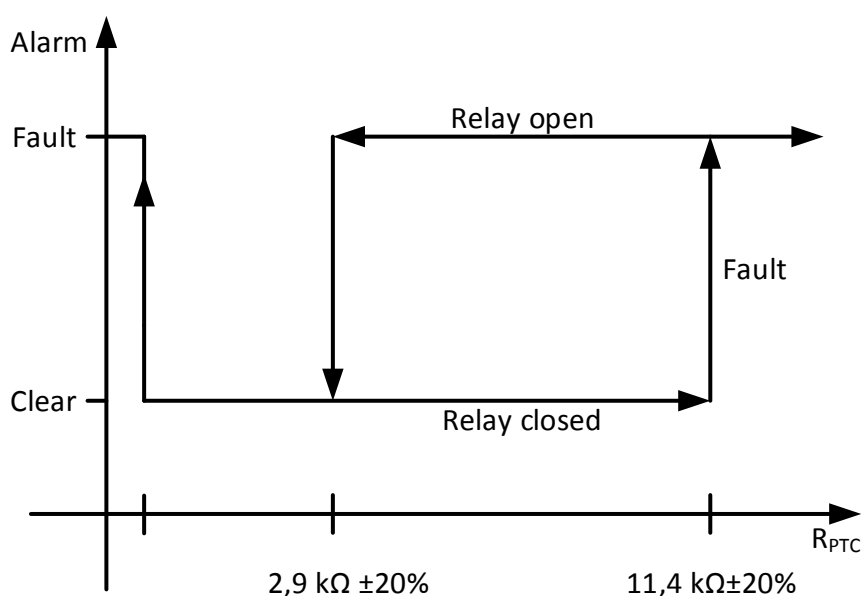
Reset using the serial bus is preferable as this gives better statistical data of compressor operation.

3.1 Protection functions

3.1.1 Temperature monitoring

One of the functions of the SE-i1 is to protect the compressor motor against overload.

By monitoring the resistance in a PTC sensor mounted in the motor windings, the SE-i1 will lockout and stop the motor if the resistance increases above the limit as shown below.



Since the increase in resistance is so steep, from 1 up to 9 PTC-sensors can be coupled in series. There is a restart blocking function to prevent a motor from being started too soon after having been overheated.

If the SE-i1 is locked, an external reset must be performed by either powering off the device for minimum 5 seconds or sending a reset command on the serial bus.

When power is turned on to the SE-i1 module, the PTC resistance is measured:

- If the PTC resistance is below 2,9 kΩ:
No alarm: The relay is energized immediately (if no other faults are present)
- If the PTC resistance is between 2,9 kΩ and 11,4 kΩ:
Alarm: The relay is first energized when the resistance is below 2,9 kΩ (compressor motor has cooled down)
- If the PTC resistance is above 11,4 kΩ:
Alarm lock: The relay is not energized and the module is locked

3.1.2 Rotation direction monitoring

Within the first 5 seconds after start of the compressor, the phases for the compressor are monitored against wrong rotation direction (wrong phase sequence) and phase loss. In case of a wrong rotation direction, the relay is immediately de-energized and the device locks.

If the SE-i1 is locked, an external reset must be performed by either powering off the device for minimum 5 seconds or sending a reset command on the serial bus.

When the compressor is stopped, a pressure difference in the compressor can make it turn backwards and thereby generating a false phase sequence. Therefore, the detection of phase sequence is disabled the first 10 seconds after a compressor stop to avoid a false alarm condition.

3.1.3 Phase failure monitoring

Phase-loss within the first 5 seconds after compressor start de-energizes the relay and thereby the security chain.

After approximate 6 minutes, the relay is energized again. If phase loss is detected 4 times in a row or 10 times within 24 hours the device is locked.

If the SE-i1 is locked, an external reset must be performed by either powering off the device for minimum 5 seconds or sending a reset command on the serial bus.

The count of the 4 events in a row is reset when start is detected with no "phase loss".

3.2 Diagnose functions

3.2.1 Oil fault monitor

Depending on the compressor type, the oil supply monitor is configured for either oil level, oil flow or oil pressure difference monitoring. Actual status is always accessible via Modbus.

If an **oil level fault** is detected, the status is immediately updated via Modbus. However, the first 90 seconds after compressor start, the fault signal is not activated. If the oil level is still too low, the SE-i1 releases the fault relay and locks out immediately.

24 V versions must be used for the oil supply monitoring.

A warning signal is set immediately if the compressor is running and one of the two oil supply monitor inputs are open. Number of inputs used depends on the compressor model.

If an **oil pressure difference fault** is detected, the status is immediately updated via Modbus. The first 90 seconds after compressor start, the fault signal is not activated. If the oil pressure difference is still too low, the SE-i1 releases the fault relay and locks out immediately.

Both oil fault alarms must be externally reset by either powering off the device for minimum 5 seconds or sending a reset command on the serial bus.

3.2.2 Discharge temperature monitor

A temperature sensor is mounted on the discharge side of the compressor; the SE-i1 will open the relay and break the safety chain if the discharge temperature threshold is exceeded.

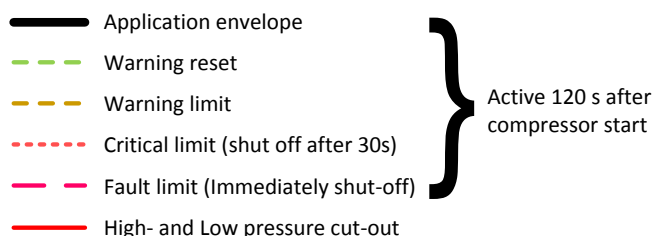
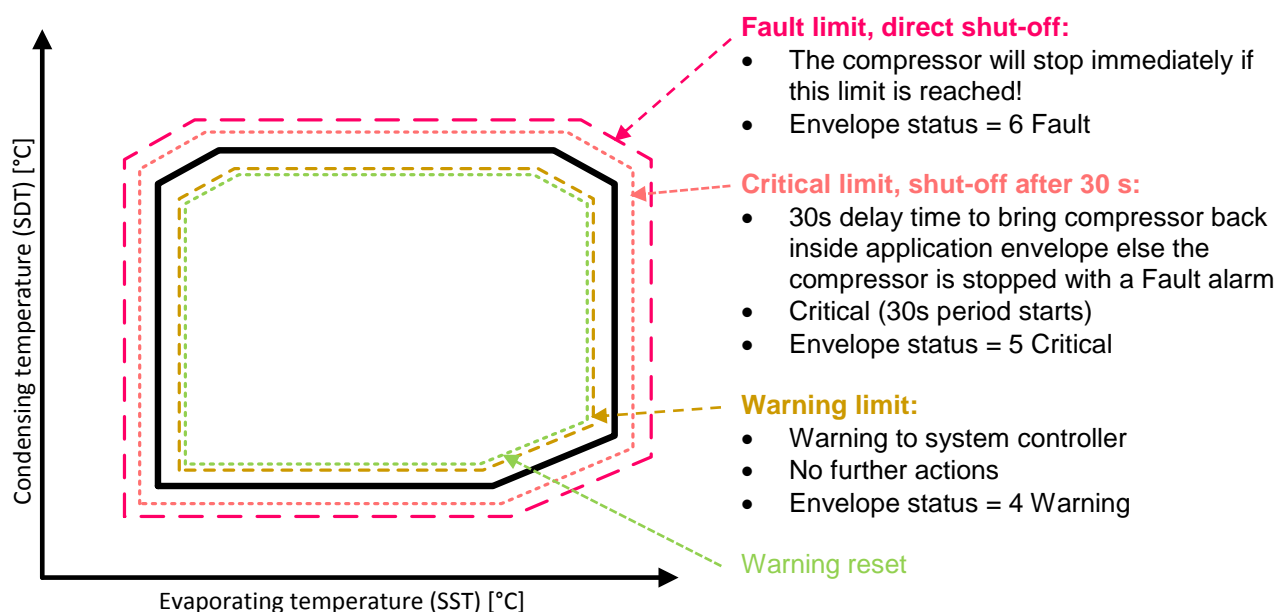
3.2.3 Application envelope monitoring

The application envelope function monitors if the operating conditions of the compressor is within the safe operation area envelope – 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.

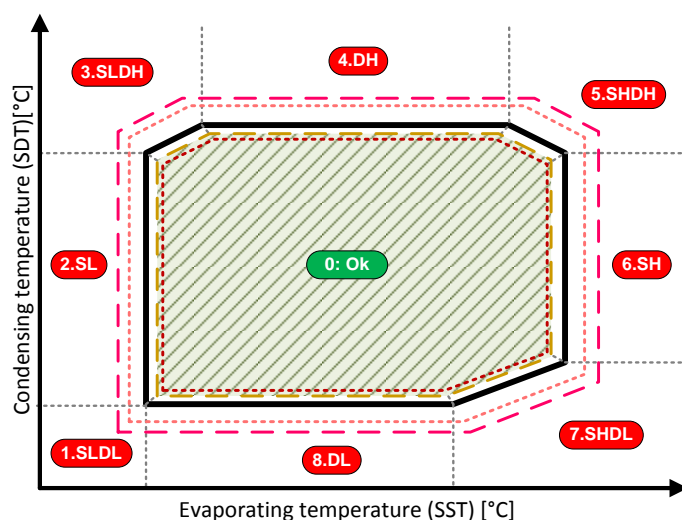
The operating point is determined by the saturated suction and discharge gas temperatures, which are calculated from the suction and discharge gas pressures based on the selected refrigerant.

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 alarm 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 no alarms

SST = Evaporating temperature
SDT = Condensing temperature

A warning and a fault will be given if the warning level or fault level is reached.

Please also see envelope faults '30-*' in section 9 Alarm system.

After a stop due to envelope fault, the fault can be reset when the compressor is stopped. If timed resets are enabled the SE-i1 will perform a timed reset otherwise an external reset is required. The SE-i1 will activate the relay 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 10.4.2 Status - Compressor lists 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. Datalog

The built-in data logger stores operation data, sensor data, alarms and events for further analysis using the BEST Software.

The data are stored in the data logger flash memory at regular intervals together with counters and statistics data collected and summarized over time. The lifetime of the different data varies.

The datalog contains the following type of entries

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

4.1.1 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.

23-11-2015 03:58	4301: Motor Temperature High - Warning - Set
...	
23-11-2015 04:02	4301: Motor Temperature High - Warning - Clear

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

07-11-2015 11:01	3431: High Pressure Switch - Fault - Set
-------------------------	---

When all faults are successfully reset and the SE-i1 is no longer in fault state, there is an entry like this:

02-12-2015 10:45	0: No Fault - Fault - Clear
-------------------------	------------------------------------

Lifetime of alarm entries: 365 days.

4.1.2 Events

Possible events:

- Power Up
- Power Down
- Extern alarm reset
- Compressor Start
- Compressor Stop
- Service tool connect

Lifetime of events: 30 days

4.1.3 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.

4.1.4 Periodic data

Data are stored on a regularly basis.

10 seconds interval when the compressor is running, 60 seconds when stopped.

3 seconds interval for fault traces.

Lifetime of events: 1 – 3 weeks

4.1.5 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.

4.1.6 Accumulated operation counters

All accumulated since first power up

- No of PowerUps
- No of Motor Starts
- Operating Hours
- Motor Operating Hours

Lifetime: 365 days

4.1.7 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 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

4.1.8 Daily counters

- Device Power Ups
- Compressor Starts
- Number of Faults
- Number of Criticals
- Number of Warnings
- Device Operating Time
- Compressor Runtime
- Fault Runtime
- Critical Runtime
- Warning Runtime
- Capacity Usage Rate

Lifetime: 365 days

4.1.9 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

4.1.10 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. Communication with the SE-i1

The serial protocol is Modbus (RTU) via the COM2 port. Modbus can be connected for monitoring of the compressor status.

Please see also section 10 Programming and monitoring for details about the Modbus parameters.

5.1 Status Word bit definitions

SE-i1 Status Word

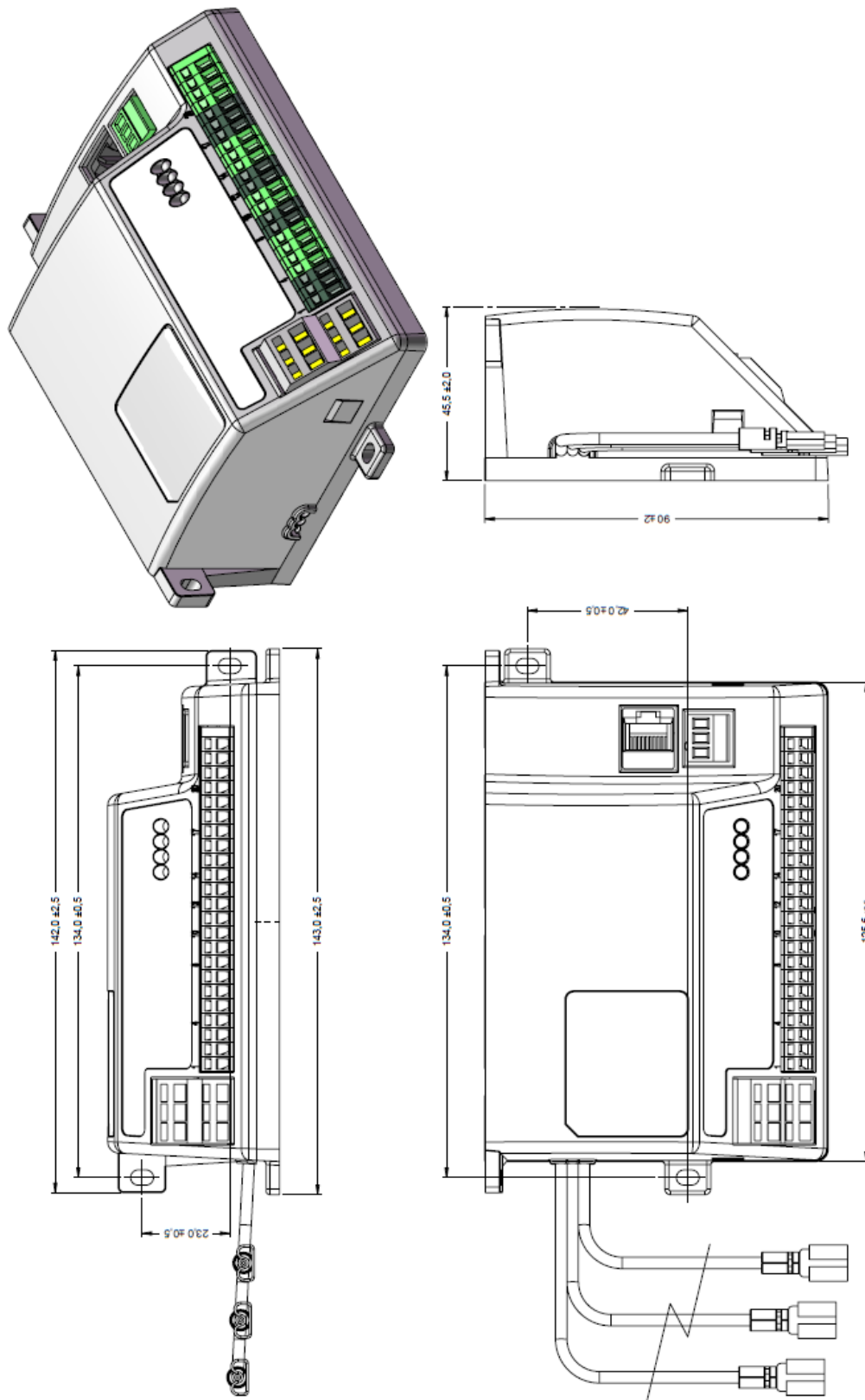
Bit	Function	Description
0	Control ready	The control is ready to switch on 0: Control not operational 1: The control is ready for operation
1	Operation ready	The SE-i1 is ready to operate 0: Output is not ready 1: Output is ready
2	Operation enabled	0: Output is off. Compressor is stopped 1: Compressor is on
3	Fault	0: No fault present 1: A fault is present. The compressor is stopped
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 SE-i1 continues operation, but attention may be required
8	On reference	0: The compressor is ramping or not running 1: The compressor is operating at setpoint
9	Reserved	
10	Reserved	
11	Running	0: Compressor is not running 1: The compressor is running
12	Start active	0: Start command is not given OR start is prohibited 1: Start command is given (e.g. start signal is given, setpoint > 0 %) and Operation is enabled
13	Critical	0: No critical present 1: A critical is present. The SE-i1 is close at its limits and may soon stop the compressor
14-15	Reserved	

6. I/O List for SE-i1

Connector	Name/ Terminal no.	Type/ Function	Logic	Description
Supply	L N	Supply	-	Supply for SE-i1; 115 V-230 V; +10% ~ -15%, 50/60 Hz; typical 5 VA Fuse 4A quick-blow Protective earth
	PE			
Phase Detection	L1-Black	Input	-	200 – 690 VAC +10% ~ -15%, 50/60 Hz; for AC3 and soft starter; FC down to 83 VAC _{RMS} ; 20 - 135 Hz
	L2- Brown	Input	-	
	L3-Blue	Input	-	
Relay	Relay NC		NC	Fault relay; 115 V-230 V; +10% ~ -15%, 50/60 Hz; max 2,5A; C300 max 100.000 cycles
	Relay NO		NO	Compressor ok relay 115 V-230 V; +10% ~ -15%, 50/60 Hz
	Relay C	Input	-	Compressor run signal 115 V-230 V; +10% ~ -15%, 50/60 Hz
Oil flow	1: Not in use 2: Signal 3: GND	- Input GND	NO	Not in use 24 VDC ±10%; max 100 mA 0 V ground
OLC/ Oil stop	4: +24V Supply 5: GND 6: Signal	Supply Ground Input	NO	+24 VDC ±10%; max 100 mA 0 V ground Oil level signal. Sourcing to ground; max 24 VDC; max 20 mA 0V ground for Signal
	7: GND	Ground		
Mot. PTC	8: PTC-1 9: PTC-2	Signal Signal	Temperature Temperature	Motor temperature 0 – 50 kΩ; PTC sensor according to DIN 44081/44082 1 – 9 in series. Max. total resistance: < 1,8 kΩ Short circuit fault detection implemented Rtrig: 11,4 kΩ ±20% Rreset: 2,9 kΩ ±20%
Taux	10: Signal	Input	Temperature	Auxiliary temperature. NTC sensor -40°C ~ +100°C; accuracy: +/- 1°C @ -30 °C - 30 °C / +/-3°C @ 30 °C - 70 °C 0V
	11: GND	Ground		
Toil/Tdis	12: Signal	Input	Temperature	Discharge temperature NTC sensor 0°C ~ +120°C; accuracy: +/- 1°C @ 20 °C - 70 °C / +/-3°C @ 70 °C - 120 °C; optimum @ 50 °C 0V
	13: GND	Ground		
Pdis	14: +5V Supply 15: Signal	Supply Input	Pressure	Discharge pressure. Sensata 2CP5-71-47 (rel) or equivalent +5 VDC; max 10 mA 1 - 35 bar abs.; 0 - 5V ratio metric; accuracy ±1% F.S. 0V
	16: GND	Ground		
Psuc	17: +5V Supply 18: Signal	Supply Input	Pressure	Suction pressure. Sensata 2CP5-71-49 (abs) or equivalent +5 VDC; max 10 mA 0 - 13 bar abs.; 0 - 5V ratio metric; accuracy ±1% F.S. 0V
	19: GND	Ground		
COM2 Sensor bus	20: +24V Supply 21: DATA+ 22: DATA- 23: GND	Supply RS485 RS485 GND	Optional Serial Serial Ground	Optional 24 VDC supply Modbus (RTU) serial communication; DATA+ Modbus (RTU) serial communication; DATA- Ground for serial communication
Service	COM3	RS485	Serial	RJ12 serial port for BEST converter

Connector	Name/ Terminal no.	Type/ Function	Logic	Description
Control COM1	DATA+ DATA- GND	RS485 RS485 GND	Serial Serial Ground	Modbus (RTU) serial communication; DATA+ Modbus (RTU) serial communication; DATA- Ground for serial communication

7. Drawings



Mounting is horizontal and vertical with screws.

8. Standards

The product is manufactured according to the following standards.

- 2011/65/EC RoHS directive
- 2014/35/EC Low voltage directive
- 2014/30/EC EMC directive

The following standards have been used

- EN 61010-1:2010 Safety requirement for electrical equipment for measurement and control
- EN 61000-6-2:2005 Generic EMC Immunity for industrial environment
- EN 61000-6-3:2007 Generic EMC Emission for residential, commercial and light-industrial environments

9. Alarm system

Both warning, alarm and locked states are visible via LEDs and via the serial communication bus. Via the serial communication bus, more information regarding a warning or alarm is available as listed in the table below.

9.1 Alarm severity types

There are the following alarm severity types:

Fault:

- If a fault-level alarm condition is detected, the SE-i1 will open the relay, thereby breaking the control voltage to the contactor and stop the compressor.
- 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 compressor. 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.

9.2 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 SE-i1

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

Timed reset: Timed reset is an automatic, repetitive, timed reset.
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.

9.3 Alarm list

No.	Text	Warning	Critical	Fault	Fault type
10-*	System - Operation				
1000	Too many identical timed reset faults in 24 hours	No	No	Yes	Extern
1001	Too many timed reset faults in 1 hour	No	No	Yes	Extern
11-*	System - Communication				
1100	Serial Control Timeout	Yes	No	Yes	Timed
12-*	System - Supply				
1200	Mains Failure	No	No	Yes	Timed
20-*	Application - Operation				
2000	LOCKED	No	No	Yes	Extern
27-*	Application - SW Configuration				
2700	Setup Fault	No	No	Yes	Restart
30-*	Compressor - Operation				
3001	Envelope: SST Low, SDT Low	Yes	Yes	Yes	Timed
3002	Envelope: SST Low	Yes	Yes	Yes	Timed
3003	Envelope: SST Low, SDT High	Yes	Yes	Yes	Timed
3004	Envelope: SDT High	Yes	Yes	Yes	Timed
3005	Envelope: SST High, SDT High	Yes	Yes	Yes	Timed
3006	Envelope: SST High	Yes	Yes	Yes	Timed
3007	Envelope: SST High, SDT Low	Yes	Yes	Yes	Timed
3008	Envelope: SDT Low	Yes	Yes	Yes	Timed
3010	Envelope: Startup Timeout	No	No	Yes	Timed
3011	Envelope: Configuration Failure	No	No	Yes	Restart
3022	Too Many Compressor Starts	Yes	No	No	N/A
3024	Minimum Compressor Stop Time Not Respected	Yes	No	No	N/A
3025	Minimum Compressor Run Time Not Respected	Yes	No	No	N/A
3026	Minimum Compressor Start To Start Time Not Respected	Yes	No	No	N/A
3027	Compressor Start without being fully unloaded	Yes	No	No	N/A
33-*	Compressor - Temperature				
3302	Discharge Temperature High	Yes	Yes	Yes	Timed
34-*	Compressor - Pressure				

No.	Text	Warning	Critical	Fault	Fault type
3400	Suction Pressure Low	No	No	Yes	Timed
3411	Discharge Pressure High	No	No	Yes	Timed
3431	High Pressure Switch	No	No	Yes	Extern
35-*	Compressor - Other Input				
3500	Oil Level Low	No	Yes	Yes	Extern
3501	Oil Fault Level	No	Yes	Yes	Extern
3502	Oil Pressure Low	No	Yes	Yes	Extern
3503	Oil Stop Valve	No	Yes	Yes	Extern
3520	Oil Injection Has No Effect	Yes	No	Yes	Extern
42-*	Motor - Supply				
4201	Motor Phase Loss	No	No	Yes	Timed
4202	Motor Phase Sequence	No	No	Yes	Extern
4220	Motor frequency low	No	No	Yes	Extern
4221	Motor frequency high	No	No	Yes	Extern
43-*	Motor - Temperature				
4301	Motor Temperature High	Yes	Yes	Yes	Extern
4302	Motor Temperature Cooldown	No	No	Yes	Timed
58-*	FC - Electronics Fault				
5851	HW: 24V	No	No	Yes	Restart
67-*	Device - SW Configuration				
6700	Config Data: No File	No	No	Yes	Restart
6701	Config Data: CRC Error	No	No	Yes	Restart
6702	Config Data: Wrong Version	No	No	Yes	Restart
6703	Config Data: Read Only	No	No	Yes	Restart
68-*	Device - Electronics Fault				
6810	HW: 3.3V	No	No	Yes	Restart
6811	HW: User 5V	No	No	Yes	Restart
6813	HW: 24V	No	No	Yes	Restart
69-*	Device - Other				
6900	Datalog error	Yes	No	No	N/A
73-*	Sensor - Temperature				

No.	Text	Warning	Critical	Fault	Fault type
7304	Sensor: Motor Thermistor	No	Yes	Yes	Timed
7308	Sensor: Discharge Temperature	No	No	Yes	Timed
7320	Sensor: Aux Temperature	No	No	Yes	Timed
74-*	Sensor - Pressure				
7401	Sensor: Suction Pressure	No	No	Yes	Timed
7402	Sensor: Discharge Pressure	No	No	Yes	Timed
7403	Sensor: Suction Pressure Signal Low	No	No	Yes	Timed
7404	Sensor: Suction Pressure Signal High	No	No	Yes	Timed
7405	Sensor: Discharge Pressure Signal Low	No	No	Yes	Timed
7406	Sensor: Discharge Pressure Signal High	No	No	Yes	Timed
75-*	Sensor - Other Input				
7510	Sensor: Oil protection	No	No	Yes	Timed
7511	Sensor: Oil protection 2	No	No	Yes	Timed

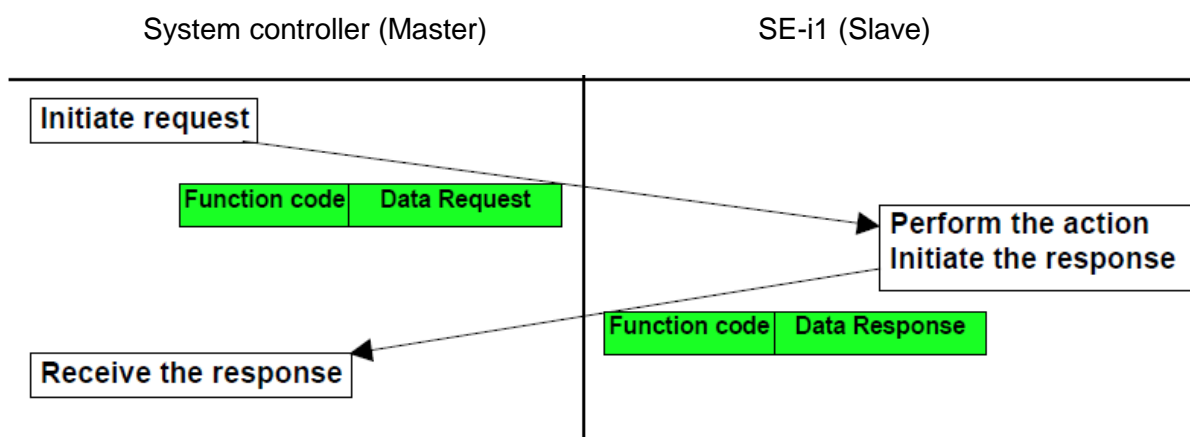
10. Programming and monitoring

10.1 Introduction

For monitoring and controlling the SE-i1, there is a built-in Modbus (RTU) interface.

10.2 Serial communication

Communication with the SE-i1 is via Modbus (RTU). Configuration and reading of status from the SE-i1 is described in the following sections.



10.2.1 Modbus (RTU) configuration

Specification of the protocol:

Protocol:	Modbus (RTU mode). See http://www.modbus.org/specs.php
Modbus address:	Default address 48 (30 hex), can be changed to 1 – 247.
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:	Default 1; 2 (only 2 if Parity is set to None)

Setup of communication configuration is done via the BEST tool using COM3.

Please observe that register numbers are used in this manual!

10.2.2 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

10.2.3 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.

10.2.4 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.

10.3 Parameters

The parameters are separated into logical groups. Setup of the parameters is possible via either Modbus or the BEST Software.

Modbus type & addr.: Modbus register address and type of register.

IR is an Input register

HR is a Holding register.

Please observe that it is registers that are listed, NOT the index.

Name: Parameter name. The name in parenthesis is the LMT 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.

10.3.1 Control - Application

Modbus type & addr	Name	Possible values	Default	Description
IR 103	Status Word (Control.StatusWord)	unit None scale 1 uint16	-	Bit coded operation status word Bit: Description 0: Control ready (0x0001) 1: Operation ready (0x0002) 2: Operation enabled (0x0004) 3: Fault alarm (0x0008) 6: Start disabled (0x0040) 7: Warning alarm (0x0080) 8: On reference (0x0100) 11: Running (0x0800) 12: Start active (0x1000) 13: Critical alarm (0x2000)
HR 110	Serial Control Word (Control.SerCtrlWord)	0 - expr scale 1 uint16	expr	Control word written by serial communication Bit coded operation control word Bit: Description 7: Reset alarms (0x0080) 10: Serial control enable (0x0400)

10.4 Status data

10.4.1 Status - Alarm

Modbus type & addr	Name	Possible values	Default	Description
IR 11100	Number of active alarms (AlarmStatus.Count)	unit None scale 1 uint16	-	Number of active alarms
IR 11101	Number of listed alarms that has not yet been cleared (AlarmStatus.CountList)	unit None scale 1 uint16	-	Number of listed alarms that has not yet been cleared
IR 11102	Highest state of any listed alarm (AlarmStatus.State)	unit None scale 1 uint8	-	Highest state of any listed alarm 0=Clear 1=Inactive 2=Active 3=Set
IR 11103	Highest severity level of any active alarm (AlarmStatus.Severity)	unit None scale 1 uint8	-	Highest severity level of any active alarm 0=None 1=Log 2=Event 4=Info 8=Warning 16=Critical 32=Fault
IR 11104	If locked, ICP is waiting for external reset command or restart (AlarmStatus.Locked)	unit None scale 1 uint8	-	If locked, ICP is waiting for external reset command or restart 0=No 1=Yes
IR 11105	Reset level required to clear any active alarm (AlarmStatus.ResetLevel)	unit None scale 1 uint8	-	Reset level required to clear any active alarm 0=NA 1=Auto 2=Timer 3=Extern 4=Restart
IR 11201	Code of highest ranked alarm (AlarmStatus.Alarm1)	unit None scale 1 uint16	-	Code of highest ranked alarm
IR 11202	Code of second highest ranked alarm (AlarmStatus.Alarm2)	unit None scale 1 uint16	-	Code of second highest ranked alarm
IR 11203	AlarmStatus.Alarm3 (AlarmStatus.Alarm3)	unit None scale 1 uint16	-	
IR 11204	AlarmStatus.Alarm4 (AlarmStatus.Alarm4)	unit None scale 1 uint16	-	
IR 11205	AlarmStatus.Alarm5 (AlarmStatus.Alarm5)	unit None scale 1 uint16	-	
IR 11206	AlarmStatus.Alarm6 (AlarmStatus.Alarm6)	unit None scale 1 uint16	-	
IR 11207	AlarmStatus.Alarm7 (AlarmStatus.Alarm7)	unit None scale 1 uint16	-	

Modbus type & addr	Name	Possible values	Default	Description
IR 11208	AlarmStatus.Alarm8 (AlarmStatus.Alarm8)	unit None scale 1 uint16	-	
IR 11209	AlarmStatus.Alarm9 (AlarmStatus.Alarm9)	unit None scale 1 uint16	-	
IR 11210	AlarmStatus.Alarm10 (AlarmStatus.Alarm10)	unit None scale 1 uint16	-	

The registers AlarmStatus.Alarm 1 .. Alarm10 are 16 bit values. The bit decoding is as follows:

Bit	Description
0 .. 9	Index number (not display code) - Please refer to Alarm Definition table
10..12	Alarm severity: 0: None, 1: Log, 2: Info, 3: Warning, 4: Critical, 5: Fault
13..13	(reserved)
14..15	Alarm state: 0: Clear, 1: Inactive, 2: Active, 3: Set (condition is present)

10.4.2 Status - Compressor

Modbus type & addr	Name	Possible values	Default	Description
IR 12001	Suction Pressure (Input.Psuc)	unit bar(a) scale 100 sint16	-	Suction Pressure
IR 12002	Discharge Pressure (Input.Pdis)	unit bar(a) scale 100 sint16	-	Discharge Pressure
IR 12003	Evaporating Temperature (SST) (CompStatus.SatTempS uc)	unit °C scale 10 sint16	-	Calculated saturated suction temperature (SST)
IR 12004	Condensing Temperature (SDT) (CompStatus.SatTempDis)	unit °C scale 10 sint16	-	Calculated saturated discharge temperature (SDT)
IR 12005	Envelope Status (Envelope.Status)	unit None scale 1 uint8	-	Envelope operation status 0=Stopped 1=Starting 2=Running 3=Stopping 4=Warning - inside envelope 5=Critical - outside envelope 6=Fault

Modbus type & addr	Name	Possible values	Default	Description
IR 12006	Envelope Zone (Envelope.Zone)	unit None scale 1 uint8	-	Actual zone of operation 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 12007	Remaining time for short cycling protection (CprStart.ShCycRemain)	unit s scale 10 uint16	-	Remaining time for short cycling protection
IR 12008	Describe why the warning has been set for Compressor start monitoring (CprStart.WarningState)	unit None scale 1 uint8	-	Describe why the warning has been set for Compressor start monitoring 0=NoneWarn 1=StartStopWarn 2=StopStartWarn 3=StartStartWarn 4=StartCount1HWarn
IR 12010	Discharge temperature (CompStatus.Tdis)	unit °C scale 10 sint16	-	Discharge temperature
IR 12011	AUX temperature (CompStatus.Taux)	unit °C scale 10 sint16	-	AUX temperature
IR 12025	Oil Sensor 1 (Input.OilFault)	unit None scale 1 uint8	-	Oil Sensor 1 0=Off 1=On
IR 12026	Oil Sensor 2 (Input.OilFault2)	unit None scale 1 uint8	-	Oil Sensor 2 0=Off 1=On

10.4.3 Status - Motor

Modbus type & addr	Name	Possible values	Default	Description
IR 13001	Motor overheat thermistor resistance (PTC) (Input.Thermistor)	unit Ohm scale 1 uint16	-	Motor overheat thermistor resistance (PTC)
IR 13002	Estimated motor power consumption (Input.Power)	unit kW scale 10 uint16	-	Estimated motor power consumption
IR 13003	Motor drive frequency (speed) (Input.PhaseFreq)	unit Hz scale 10 uint16	-	Motor drive frequency (speed)
IR 13004	Motor phase detection state (Input.PhaseStatus)	unit None scale 1 uint8	-	Motor phase detection state 0=STOP 1=RUN 2=REVERSE 3=L1_LOSS 4=L2_LOSS 5=L3_LOSS 6=L1_L3_LOSS

Modbus type & addr	Name	Possible values	Default	Description
				7=FREQ_LOW 8=FREQ_HIGH 9=ERROR

10.4.4 Status - Device

Modbus type & addr	Name	Possible values	Default	Description
IR 14000	System operating state (System.State)	unit None scale 1 uint8	-	System operating state 0=CONFIG 1=INPUT 2=STARTUP 3=READY 4=SUSPEND 5=SERVICE 6=PRODUCTION

10.4.5 Status - IO

Modbus type & addr	Name	Possible values	Default	Description
IR 15900	Fault relay state (Output.FaultRelay)	unit None scale 1 uint8	-	Fault relay state 0=Off 1=On
IR 15990	State of the Operation LED (Output.OperaLight)	unit None scale 1 uint8	-	State of the Operation LED 0=OFF 1=ON 2=SLOW_SHORT 3=SLOW_MED 4=SLOW_LONG 5=FAST_SHORT 6=FAST_MED 7=FAST_LONG
IR 15991	State of the Warning LED (Output.WarningLight)	unit None scale 1 uint8	-	State of the Warning LED 0=OFF 1=ON 2=SLOW_SHORT 3=SLOW_MED 4=SLOW_LONG 5=FAST_SHORT 6=FAST_MED 7=FAST_LONG
IR 15992	State of the Fault LED (Output.FaultLight)	unit None scale 1 uint8	-	State of the Fault LED 0=OFF 1=ON 2=SLOW_SHORT 3=SLOW_MED 4=SLOW_LONG 5=FAST_SHORT 6=FAST_MED 7=FAST_LONG
IR 15993	State of the Communication LED (Output.OptLight)	unit None scale 1 uint8	-	State of the Communication LED 0=OFF 1=ON 2=SLOW_SHORT

Modbus type & addr	Name	Possible values	Default	Description
				3=SLOW_MED 4=SLOW_LONG 5=FAST_SHORT 6=FAST_MED 7=FAST_LONG

10.5 Configuration data

10.5.1 Configuration - Application

Modbus type & addr	Name	Possible values	Default	Description
HR 20100	Year (DateAndTime.Year)	expr - expr scale 1 uint16	0 y	Year
HR 20101	Month and Day (DateAndTime.MonthDay)	257 - 3103 scale 1 uint16	0	Month and Day
HR 20102	Hour and Minute (DateAndTime.HourMinute)	0 - 5947 scale 1 uint16	0	Hour and Minute
HR 20103	Millisecond (DateAndTime.MilliSec)	0 ms - 59999 ms scale 1 uint16	0 ms	Millisecond

10.5.2 Configuration - Compressor

Modbus type & addr	Name	Possible values	Default	Description
IR 22100	Refrigerant selection (Config.RfgType)	unit None scale 1 uint8	-	Refrigerant selection 0=NONE 1=R134a 2=R404A 3=R507A 4=R407C 5=R22 6=R407A 7=R407F 9=R448A 10=R449A 11=R450A 12=R513A 13=R1234yf 14=R1234ze
IR 22200	Dedicated OEM functionality selection (Config.OEMType)	unit None scale 1 uint8	-	Dedicated OEM functionality selection 0=NONE

10.5.3 Configuration - Device

Modbus type & addr	Name	Possible values	Default	Description
HR 24000	Modbus Register Mapping (COM1.Scheme)	0 - 0 scale 1 uint8	0	Modbus Register Mapping

10.5.4 Configuration - IO

Modbus type & addr	Name	Possible values	Default	Description
HR 65409	COM1 Address (COM1.Address)	1 - 247 scale 1 uint8	48	Device address for Modbus connection
HR 65410	COM1 Baudrate (COM1.Baudrate)	1 - 132 scale 1 uint8	2	Communication speed 1=9600 2=19200 3=115200 131=4800 132=38400
HR 65411	COM1 Stop Bits (COM1.StopBits)	1 - 2 scale 1 uint8	1	Number of stop bits 1=1 Stopbit 2=2 Stopbits
HR 65412	COM1 Parity (COM1.Parity)	0 - 2 scale 1 uint8	1	Parity check 0=None 1=Even 2=Odd

10.6 Log data

10.6.1 Logs - Application

Modbus type & addr	Name	Possible values	Default	Description
IR 30000-30001	Device Operating Hours (Log.OperateTime)	unit h scale 1 uint32	-	Device Operating Hours
IR 30010-30011	Compressor Running Hours (Log.RunTime)	unit h scale 1 uint32	-	Compressor Running Hours
IR 30012-30013	Compressor Start Count (Log.StartCount)	unit None scale 1 uint32	-	Compressor Start Count
IR 30020-30021	Power Up Count (System.ResetCount)	unit None scale 1 uint32	-	Number of module power cycles

10.7 Info data

10.7.1 Info - Compressor

Modbus type & addr	Name	Possible values	Default	Description
IR 42100	Compressor type selection (Config.CprType)	unit None scale 1 uint16	-	Compressor type selection (0=NONE, 900=SE-C1 Replacement, 901=SE-C2 Replacement, 1000=CSH6551-35Y, 1001=CSH6551-50(Y), 1002=CSH6561-40Y, 1003=CSH6561-60(Y), 1004=CSH6581-50Y, 1005=CSH6591-60Y, 1006=CSH7551-50Y, 1007=CSH7551-70(Y), 1008=CSH7561-60Y, 1009=CSH7561-80(Y), 1010=CSH7571-70Y, 1011=CSH7571-90(Y), 1012=CSH7581-80Y, 1013=CSH7581-90Y, 1014=CSH7591-90Y, 1015=CSH7591-100Y, 1016=CSH8551-80Y, 1017=CSH8551-110(Y), 1018=CSH8561-90Y, 1019=CSH8561-125(Y), 1020=CSH8571-110Y, 1021=CSH8571-140(Y), 1022=CSH8581-125Y, 1023=CSH8581-140Y, 1024=CSH8591-140Y, 1025=CSH8591-160Y, 1026=CSH9551-180(Y), 1027=CSH9561-160Y, 1028=CSH9561-210(Y), 1029=CSH9571-180Y, 1030=CSH9571-240(Y), 1031=CSH9581-210Y, 1032=CSH9581-280(Y), 1033=CSH9591-240Y, 1034=CSH9591-300(Y), 1035=CSH95101-280Y, 1036=CSH95111-320Y, 1050=CSH6553-35Y, 1051=CSH6553-50(Y), 1052=CSH6553-60, 1053=CSH6563-40Y, 1054=CSH6563-60(Y), 1055=CSH6583-50Y, 1056=CSH6593-60Y, 1057=CSH7553-50Y, 1058=CSH7553-70(Y), 1059=CSH7553-80, 1060=CSH7563-60Y, 1061=CSH7563-80(Y), 1062=CSH7563-90, 1063=CSH7573-70Y, 1064=CSH7573-90(Y), 1065=CSH7573-100, 1066=CSH7583-80Y, 1067=CSH7583-90Y, 1068=CSH7583-100(Y),

Modbus type & addr	Name	Possible values	Default	Description
				1069=CSH7583-110, 1070=CSH7593-90Y, 1071=CSH7593-100Y, 1072=CSH7593-110(Y), 1073=CSH8553-80Y, 1074=CSH8553-110(Y), 1075=CSH8553-125, 1076=CSH8563-90Y, 1077=CSH8563-125(Y), 1078=CSH8563-140, 1079=CSH8573-110Y, 1080=CSH8573-140(Y), 1081=CSH8573-160, 1082=CSH8583-125Y, 1083=CSH8583-140Y, 1084=CSH8583-160(Y), 1085=CSH8583-180, 1086=CSH8593-140Y, 1087=CSH8593-160Y, 1088=CSH8593-180(Y), 1089=CSH9553-180(Y), 1090=CSH9553-210, 1091=CSH9563-160Y, 1092=CSH9563-210(Y), 1093=CSH9563-240, 1094=CSH9573-180Y, 1095=CSH9573-240(Y), 1096=CSH9573-280, 1097=CSH9583-210Y, 1098=CSH9583-280(Y), 1099=CSH9593-240Y, 1100=CSH9593-300(Y), 1101=CSH95103-280Y, 1102=CSH95103-320(Y), 1103=CSH95113-320Y, 1500=CSW6583-40Y, 1501=CSW6583-50(Y), 1502=CSW6583-60, 1503=CSW6593-50Y, 1504=CSW6593-60(Y), 1505=CSW7573-60Y, 1506=CSW7573-70(Y), 1507=CSW7573-80, 1508=CSW7583-70Y, 1509=CSW7583-80(Y), 1510=CSW7583-90, 1511=CSW7593-80Y, 1512=CSW7593-90(Y), 1513=CSW7593-100, 1514=CSW8573-90Y, 1515=CSW8573-110(Y), 1516=CSW8573-125, 1517=CSW8583-110Y, 1518=CSW8583-125(Y), 1519=CSW8583-140, 1520=CSW8593-125Y, 1521=CSW8593-140(Y), 1522=CSW8593-160, 1523=CSW9563-140Y, 1524=CSW9563-160(Y),

Modbus type & addr	Name	Possible values	Default	Description
				1525=CSW9563-180, 1526=CSW9573-160Y, 1527=CSW9573-180(Y), 1528=CSW9573-210, 1529=CSW9583-180Y, 1530=CSW9583-210(Y), 1531=CSW9583-240, 1532=CSW9593-210Y, 1533=CSW9593-240(Y), 1534=CSW9593-280, 1535=CSW95103-240Y, 1536=CSW95103-280(Y), 1537=CSW95103-320, 1538=CSW95113-280Y, 1539=CSW95113-320(Y), 2000=HSK5343-30(Y), 2001=HSK5353-35(Y), 2002=HSK5363-40(Y), 2003=HSK6451-40Y, 2004=HSK6451-50(Y), 2005=HSK6461-40Y, 2006=HSK6461-60(Y), 2007=HSK7451-50Y, 2008=HSK7451-70(Y), 2009=HSK7461-60Y, 2010=HSK7461-80(Y), 2011=HSK7471-70Y, 2012=HSK7471-90(Y), 2013=HSK8551-80Y, 2014=HSK8551-110(Y), 2015=HSK8561-90Y, 2016=HSK8561-125(Y), 2017=HSK8571-110Y, 2018=HSK8571-140(Y), 2019=HSK8581-125Y, 2020=HSK8581-160(Y), 2021=HSK8591-140Y, 2022=HSK8591-180(Y), 2100=HSN5343-20(Y), 2101=HSN5353-25(Y), 2102=HSN5363-30(Y), 2103=HSN6451-40(Y), 2104=HSN6461-50(Y), 2105=HSN7451-60(Y), 2106=HSN7461-70(Y), 2107=HSN7471-75(Y), 2108=HSN8571-125(Y), 2109=HSN8591-160(Y), 2200=HSK7471-70VS, 2201=HSK8561-90VS, 2202=HSK8571-110VS, 2203=HSK8591-140VS)

11. Trouble shooting

- Check if there is power to the unit according to specification.
If the power is ok,
- Turn off the power for 5 seconds and see if the relay is energized after power on again.
- If not energized:



turn off all the power to avoid risk of injury!

- Un-mount one of the cables to the PTC element in the motor
- If the measured resistance is above 11.4 kOhm $\pm 20\%$, the temperature of the PTC-sensor is above the threshold limit and the relay has been released to protect the motor or installation.
- If the measured resistance is more than 1 M Ω , there is a broken connection to the PTC-sensor and the relay will not be engaged.
- If the measured resistance is close to 0 Ω , there is a short circuit on the PTC-sensor cables and there is no overheat protection!
- If all three phases are within range and resistance is below 2.9 kOhm $\pm 20\%$, the protection module may be defect and needs replacement.
- Envelope
Via the serial communication the actual zone where the warning or alarm is raised can be read via the BEST service tool.
- Verify using BEST service tool that SE-i1 is configured for the correct compressor and application.

11.1 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 48.
- Check if the communication speed matches the selected. Use BEST to read the settings.
- Check if communication is active. There is one LED for communication activity, please see next section.
- 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.

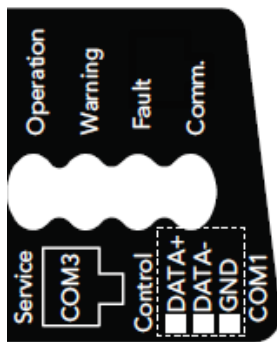
Return codes from Modbus communication if a telegram is not accepted by the SE-i1.

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 warning, critical and fault messages via Modbus or BEST.

11.2 Status LEDs

There are four LEDs as shown on the picture below, 1 LED for communication and three status LEDs.



LED Status		Operation Mode	Warning/Critical	Fault	Communication
Flash Frequency	Flash Period	Green	Yellow	Red	Blue
OFF	OFF	Not operational / Start-up / Terminate	No warn/crit	No fault	No communication
Slow Flashing	Short	Service	Warning		
	Medium		Critical	Fault - Auto Resume	
	Long	Test		Fault - Timer Reset	
Fast Flashing	Short				BEST
	Medium	Terminate	Terminate	Fault - Ext. Reset / Terminate	
	Long			Fault - Restart	Modbus + BEST
ON	ON	Normal / Start-up	Start-up	Start-up	Modbus








LED pattern description

LED pattern	Description
Flash frequency	Fast flashing indicates user or system action is required, slow flashing indicates user or system action may be required
Green LED	Indicates the actual mode of operation -the longer the on period the closer to normal operation -Note 2) off/fast flash indicates "terminate" due to exception or assert
Yellow LED	Indicates possible problems but the product is still operational -the longer on period the higher the severity of the alarm
Red LED	Indicates operation has stopped due to a fault -the longer the on period the higher the severity of the alarm -Slow: stopped but will resume when the fault condition is removed -Fast: user or system action is required
Normal Mode	Device is ready for "full" operation
Service Mode	A mode where config. files, exception logs etc. can be up/downloaded
Test Mode	A mode where either automatic or manual tests can be performed
Production Mode	A mode where special functionality required for production test etc. is enabled
Start-up state	During start-up LEDs are lit constantly according to the table below.
Terminate state	LEDs are flashing fast + medium on period in case of an assert or exception according to the table below









11.3 LED flashing patterns of the three operation status LEDs



































Note: Text in **Bold** is the most normal situations/patterns

- Start-up state: During start-up the LEDs are constant on or off depending on the state of the system. Either the yellow or the red LED will be constant on when the Control Micro is in one of the start-up states.
- Operation modes: When the unit has been initialised and is ready for operation.
 - If the unit is started in normal operation mode the green LED will be constant ON.**
 - If the unit is started in Service mode the green LED will be flashing slowly with a short on period.
 - If the unit is started in Production mode the green LED will be flashing slowly with a long on period.
- Slow flashing patterns in normal operation mode:**
 - Yellow LED is flashing: Warning or critical is active.
 - Red LED is flashing: Fault is active (It is possible to start the motor again when the fault condition disappears AND the fault has been reset).
- The faster and the longer an LED flashes the more severe the alarm
- Fast flashing of any of the 3 LEDs means that a fault has occurred and it can only be reset via external reset (digital input or serial communication) or only by a power cycle in some situation. In such a situation it may be a good idea to take a note about the flashing pattern since this could help to locate the problem.
- Alarms: Warnings, criticals and faults may be present at the same time. If a warning and a critical both are present only critical will be shown on LEDs as this is more severe than warning. Any of the fault flashing patterns may also be combined with either a warning or a critical.

	= Constant on		= Constant off		= Slow flash (0.5 Hz) and long on period
	= Fast flash (2 Hz) and long on period		= Slow flash (0.5 Hz) and medium on period		= Slow flash (0.5 Hz) and short on period
	= Fast flash (2 Hz) and medium on period				

An empty field indicates any other combination might be possible.

Operation Mode			
Normal operation			
Service mode			
Test mode (reserved for future use)			
Production mode			
Alarms (warning,critical,fault)		Warn/Crit	Fault
No Warning, Critical or fault			
Warning Active			
Critical Active (warning may also be active)			

Fault (auto resume reset type)			
Fault (Timed reset)			
Fault (Extern reset)			
Fault (Restart / power cycle)			
Start-up state			
- init ressources			
- init subscriptions			
- init configuration			
- init config ready			
Terminate state, asserts and exceptions			
Assert in code			
NMI fault (exception)			
Hard fault (exception)			
Memory management fault (exception)			
Bus fault (exception)			
Usage fault (exception)			

[illegible]

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