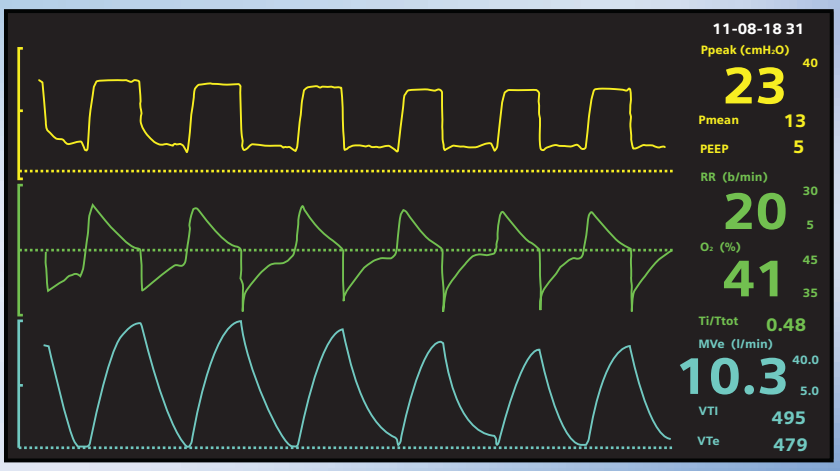
MAQUET

SERVO-i / SERVO-s, Computer Interface Emulator
Reference Manual, Revision 07

CRITICAL CARE



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Important

General information

- The following conventions are used throughout this Reference Manual:
  - **SERVO-i** represents SERVO-i Ventilator System of System version 4.0 or higher.
  - **SERVO-s** represents SERVO-s Ventilator System of System version 4.0 or higher.
- The information in this Reference Manual is valid for both the SERVO-i v4.0 and the SERVO-s v4.0 Computer Interface Emulator (CIE) unless stated otherwise.
- The SERVO-i / SERVO-s Computer Interface Emulator is an integrated part of the SERVO-i / SERVO-s Ventilator System. In addition to the information given here, always pay attention to the information in the ventilators User's Manual.
- The SERVO-i / SERVO-s Computer Interface Emulator must not be used as a component in a remote alarm system.
- MAQUET has no responsibility for the safe operation of the equipment if service or repair is done by a non-professional or by persons who are not employed by or authorized by MAQUET. We recommend that service be done as part of a service contract with MAQUET.
- **Caution**: Federal law in the USA restricts this device to sale by, or on the order of a physician (or a properly licensed practitioner).

Operation

- Due to factors not controlled by MAQUET, the correctness of processed metering values obtained from the SERVO-i / SERVO-s Computer Interface Emulator cannot be guaranteed in all situations. It is therefore recommended that the data be verified against actual preset and measured values of the SERVO-i / SERVO-s and auxiliary equipment. In the case of software not manufactured by MAQUET, MAQUET disclaims all responsibility for the correctness of signals processed by such software.
- Values measured at the signal outputs of the SERVO-i / SERVO-s Ventilator System and which have been processed in auxiliary equipment must not be used as a substitute for therapeutic or diagnostic decisions. Such decisions can be made only by staff with medical expertise, according to established and accepted practice. If auxiliary equipment that has not been delivered by MAQUET with the system is used, MAQUET denies all responsibility for the accuracy of signal processing.

Equipment combinations

- Accessories and auxiliary equipment used with the ventilator should:
  – meet IEC 60601-1-1 standards
  – meet IEC standards as a whole system.

1 Introduction

The following conventions are used throughout this Reference Manual:

– **SERVO-i** represents SERVO-i Ventilator System of System version 4.0 or higher.

– **SERVO-s** represents SERVO-s Ventilator System of System version 4.0 or higher.

The information in this Reference Manual is valid for both the SERVO-i v4.0 and the SERVO-s v4.0 Computer Interface Emulator (CIE) unless stated otherwise.

The purpose of this manual is to provide information about commands and responses in using the SERVO-i / SERVO-s Computer Interface Emulator (CIE).

The SERVO-i / SERVO-s Computer Interface Emulator (CIE) described herein emulates the Computer Interface (CI) of the Servo Ventilator 300/300A (SV 300) protocol, ref. [1], and the Servo Computer Module 990 (SCM 990) protocol, ref. [2], and interfaces an external computer system via an RS-232C serial interface.

This Reference Manual describes the communications protocol between the CIE and an external computer system.

In the Appendix part of the Servo Ventilator 300/300A – Reference Manual, ref. [1], there is a programming example that possibly clarifies how to use the communication commands as presented in this manual in a C programming environment.

Regarding the basic principles for programming the computer, please refer to the computer's reference manual.

In the case of software not manufactured by MAQUET, MAQUET disclaims all responsibility for the correctness of signals processed by such software.

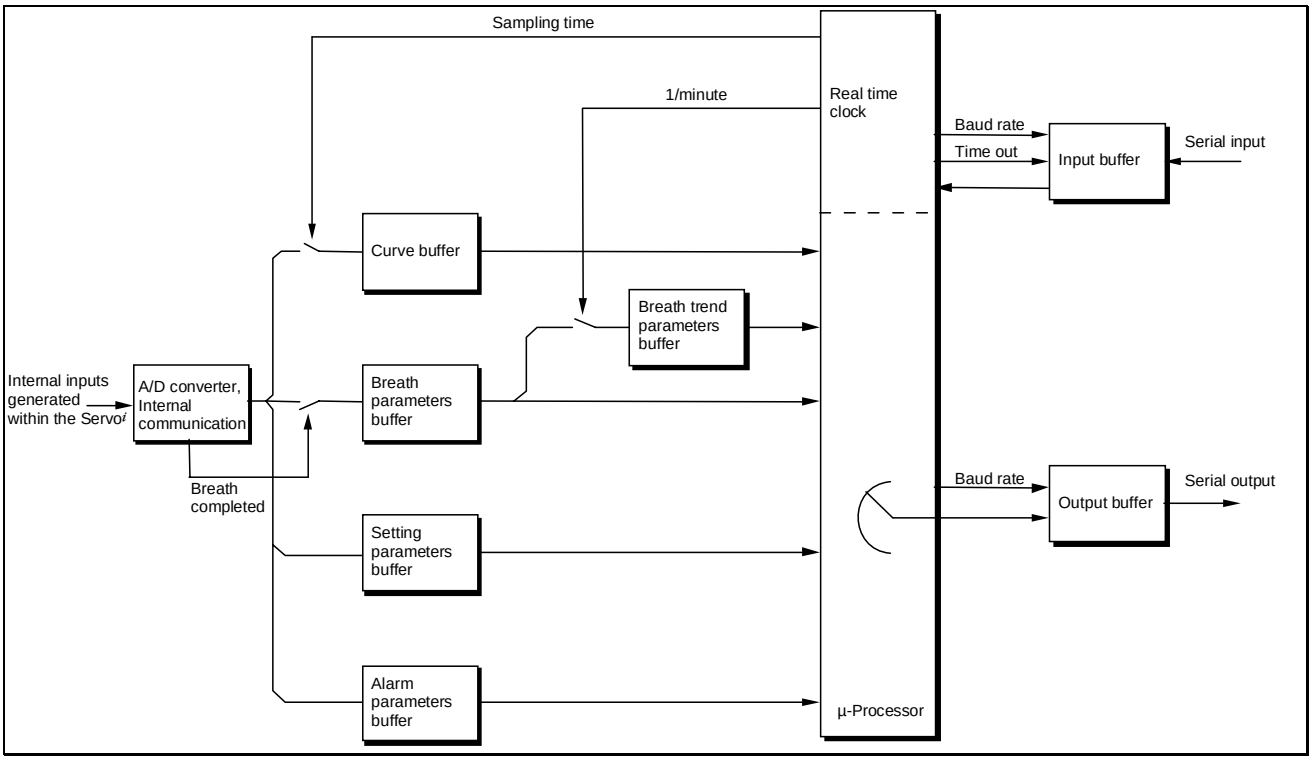
Important note – This Reference Manual is intended for computer programmers only

The SERVO-i / SERVO-s Computer Interface Emulator (CIE) is intended to be used to interface a monitoring system to the ventilator. The monitoring systems software communicates with the CIE using the commands described in this manual.

This manual contains technical information to assist qualified computer programmers in writing software programs to allow external computer systems to utilize the Computer Interface Emulator to query data from the ventilator. The qualifications of the programmer should include knowledge and experience in programming real-time data acquisition systems.

The Computer Interface Emulator can be used with computer systems equipped with an RS 232/9600 baud serial interface, a graphical display device and temporary storage for incoming message packets. The operating system and application programming software must be capable of sensing the presence of received data, reading ASCII and binary data from the temporary storage buffers, performing arithmetic and Boolean logic functions and string manipulation functions to interpret and organize data in displayable form, and transmitting to a graphical display device. These system requirements are met by many general purpose computers available today, whether they be personal computers, professional workstations, or mainframe systems. The software requirements are met by most popular programming languages, such as BASIC, 'C', C++, and Assembler. It is the responsibility of the programmer to determine (through analysis and exhaustive testing) if a particular computer system has sufficient memory, processing speed and other performance characteristics to support a given application.

2 Functional Overview



The information transfer between the CIE and the computer is performed via the serial communication link. The computer acts as the master and transmits commands to the CIE in order to retrieve information.

For Curve data, the desired channels, the sampling speed and the number of samples to be read by the computer are defined by commands. Due to memory limitation, a maximum of 4 channels can be sampled at the same time.

When a breath is completed, all applicable channels are read to the Breath parameters buffer. Once a minute a number of channel data are stored into the Breath Trend parameters buffer, calculated as filtered values over the last minute. The buffer stores trend values for the last 24 hours of operation. The channel numbers are defined by the firmware of the CIE and cannot be changed.

Setting parameters buffer is updated at every change of settings, Alarm parameters buffer is updated every 500 ms.

On command from the computer, the parameter values are fed to the Output buffer and clocked out via the serial port. In order to fulfill isolation requirements, the CIE uses opto couplers on the serial input and output.

3 Compatibility

About SCM 990 compatibility

The SCM 990, Firmware version 2.1 protocol (see ref. [2]) is emulated - BASIC commands.
The following items are the major differences as compared with the SCM 990 – Reference Manual:

- The minimum internal sampling period is 10 ms.
- Aux. channels are emulated.
- The SCM 990 internal battery. (Other voltage level emulated, corresponding to SV 300.)
- The EXTENDED commands. (Not present in the SCM 990.)
- More channels are trended, see further section 4.8.
- The parameter Airway flow * 10, channel 13, only gives the Airway flow, channel 00, multiplied by 10.
- The 'Read Version' command.
- Communication settings.

About SV 300 compatibility

The SV 300 CI, Version 2.0 and above communication protocol (see ref. [1]) is emulated - EXTENDED commands. The following items are the major differences as compared with the SV 300 – Reference Manual:

- Aux. channels are emulated (channels: 32 - 39, 104 - 111, 214 - 221, 237).
- Some channels are emulated and some are not supported, for further details see the section 4.8 and the ref. [1] document.
- Settings and alarm channels are not available as trends.
- In SV 300, all basic channels 0-39 are available as both curve channels and breath channels. In SERVO-i / SERVO-s, curve channels are available as breath channels but not vice versa.
- In SV 300, it is possible to read all basic trend channels 0-33. In SERVO-i / SERVO-s, only the specified trend channels are possible to read. For further details see section 4.8 and the ref. [1] document.
- The minimum internal sampling period is 10 ms.
- The commands ADMP, DISP, RADN, RAIC, RBAT, RCTY, RSWV, RV and STIM.

About SERVO-i / SERVO-s compatibility

The information in this Reference Manual is valid for both the SERVO-i and the SERVO-s Computer Interface Emulator (CIE) unless stated otherwise.

To consider when writing a CIE driver

The CIE protocol is designed to be backwards compatible. The different CIE revisions will affect the output from the commands RCCO (See chapter 6.11) and RSWV (See chapter 6.16). If changes in the output from RCCO and RSWV are considered and appropriately taken care of, implemented CIE drivers will work together with new SERVO-i and SERVO-s software's in the future. The information in this Reference Manual is valid for both SERVO-i and SERVO-s Computer Interface Emulator (CIE) unless stated otherwise.

3.1 References

[1] Servo Ventilator 300/300A, Computer Interface, Firmware version 2.X, Reference Manual, Order No. 63 14 061 E380E.

[2] Servo Computer Module 990, Firmware version 2.1, Reference Manual, Order No. 63 09 178 E357E.

4 Communication - General

4.1 General

The CIE emulates the SV 300 CI and the SCM 990 protocols and interfaces an external computer system via an RS-232C serial interface.

The information transfer between the CIE and the computer is performed via a serial communication line. The computer acts as the master and transmits commands to the CIE in order to retrieve information.

Curve data, breath data, trend data, settings data, alarm data and technical information may be retrieved from the ventilator through CIE.

4.2 Typographical conventions

When reading this manual, note that:

< >	Encloses abbreviations, numerical value, etc.
NN_{16}	Means hexadecimal value.
[ ]	Encloses parameters that are not necessary to use.
{ }	Encloses the set of valid data.
...	Indicates sequence.

4.3 Definitions and Acronyms

4.3.1 Definitions

Alarm	Alarm data is alarm information generated by the ventilator. Alarms are not available as trends.
BASIC Mode	Only BASIC commands are valid, see further section 5.
Breath	Breath data changes at maximum once a breath.
Curve	Curve data changes very often and is typically used to draw real time graphs. It is sampled periodically.
Edi	Electrical activity of the diaphragm
Extended Alarm	Alarm data that also contains information if the alarm is active, but silenced on the ventilator.
EXTENDED Mode	Only EXTENDED commands are valid, see further section 6.
NAVA	Neurally Adjusted Ventilatory Assist
NIV	Non-invasive ventilation.
Parameter	CIE command parameter, i.e. extra information needed to define the semantics of a given CIE command message. For instance, for a read command the parameter designates the data to read.
Preset cycle time	The time equal to 1/CMV freq. (BPM).
Settings	Settings data represent panel settings. Settings are not available as trends.
Technical	Technical information, e.g. module version, configuration, etc.
Trend	Trend data is calculated and stored as one value every minute.

4.3.2 Date format

If year < 90 it will be interpreted as the 21th century, i.e. year 10 is interpreted as 2010. Otherwise, if year ≥ 90 it will be interpreted as the 20th century, i.e. year 99 is interpreted as 1999. The valid date range of SERVO-i / SERVO-s is 1970-01-01 – 2037-12-31.

4.3.3 Common acronyms

AD	Alarm data
BPM	Breaths per minute
BR	Breath data
BT	Breath data (as trend)
CI	Computer Interface
CIE	Computer Interface Emulator
CMV	Continuous Mandatory Ventilation
CPAP	Continuous Positive Airway Pressure
CU	Curve data
Exp time	Expiration time
Insp time	Inspiration time
N/A	Not applicable
PCB	Printed Circuit Board
PEEP	Positive End Expiratory Pressure
SCM 990	Servo Computer Module 990
SD	Settings data
SV 300	Servo Ventilator 300/300A
SV 900	Servo Ventilator 900C/D/E

4.4 The RS-232 communication settings

Baud rate: 9600

Data length: 7 or 8 bits

Stop bits: 1 or 2 bits

Parity: Even

Data format: ASCII or Binary (Binary format requires 8 data bits)

Handshake: XON/XOFF

Both the Data length (7 or 8 bits) and Stop bits (1 or 2 bits) are auto-detected.

4.5 Signal Handshake protocol

The CIE enters BASIC mode in connection with startup and when receiving the command 'Hello', HO. When CIE enters BASIC mode, all activated channels are cleared.

In BASIC Mode the CIE only recognizes the BASIC commands and the 'Read CI Type', RCTY command, which is an EXTENDED command.

When the CIE receives the command 'Read CI Type', RCTY, it enters EXTENDED Mode and all activated channels are cleared.

In EXTENDED Mode the CIE only recognizes the EXTENDED commands and the 'Hello', HO command which is a BASIC command.

The following control characters are used, in order to control the data flow from the CIE:

<EOT>= 04_{16}	End of transmission. General character to be used to define the end of an instruction or end of an ASCII response from the CIE.
<CR> = $0D_{16}$	Carriage Return character.
<LF> = $0A_{16}$	Line Feed character.
<XON>= 11_{16}	Issued by the computer to start the data flow from the CIE if the computer has previously stopped the data flow. (Note 1)
<XOFF>= 13_{16}	Issued by the computer to stop the data flow from the CIE. Upon reception of XOFF, CIE stops transmission as soon as possible. (Note 1)
<ESC> = $1B_{16}$	Issued by the computer to interrupt the data transfer from the CIE. Upon reception of ESC, CIE stops transmission and any running command, e.g. RADC, as soon as possible. Transmission is restarted upon reception of the next valid command.
<CHK>	Calculated checksum (EXTENDED mode only). The checksum calculation is defined in section 7.

Note 1: Computers with automatic Xon/Xoff control may automatically remove the 11_{16} and 13_{16} .
To avoid this it, is recommended to implement Xon/Xoff control in the application

4.6 Error handling

The CIE validates input data in order to detect errors. In case of error, the CIE replies with an error message depending on the type of error and the command type, i.e. ASCII or binary.

The following error messages apply to commands with ASCII response:

Error	Error code	BASIC commands error message	EXTENDED commands error message
Not a valid command	ER10	ER10<EOT>	ER10<CHK><EOT>
Syntax error, e.g. too many or too few parameters	ER11	ER11<EOT>	ER11<CHK><EOT>
Parameter value out of range or parameter not supported by the ventilator	ER12	ER12<EOT>	ER12<CHK><EOT>
No trend values, i.e. requested start time not within trend buffer, no trend values within the time period requested, or requested trend length less than one minute	ER13	ER13<EOT> (Note 1)	ER13<CHK><EOT> (Note 1)
Trend length error, i.e. requested trend length exceeds available trend buffer	ER14	ER14<EOT> (Note 1)	ER14<CHK><EOT> (Note 1)
Trend channel not defined	ER15	ER15<EOT>	ER15<CHK><EOT>
CIE not configured	ER16	Not applicable	ER16<CHK><EOT>
Ventilator is in Stand by mode	ER17	Not applicable	ER17<CHK><EOT>
Checksum error	ER18	Not applicable	ER18<CHK><EOT>
Buffer full	ER19	ER19<EOT>	ER19<CHK><EOT>

Note 1: Not applicable for SERVO-s of System version 1.0. No trend data is available in SERVO-s v1.0.

The following error messages apply to commands with Binary response:

Error	Error code	BASIC commands error message	EXTENDED commands error message
Not a valid command	N/A	Not applicable	Not applicable
Syntax error, e.g. too many or too few parameters	$0B_{16}$	E00B7F	E00B7F<CHK>
Parameter value out of range or parameter not supported by the ventilator	$0C_{16}$	E00C7F	E00C7F<CHK>
No trend values, i.e. requested start time not within trend buffer, no trend values within the time period requested or requested trend length less than one minute	$0D_{16}$	E00D7F (Note 1)	E00D7F<CHK> (Note 1)
Trend length error, i.e. requested trend length exceeds available trend buffer	$0E_{16}$	E00E7F (Note 1)	E00E7F<CHK> (Note 1)
Trend channel not defined	$0F_{16}$	E00F7F	E00F7F<CHK>
CIE not configured	10_{16}	Not applicable	E0107F<CHK>
Ventilator is in Stand by mode	11_{16}	Not applicable	E0117F<CHK>
Checksum error	12_{16}	Not applicable	Not applicable
Buffer full	13_{16}	E0137F	E0137F<CHK>

Note 1: Not applicable for SERVO-s of System version 1.0. No trend data is available in SERVO-s v1.0.

Note that since all CIE command messages are ASCII messages, the error 'Not a valid command' is always returned as an ASCII response message. This is the reason why the error 'Not a valid command' is not applicable as a binary response message.

Note that 'Checksum error' is always returned as an ASCII response message since it is not possible to determine what command generated the error.

If it is not possible to calculate or retrieve data designated by a command parameter within the CIE, a 'Missing value' is transferred, which is 9999 for ASCII and $7EFF_{16}$ for Binary.

4.7 Performance

The CIE sends the first character of the response to all commands within 500 ms, unless otherwise stated in the description of each specific command.

4.8 Channels

Each parameter corresponds to a channel number. The following tables define channels and corresponding parameter:

Channels 00 - 99 are reserved for the BASIC protocol.

Channels 100 - 999 are reserved for the EXTENDED protocol. The trend channel numbers are in this area equivalent to channel No.

4.8.1 Channel 00-99:

Basic SCM 990 protocol channels according to ref. doc. [2].

CIE returns the raw value of a basic channel, which is graded in the unit [4.883mV]. The raw value 2048 corresponds to 0V. Thus, the value graded in engineering unit is calculated according to the following formula:

<value> = ((<raw_value> – 2048) * 4.883) / <scale_factor>

Note that the engineering unit is given by the scale factor of each channel, e.g. the channel airway flow has the scale factor 5000mV/l/s, which gives the engineering unit [l/s].

All curve channels are available as breath channels as well, but not vice versa.

All curve data are based on internal transducer data (even with the SERVO-i option Y-piece measurement active) unless stated as Y-piece curves. Most breath data are based on Y-piece data when Y-piece measurement active.

CIE supports basic channels according to the following table:

Ch No	Trend No	Parameter Name	Scale Factor
0		Airway Flow (curve)	5000mV/l/s
1	20	Insp. Tidal vol. (breath)	5000mV/l
2		Airway Pressure Insp (curve)	50mV/cm H_2O
3	21	Exp. Tidal vol. (breath)	5000mV/l
4	0	O_2-concentration (breath)	50mV/%
5	22	Baro. Pressure (breath) (Note 3)	4883mV/Bar
6	33	Aux_Code (breath) (emulated = 2303)	4.883 mV/bit
7	1	Pause Pressure (breath)	50mV/cm H_2O
8	2	Resp. rate calc (breath)	50mV/breaths/min
9	3	Peak pressure (breath)	50mV/cm H_2O
10	4	Exp. minute vol. (breath)	200mV/l/min
11	23	Mean airway pressure (breath)	50mV/cm H_2O
12		Airway Pressure Exp (curve)	50mV/cm H_2O
13		Airway flow *10 (curve) (Note 4)	50000mV/l/s
14		Not Used (breath) (emulated = 2048)	
15		CI Battery Voltage (curve) (emulated = 2826) (Note 2)	1000mV/V
16		Not Used (breath) (emulated = 2048) (Note 3)	
17		CO_2 concentration (curve) (Note 1)	1000mV/%CO_2
18	7	Ineff tidal volume (breath) (emulated = 2048)	
19	8	Eff tidal volume (breath) (emulated = 2048)	
20	9	CO_2 tidal prod. (breath) (Note 1)	100mV/ml CO_2
21	10	End tidal CO_2 conc. (breath) (Note 1)	1000mV/%CO_2
22	11	CO_2 minute prod. (breath) (Note 1)	10mV/ml CO_2/min
23	12	Eff. Ventilation (breath) (emulated = 2048)	
24	13	Tidal volume (breath) (emulated = 2048)	
25		Airway pressure (breath) (emulated = 2048)	
26	15	Exp. Resistance (breath)	20 mV/cm H_2O/l/s
27	16	Static Compliance (breath)	10 mV/ml/cm H_2O
28	17	End exp. Flow (breath)	1000 mV/l/s
29	18	End exp. pressure (breath)	100mV/cm H_2O
30	19	End exp. lung pressure (breath) (emulated = 2048)	
31	24	Insp. Resistance (breath)	20 mV/cm H_2O/l/s
32	25	AUX Channel 1 (curve) (emulated = 2048)	

33	26	AUX Channel 2 (curve) (emulated = 2048)	
34	27	AUX Channel 3 (curve) (emulated = 2048)	
35	28	AUX Channel 4 (curve) (emulated = 2048)	
36	29	AUX Channel 5 (curve) (emulated = 2048)	
37	30	AUX Channel 6 (curve) (emulated = 2048)	
38	31	AUX Channel 7 (curve) (emulated = 2048)	
39	32	AUX Channel 8 (curve) (emulated = 2048)	
40 - 99		Not Used	

Note 1: Not applicable for SERVO-s.

Note 2: The CI battery voltage is emulated since CIE has no battery of its own. CIE uses the Monitoring PCB battery, which is managed and supervised by the Monitoring subsystem.

Note 3: Channel 5 is not used in the SCM 990. Channel 16 is not used in the SERVO-i / SERVO-s CIE.

Note 4: Min. value for CIE output is -0.2 l/s. Output for lower actual values will be set to -0.2 l/s.

4.8.2 Channel 100-199:

Extended channels used for real-time curves. The configuration, i.e. actual scale factors and the voltage ranges, are received via the command Read Channel Configuration (RCCO). For more information about the configuration, see the description of the command RCCO.

All curve data are based on internal transducer data unless specified as Y-piece curves. When the SERVO-i option Y-piece measurement is active, data from internal transducers may differ from those presented on the User Interface. Also note that since this protocol uses one phase-flag for all curves, and Y-piece curve data are delayed 50 ms compared to internal transducer curve data, the phase-information for Y-piece curve data will be off by 50 ms.

CIE supports extended curve channels according to the following table:

Ch No	Parameter Name	Configuration (gain, offset, unit, type)
100	Airway Flow	+2713E-004, +3333E+000, 02, CU
101	Airway pressure (I)	+6510E-005, +1333E-001, 04, CU
102	Airway pressure (E)	+6510E-005, +1333E-001, 04, CU
103	CO_2 concentration (%) (Note 1)	+1000E-004, +0000E+000, 07, CU
104	AUX Channel 1 (emulated = 2048)	+4883E-003, +1000E+001, 13, CU
105	AUX Channel 2 (emulated = 2048)	+4883E-003, +1000E+001, 13, CU
106	AUX Channel 3 (emulated = 2048)	+4883E-003, +1000E+001, 13, CU
107	AUX Channel 4 (emulated = 2048)	+4883E-003, +1000E+001, 13, CU
108	AUX Channel 5 (emulated = 2048)	+4883E-003, +1000E+001, 13, CU
109	AUX Channel 6 (emulated = 2048)	+4883E-003, +1000E+001, 13, CU
110	AUX Channel 7 (emulated = 2048)	+4883E-003, +1000E+001, 13, CU
111	AUX Channel 8 (emulated = 2048)	+4883E-003, +1000E+001, 13, CU
112	CI Battery Voltage (emulated = 2826)	+4883E-003, +1000E+001, 13, CU
113	Airway pressure	+6510E-005, +1333E-001, 04, CU

114	Volume	+4000E-004, +0000E+000, 01, CU
115	Y-piece Pressure (Note 1)	+6510E-005, +1333E-001, 04, CU
116	Y-piece Flow (Note 1)	+2713E-004, +3333E+000, 02, CU
117	Y-piece Volume (Note 1)	+4000E-004, +0000E+000, 01, CU
118	Edi (Note 1)	+2000E-005, +0000E+000, 19, CU
119	CO_2 concentration (mmHg) (Note 1)	+1000E-004, +0000E+000, 10, CU
120 - 199	Not Used	

Note 1: Not applicable for SERVO-s.

4.8.3 Channel 200-299:

Extended channels used for breath data. The configuration, i.e. actual scale factors and the voltage ranges, are received via the command Read Channel Configuration (RCCO). For more information about the configuration see the description of the command RCCO.

Most breath data will be based on Y-piece data when the SERVO-i option Y-piece measurement is active.

CIE supports extended breath channels according to the following table:

Ch No	Parameter Name	Configuration (gain, offset, unit, type)
200	Measured breath frequency	+1000E-004, +0000E+000, 06, BT
201	Exp. tidal volume	+1000E-003, +0000E+000, 01, BT
202	Insp. Tidal volume	+1000E-003, +0000E+000, 01, BT
203	Insp. Minute volume	+1000E-004, +0000E+000, 08, BT
204	Exp. minute volume	+1000E-004, +0000E+000, 08, BT
205	Peak pressure	+1000E-004, +0000E+000, 04, BT
206	Mean airway pressure	+1000E-004, +0000E+000, 04, BT
207	Pause pressure	+1000E-004, +0000E+000, 04, BT
208	End exp. pressure	+1000E-004, +0000E+000, 04, BT
209	O_2 concentration	+1000E-004, +0000E+000, 07, BT
210	Barometric pressure	+1000E-003, +0000E+000, 12, BT
211	Gas supply pressure, Air	+1000E-001, +0000E+000, 12, BT
212	Gas supply pressure, O_2	+1000E-001, +0000E+000, 12, BT
213	Gas supply pressure, Optional (emulated = 0)	+1000E-001, +0000E+000, 12, BT
214	AUX Channel 1 (emulated = 2048)	+4883E-003, +1000E+001, 13, BT
215	AUX Channel 2 (emulated = 2048)	+4883E-003, +1000E+001, 13, BT
216	AUX Channel 3 (emulated = 2048)	+4883E-003, +1000E+001, 13, BT
217	AUX Channel 4 (emulated = 2048)	+4883E-003, +1000E+001, 13, BT
218	AUX Channel 5 (emulated = 2048)	+4883E-003, +1000E+001, 13, BT
219	AUX Channel 6 (emulated = 2048)	+4883E-003, +1000E+001, 13, BT
220	AUX Channel 7 (emulated = 2048)	+4883E-003, +1000E+001, 13, BT

221	AUX Channel 8 (emulated = 2048)	+4883E-003, +1000E+001, 13, BT
222	Ineff. tidal volume (Note 2)	
223	Eff. tidal volume (Note 2)	
224	CO_2 tidal production (Note 1)	+1000E-004, +0000E+000, 01, BT
225	End tidal CO_2 concentration (%) (Note 1)	+1000E-004, +0000E+000, 07, BT
226	CO_2 minute production (Note 1)	+1000E-003, +0000E+000, 03, BT
227	Eff. ventilation (Note 2)	
228	Barometric Pressure 2nd (emulated = invalid = $7EFF_{16}$)	+1000E-003, +0000E+000, 12, BT
229	Not Used, LMC reserved channel (Note 3)	
230	Not Used, LMC reserved channel (Note 3)	
231	Exp. resistance	+1588E-004, +1000E-001, 09, BT
232	Static Compliance	+4976E-004, +2000E+000, 05, BT
233	End exp. Flow	+7100E-006, +3500E-002, 15, BT
234	Not Used, LMC reserved channel (Note 3)	
235	Not Used, LMC reserved channel (Note 3)	
236	Insp. Resistance	+4000E-004, +0000E+000, 09, BT
237	Aux_Code (emulated = 255)	-, -, -, BT
238	I:E Ratio	+3260E-005, +0000E+000, -, BT
239	Ti (Insufflation time)	+3300E-006, +0000E+000, 14, BR
240	C dyn i in Open Lung Tool	+5000E-004, +0000E+000, 05, BR
241	Dynamic Characteristics	+4976E-004, +2000E-001, 05, BT
242	NIV, Leakage fraction	+1310E-005, +0000E+000, 07, BT
243	Elastance	+1000E-004, +0000E+000, 16, BT
244	Ti/Ttot	+1100E-007, +0000E+000, --, BT
245	Total PEEP	+6510E-005, +1333E-001, 04, BT
246	Shallow Breathing Index (SBI) (Note 4)	+1000E-004, +0000E+000, --, BT
247	Spontaneous Breath frequency	+1000E-004, +0000E+000, 06, BT
248	Mve spont	+1000E-004, +0000E+000, 08, BT
249	MVespont/Mve in Bivent	+1100E-007, +0000E+000, --, BR
250	Time constant	+3300E-006, +0000E+000,14, BT
251	Work of Breathing, Ventilator	+1000E-005, +0000E+000, 17, BT
252	Work of Breathing, Patient	+1000E-005, +0000E+000, 17, BT
253	CPAP (Note 1)	+1000E-004, +0000E+000, 04, BT
254	P0.1	+6510E-005, +1333E-001, 04, BT
255	Edi peak (Note 1)	+2000E-005, +0000E+000, 19, BT
256	Edi min (Note 1)	+2000E-005, +0000E+000, 19, BT

257	% Edi trigger in NAVA (Note 1)	+1310E-005, +0000E+000, 07, BR
258	% Edi cycle off in NAVA (Note 1)	+1310E-005, +0000E+000, 07, BR
259	Shallow Breathing Index (SBI)	+1000E-003, +0000E+000, 22, BT
260	End tidal CO_2 concentration (mmHg) (Note 1)	+1000E-004, +0000E+000, 10, BT
261 –299	Not Used	

Note 1: Not applicable for SERVO-s.

Note 2: Not supported.

Note 3: Not supported, See 'Servo Computer Module 990', Firmware version 2.1, Reference Manual for description of LMC.

Note 4: Obsolete but supported for backward compatibility. Use channel 259 instead.

4.8.4 Channel 300-399:

Extended channels used for settings. The configuration, i.e. actual scale factors and the voltage ranges, are received via the command Read Channel Configuration (RCCO). For more information about the configuration see the description of the command RCCO.

CIE supports extended settings channels according to the following table:

Ch No	Parameter Name	Configuration (gain, offset, unit, type)
300	CMV Frequency, Set	+1000E-004, +0000E+000, 06, SD
301	Insp. Time %, Set	+1000E-004, +0000E+000, 07, SD
302	Pause time %, Set	+1000E-004, +0000E+000, 07, SD
303	SIMV Frequency, Set	+1000E-004, +0000E+000, 06, SD
304	Insp. Rise time %, Set	+1000E-004, +0000E+000, 07, SD
305	Minute Volume, Set	+1000E-005, +0000E+000, 08, SD
306	Pressure Control Level above PEEP, Set	+1000E-004, +0000E+000, 04, SD
307	Pressure Support Level above PEEP, Set	+1000E-004, +0000E+000, 04, SD
308	PEEP, Set	+1000E-004, +0000E+000, 04, SD
309	Patient range selection, Set	-, -, -, SD (Note 3)
310	Ventilation Mode, Set	-, -, -, SD (Note 3)
311	Insp./Exp. Pause Hold, Oxygen Breaths/Start Breaths	-, -, -, SD (Note 3)
312	CPAP, Set (Note 1)	+1000E-004, +0000E+000, 04, SD
313	Exp. minute vol. Upper alarm limit, Set (Note 4)	+1000E-004, +0000E+000, 08, SD
314	Exp. minute vol. Lower alarm limit , Set (Note 4)	+1000E-004, +0000E+000, 08, SD
315	Upper pressure limit, Set	+1000E-003, +0000E+000, 04, SD
316	$EtCO_2$ concentration Upper alarm limit, Set (%) (Note 1)	+1000E-005, +0000E+000, 07, SD
317	$EtCO_2$ concentration Lower alarm limit, Set (%) (Note 1)	+1000E-005, +0000E+000, 07, SD
318	O_2 concentration Upper alarm limit	+1000E-004, +0000E+000, 07, SD
319	O_2 concentration Lower alarm limit	+1000E-004, +0000E+000, 07, SD

320	Not Used	
321	Not Used	
322	Alarm mute/pre-mute Status	-, -, -, SD (Note 3)
323	O_2 concentration, Set	+1000E-004, +0000E+000, 07, SD
324	Valve slot 1, binary code (emulated = 1)	-, -, -, SD
325	Valve slot 2, binary code (emulated = 2)	-, -, -, SD
326	Valve slot 3, binary code (emulated = 63)	-, -, -, SD
327	Trigger sensitivity level below PEEP, Set	-1000E-004, +0000E+000, 04, SD
328	Trigger sensitivity level above PEEP, Set	+1000E-004, +0000E+000, --, SD
329	Language switch	-, -, -, SD (Note 3)
330	Displayed CO_2 Unit (Note 1)	-, -, -, SD (Note 3)
331	CO_2 Mode (Note 2)	
332	CO_2 Execution Mode (Note 2)	
333	I:E Ratio, Set	+1000E-005, +0000E+000, -, SD
334	Tidal volume, Set	+1000E-003, +0000E+000, 01, SD
335	NIV, Backup RR, Set	+1000E-004, +0000E+000, 06, SD
336	NIV Backup Ti, Set	+1000E-005, +0000E+000, 14, SD
337	NIV Program Status	-,-,-,SD (Note 3)
338	High-pressure level in BIVENT, Set	+1000E-004, +0000E+000, 04, SD
339	High pressure level time in BIVENT, Set	+1000E-005, +0000E+000, 14, SD
340	Low pressure level, PEEP, time in BIVENT, Set	+1000E-005, +0000E+000, 14, SD
341	Pressure Support level above Phigh, Set	+1000E-004, +0000E+000, 04, SD
342	Pressure Support level above PEEP, Set	+1000E-004, +0000E+000, 04, SD
343	Insp. Time in Seconds, Set	+1000E-005, +0000E+000, 14, SD
344	Pause Time in Seconds, Set	+1000E-005, +0000E+000, 14, SD
345	Insp. Rise time, seconds, Set	+1000E-005, +0000E+000, 14, SD
346	Breath duration, Set	+1000E-005, +0000E+000, 14, SD
347	Back-up Pressure Level Above PEEP, Set	+1000E-004, +0000E+000, 04, SD
348	Insp. flow, Set	+1000E-006, +0000E+000, 15, SD
349	Suction support Status	-,-,-,SD (Note 3)
350	Cycle off Fraction Level, Set	+1000E-005, +0000E+000, 07, SD
351	Circuit compliance compensation Status	-,-,-,SD (Note 3)
352	Trigger timeout in Automode	+1000E-005, +0000E+000, 14, SD
353	Breath frequency Upper alarm limit, Set	+1000E-004, +0000E+000, 06, SD
354	Breath frequency Lower alarm limit, Set	+1000E-004, +0000E+000, 06, SD
355	Apnea time alarm limit, Set	+1000E-004, +0000E+000, 14, SD

356	PEEP Lower alarm limit, Set	+1000E-004, +0000E+000, 04, SD
357	PEEP Upper alarm limit, Set	+1000E-004, +0000E+000, 04, SD
358	CPAP Upper alarm limit, Set (Note 1)	+1000E-004, +0000E+000, 04, SD
359	CPAP Lower alarm limit, Set (Note 1)	+1000E-004, +0000E+000, 04, SD
360	Y-piece measurement status (Note 1)	-, -, -, SD (Note 3)
361	Edi trigger (Note 1)	+2000E-006, +0000E+000, 19, SD
362	NAVA level (Note 1)	+3000E-006, +0000E+000, 21, SD
363	Gas Type Setting (Note 1)	-,-,-,SD (Note 3)
364	Exp. minute vol. Upper alarm limit, Set	+1000E-005, +0000E+000, 08, SD
365	Exp. minute vol. Lower alarm limit, Set	+1000E-005, +0000E+000, 08, SD
366	$EtCO_2$ concentration Upper alarm limit, Set (mmHg) (Note 1)	+1000E-004, +0000E+000, 10, SD
367	$EtCO_2$ concentration Lower alarm limit, Set (mmHg) (Note 1)	+1000E-004, +0000E+000, 10, SD
368–399	Not Used	

Note 1: Not applicable for SERVO-s.

Note 2: Not supported.

Note 3: See 4.8.5 Switch Parameters for channels No. 300 to 399.

Note 4: Obsolete but supported for backward compatibility. Use channels 364/365 instead.

4.8.5 Switch Parameters for Channels 300 to 399:

Ch No	Switch Parameters
309	Patient range selection, Set Value: 1 = Neonate 2 = Adult 3 = Pediatric (Not supported)
310	Ventilation Mode, Set Value when ”**automode**” is **OFF**: 1 = Stand By 2 = Pressure Control 3 = Volume Control 4 = Pressure Reg. Volume Control 5 = Volume Support 6 = SIMV (Vol. Contr.) + Pressure Support 7 = SIMV (Press. Contr.) + Pressure Support 8 = Pressure Support / CPAP 9 = Ventilation mode not supported by CIE 10 = SIMV (Pressure Reg. Volume Control) + Pressure Support 11 = Bivent 12 = Pressure Control in NIV 13 = Pressure Support / CPAP in NIV 14 = Nasal CPAP 15 = NAVA 16 = ”Pressure Reg. Volume Control” mode automatically activated during ”Volume Support” mode (Not supported) Value when ”automode” is ON: 18 = Pressure Control, patient does not trigger the ventilator 19 = Volume Control, patient does not trigger the ventilator 20 = Pressure Reg. Volume Control, patient does not trigger the ventilator 21 = Pressure Support / CPAP (switches to mode 18 if the patient does not trigger the ventilator) 22 = Volume Support (switches to mode 19 if the patient does not trigger the ventilator) 23 = Volume Support (switches to mode 20 if the patient does not trigger the ventilator)

311	Insp./Exp Pause Hold, Oxygen Breaths/Start Breaths Combined channel. Output value is the sum of all active functions. Example: 5 = Oxygen breaths and Insp. Pause hold. Value: 0 = Normal state, no active function 1 = Insp. Pause hold 2 = Exp. Pause hold 4 = Oxygen breaths 8 = Start breath
322	Alarm mute/pre-mute Status Value: 8 = Normal state 10 = Alarm muted/pre-muted
329	Language Switch Value: 0 = English 1 = Swedish 2 = German 3 = French 4 = Italian 5 = Spanish 7 = Other language In SV 300, value 0-15 is used for language and barometer display unit.
330	Displayed CO_2 Unit Value: 1 = % 2 = kPa (Note 1) 4 = mmHg (Note 2)
337	NIV Program Status Value: 0 = Undefined Status 1 = Waiting position 2 = Ventilation 3 = Disconnected

349	Suction Support Status Value: 0 = Undefined Status 1 = Normal ventilation 2 = Waiting for disconnect 3 = Disconnected 4 = Post oxygenation
351	Circuit compliance compensation Status Value: 1 = OFF 2 = ON
360	Y-piece Measurement Status Value: 1 = Inactive 2 = Active
363	Gas Type Setting Value: 0 = Undefined Gas Type 1 = Heliox 2 = Air

Note 1: The following formula is used to convert from % to kPa:

$$\frac{\text{Value [\%]} \times \text{Barometric Pressure [mbar]}}{1000}$$

Barometric Pressure can be reached via channel 210.

Note 2: The following formula is used to convert from % to mmHg:

$$\frac{760\ [\text{mmHg}]}{1013\ [\text{mbar}]} \times \text{Barometric Pressure [mbar]} \times \frac{\text{Value [\%]}}{100}$$

4.8.6 Channel 400-499:

Extended channels used for alarms. The configuration, i.e. actual scale factors and the voltage ranges, are received via the command Read Channel Configuration (RCCO). For more information about the configuration, see the description of the command RCCO.

CIE supports alarm channels according to the following table:

Ch No	Parameter Name
400	O_2 conc. too high – alarm
401	O_2 conc. too low – alarm
402	$EtCO_2$ conc. too high – alarm (Note 1)
403	$EtCO_2$ conc. too low – alarm (Note 1)
404	Breathing system µP Module error – alarm (emulated = 0)
405	Inspiratory control µP Module error – alarm (emulated = 0)
406	Panel Interface µP Module error – alarm (emulated = 0)
407	Exp. flow & CO_2 linearization µP Module error – alarm (emulated = 0) (Note 1)
408	Monitoring System µP Module error – alarm (emulated = 0)
409	Computer Interface Emulator technical error – alarm (emulated = 0)
410	Airway pressure alarm Upper pressure limit exceeded – alarm
411	Exp. minute volume – alarm Combination of exp. minute volume too high/low
412	Apnea alarm/Backup ventilation
413	Gas supply alarm
414	Battery alarm
415	Not Used
416	Power Failure – alarm Combination of: -12V too low/high 12V too low/high 24V too low/high
417	Mains Failure – alarm
418	O_2 potentiometer error – alarm (emulated = 0)
419	CMV potentiometer error – alarm (emulated = 0)
420	Range Switch error – alarm (emulated = 0)
421	Mode Switch error – alarm (emulated = 0)
422	Barometer error – alarm Combination of Baro. Press. too high/low
423	High continuous pressure – alarm
424	Overrange – alarm Combination of: Insp. Tidal volume overrange Insp. Flow overrange

425	O_2 cell disconnect – alarm
426	Computer Interface Emulator Internal communication failure – alarm Combination of: Panel/Breathing/ExpFlowMtr disconnect Panel/Breathing/ExpFlowMtr connect timeout
427	Computer Interface Emulator hardware error – alarm (emulated = 0)
428	Alarm buff (emulated = 0)
429	CI Battery Voltage – alarm (emulated = 0)
430	NIV, Time in waiting position exceeds 2 min
431	NIV, No patient effort detected
432	NIV, Leakage out of range
433	Check tubing
434	Regulation pressure limited
435	Breath frequency High
436	Breath frequency Low
437	PEEP Low
438	PEEP High
439	CPAP High (Note 1)
440	CPAP Low (Note 1)
441	Pneumatic-Edi out of synch (Note 1)
442	Edi activity low (Note 1)
443	No Edi signal detected (Note 1)
444	Unsuccessful manual gas change alarm (Note 1)
445	Exp. Minute volume too high – alarm
446	Exp. Minute volume too low – alarm
447 –497	Not Used
498	High Priority Alarm
499	Computer Interface Emulator Summary Alarm

Note 1: Not applicable for SERVO-s.

The data output of the alarm channels is configurable with the command SDADA, or SDADE (alarm channels with extended output).

Alarm data output without any alarm channels configured:

Alarm status	Readout command			
	RALO	RADAA (Note 1)	RADAE (Note 1)	RADC (Note 2)
No alarm	0	ER16	ER16	10_{16}
Alarm active	1	ER16	ER16	10_{16}
Alarm active but silenced	1	ER16	ER16	10_{16}

Note 1: ASCII coded error message ER16, CIE not configured.

Note 2 Binary coded error message $E0107F_{16}$, CIE not configured.

Alarm data output when configured with SDADA:

Alarm status	Readout command			
	RALO	RADAA	RADAE Note 1	RADC
No alarm	0	0	ER16	00_{16}
Alarm active	1	1	ER16	FF_{16}
Alarm active but silenced	1	1	ER16	FF_{16}

Note 1: ASCII coded error message ER16, CIE not configured.

Alarm data output when configured with SDADE:

Alarm status	Readout command			
	RALO	RADAA Note 1	RADAE	RADC
No alarm	0	ER16	0	00_{16}
Alarm active	1	ER16	1	01_{16}
Alarm active but silenced	2	ER16	2	02_{16}

Note 1: ASCII coded error message ER16, CIE not configured.

4.8.7 Channel 500-999:

Extended channels not used.

500-999	Not Used

5 Basic Commands

5.1 General

The BASIC commands below are according to the SCM 990, Firmware version 2.0 protocol, see ref. [2].

Equipment administration commands:

Empty command	The empty command can be used for connection check.
Address Number, AN	Reads the address number of the ventilator (emulated).
Battery Check, BC	Reads the internal battery voltage (emulated).
Change Time Out, CT	Defines the command timeout.
Firmware Version, SV	Reads the firmware version.
Hello, HO	General call from the computer to the CIE to check the connection.
Read Time, RT	Reads the Real Time Clock.
Read Version, RV	Reads the version of the ventilator.
Set Time, ST	Sets the Real Time Clock (not supported).

Data acquisition commands:

Define Breath, DB	Defines which channels to be read by the instruction Read Breath.
Read Breath, RB	Reads the channels defined by the command Define Breath.
Change Sampling Time, CS	Sets the sampling time in milliseconds.
Read Sampling Time, RS	Reads the sampling time in milliseconds.
Define Curve, DC	Defines which channels to be read by the instruction Read Curve or Ultra Curve.
Read Curve, RC	Reads the channels defined by the command Define Curve.
Ultra Curve, UC	Reads the values, in compressed binary format, of the channels defined by the command Define Curve.
Alarm Output, AO	Requests alarm status.
Trend Output, TO	Reads one of the trend channels from the trend memory.
Ultra Trend, UT	Reads one of the trend channels from the trend memory (compressed binary).

5.2 Empty command

CIE responds to the empty command in basic mode.

Input syntax: <EOT>

Output syntax: *<EOT>

5.3 Address Number AN

The CIE returns the address number of the unit (emulated).

Input syntax: AN<EOT>

Output syntax: <n><EOT>

Emulated Output: 00<EOT>

Parameters: <n> = 00-99

5.4 Alarm Output AO

The CIE returns the summary alarm status.

Input syntax: AO<EOT>

Output syntax: <value><EOT>

Parameters: <value> = {0 (no alarm),1 (alarm)}

When SERVO-i / SERVO-s is in standby mode this command returns ER10, i.e. it is not a valid command in standby mode.

5.5 Battery Check BC

The CIE returns the internal battery voltage.

Input syntax: BC<EOT>

Output syntax: <value><EOT>

Emulated Output: 380<EOT>

Parameters: <value> = 000-999 (steps of 10 mV)

Since CIE has no battery of its own within SERVO-i / SERVO-s, the emulated value 380 (3.8 V) is returned.

5.6 Change Time Out CT

This command defines the input character timeout. Due to serial communications, the CIE needs to receive any character within the set timeout. Otherwise the previous characters will be ignored.

Input syntax: CT<value><EOT>

Output syntax: *<EOT>

Parameters: <value> = 001-250 (steps of 0.1 seconds)

If this command has not been received, the default timeout of 10 seconds applies.
The new timeout will be activated within 500 ms after command is received.

The timeout is shared between Basic and Extended mode, e.g. if the timeout is changed in basic mode, the new value is applicable in both basic and extended mode.

5.7 Define Breath DB

This command defines which channels to be read by the instruction Read Breath. A minimum of 1 and a maximum of 32 channels can be defined. It is possible to choose an arbitrary number of channels in arbitrary row of order. The definition is valid until next time the command Define Breath is issued.

Input syntax: DB<n_1>[<n_2>...<n_{32}>]<EOT>

Output syntax: *<EOT>

Parameters: <n_1>...<n_{32}> = 00 – 39, channel number

The new channel table is activated within 500 ms after the response has been sent.

5.8 Define Curve DC

This command defines which channels to be read by the instruction Read Curve or Ultra Curve. A minimum of 1 and a maximum of 4 channels can be defined. It is possible to choose an arbitrary number of channels in arbitrary row of order. The definition is valid until next time the command Define Curve is issued.

Input syntax: DC<n_1>[<n_2>...<n_4>]<EOT>

Output syntax: *<EOT>

Parameters: <n_1>...<n_4> = 00 – 39, channel number

The new channel is activated within 500 ms after the variable has been set.

5.9 Firmware Version SV

This command requests information about the firmware version. The reason for this command is only to keep compatibility with the SCM 990, see ref. [2].

Input syntax: SV<EOT>

Output syntax: 002200<EOT>

5.10 Hello HO

This command is a general call from the computer to the CIE to check the connection. The reason for this command is only to keep compatibility with the SCM 990, see ref. [2].

Input syntax: HO<EOT>

Output syntax: 900PCI<EOT>

Please see section 4.5 for further details about this command.

5.11 Read Breath RB

This command reads the channels defined by the command Define Breath. The read channel information always comes from the last completed breath cycle.

Input syntax: RB<EOT>

Output syntax: <$value_{(0)}$>...<$value_{(n)}$><EOT>

Parameters: <$value_{(0)}$>...<$value_{(n)}$> = 0000 – 9999

n = 0 – 31

When SERVO-i / SERVO-s is in standby mode, this command returns ER10, i.e. it is not a valid command in standby mode.

5.12 Read Curve RC

This command reads the channels defined by the command Define Curve. When CIE receives this command, it waits until the given trigger condition <trigger_point> is true, e.g. start of inspiration. Then CIE samples the defined curve channels and returns the result periodically until the requested number of samples are returned. The sampling period is defined by the command Change Sampling Time.

Input syntax: RC<n>[<trigger_point>]<EOT>

Output syntax: <time_phase>[<$value_{(1,1)}$><$value_{(2,1)}$><$value_{(3,1)}$><$value_{(4,1)}$>]...

<time_phase>[<$value_{(1,n)}$><$value_{(2,n)}$><$value_{(3,n)}$><$value_{(4,n)}$>]<EOT>

Parameters: n = 0001 – 1500, number of samples
<trigger_point> = { 0 (free run),
1 (start insp), (default)
2 (end insp),
3 (start exp),
4 (end exp)}
<time_phase> = { I (insp time),
P (pause time),
E (exp time)}
$<value_{(1,1)}>...<value_{(4,n)}>$ = 0000 – 9999
During Nasal CPAP:
<trigger_point> ignored and treated as 0 (free run)
<time_phase> will always be E (exp time)

The maximum time difference between transmitted value and sampled value is less than 500 ms.

When SERVO-i / SERVO-s is in standby mode, this command returns ER10, i.e. it is not a valid command in standby mode.

If SERVO-i / SERVO-s is set in standby mode before the <trigger_point> is reached, this command returns ER10.

5.13 Read Sampling Time RS

This command reads the set sampling time (in milliseconds). See further the command Change Sampling Time.

Input syntax: RS<EOT>

Output syntax: <value><EOT>

Parameters: <value> = 010 – 224 (ms)

5.14 Read Time RT

This command reads the Real Time Clock.

Input syntax: RT<EOT>

Output syntax: <year><month><day><hour><minute><sec><EOT>

Parameters:
<year> = 00 – 99
<month> = 01 – 12
<day> = 01 – 31
<hour> = 00 – 23
<minute> = 00 – 59
<sec> = 00 – 59

5.15 Read Version RV

This command reads the ventilator product name.

Input syntax: RV<EOT>

Output syntax:

SERVO-i Servo-i<EOT>

SERVO-s Servo-s<EOT>

5.16 Change Sampling Time CS

This command sets the sampling time (in milliseconds). The default sampling time is 20 ms. Only one sampling time can be set at a time to be valid for all sampled channels until next time the command Change Sampling Time is received.

Input syntax: CS<value><EOT>

Output syntax: *<EOT>

Parameters: <value> = 004 – 224 (ms)

Odd requested sampling time is decremented by 1 ms.

The new sampling time is activated within 500 ms.

The new sampling time is shared between Basic and Extended mode, e.g. if the sampling time is changed in extended mode, the new value is applicable in both basic and extended mode.

Furthermore the sampling time is persistent, i.e. it is stored in persistent memory between ventilator sessions.

The minimum internal sampling time is 10 ms. In cases where the requested sampling time is less than 10 ms, it is set to 10 ms.

5.17 Set Time ST (not supported)

This command is supposed to set the Real Time Clock. *It is not supported anymore since it affects the existing trend data.*

Input syntax: ST<year><month><day><hour><minute><EOT>

Output syntax: ER10<EOT>

Parameters:

<year>	= 00 – 99
<month>	= 01 – 12
<day>	= 01 – 31
<hour>	= 00 – 23
<minute>	= 00 – 59

5.18 Trend Output TO

This command reads one of the trend channels from the trend memory, the last value is presented first.

Input syntax: TO<k>[<start_time>]<length><EOT>

Output syntax:

SERVO-i / SERVO-s $<t_0>,<value_{(0)}>,<value_{(-1)}>...$

$[;<t_1>,<value_{(-x)}>,...,<value_{(-n+1)}>]$<EOT>

SERVO-s of System version 1.0 ER15<EOT>

No trend data is available in SERVO-s v1.0

Parameters:

<k> = 00 – 33, trend channel number

<year> = 00 – 99
<month> = 01 – 12
<day> = 01 – 31
<hour> = 00 – 23
<minute> = 00 – 59
<sec> = 00 – 59

<start_time> = <year><month><day><hour><min><sec>

<length> = <hour><min><sec>

$<t_0>$,$<t_1>$ = <year><month><day><hour><min><sec>

$<value_{(0)}>...<value_{(-n + 1)}>$ = 0000 – 9999

If no <start_time> is selected, the default <start_time> will be the time of the last trend value.

The first time stamp $<t_0>$ of the response is mandatory, in case there are any trend values to return. Subsequent time stamps $<t_1>$ are given in case of discontinuities in the trend, e.g. if the SERVO-i has been turned off for a while.

5.19 Ultra Curve UC

This command reads the values, in compressed binary format, of the channels defined by the command Define Curve. When CIE receives this command, it waits until the given trigger condition <trigger_point> is true, e.g. start of inspiration. Then CIE samples the defined curve channels and returns the result periodically until the requested number of samples are returned. The sampling period is defined by the command Change Sampling Time.

Input syntax: UC<n>[<trigger_point>]<EOT>

Normal Output syntax: <phase_flag><phase>[<value_flag><$value_{(1,1)}$>

<value_flag><$value_{(2,1)}$><value_flag><$value_{(3,1)}$>

<value_flag><$value_{(4,1)}$>][<$diff\_value_{(1,2)}$>

<$diff\_value_{(2,2)}$><$diff\_value_{(3,2)}$><$diff\_value_{(4,2)}$>]...

<phase_flag><phase>[<$diff\_value_{(1,X)}$><$diff\_value_{(2,X)}$>

<$diff\_value_{(3,X)}$><$diff\_value_{(4,X)}$>]...

[<value_flag><$value_{(1,Y)}$>< $diff\_value_{(2,Y)}$>< $diff\_value_{(3,Y)}$>

< $diff\_value_{(4,Y)}$>]...

[<$diff\_value_{(1,n)}$><$diff\_value_{(2,n)}$><$diff\_value_{(3,n)}$>

<$diff\_value_{(4,n)}$>]

<end_flag>

Output syntax in case of error: <error_flag><error><end_flag>

Parameters: n = 0001 – 1500 (number of samples, ASCII)

<trigger_point> = { 0 (free run, ASCII),
1 (start insp, ASCII) – default
2 (end insp, ASCII),
3 (start exp, ASCII),
4 (end exp, ASCII)}

<phase_flag> = 81_{16}
<phase> = { 10_{16} (insp time),
20_{16} (pause time),
30_{16} (exp time)}

<error_flag> = $E0_{16}$
<error> = XX_{16} (binary error code)

<value_flag> = 80_{16}
<$value_{(1,1)}$>...<$value_{(4,n)}$> = 0000_{16} – $7EFF_{16}$ (MSB first)

<$diff\_value_{(1,2)}$>...<$diff\_value_{(4,n)}$> = 82_{16} – $7E_{16}$

(82_{16} = -126_{10} ; $7E_{16}$ = 126_{10})

<end_flag> = $7F_{16}$

During Nasal CPAP:

<trigger_point> ignored and treated as 0 (free run)

<phase> will always be 30_{16} (exp time)

The CIE transmits the channel values according to the channel table set up by the command Define Curve. The CIE responds to the command within 500 ms after the <trigger_point>. The maximum time difference between transmitted value and sampled value is less than 500 ms.

Values are sent as differences <diff_value> when possible in order to save bandwidth, where <diff_value> is the difference between the current and the preceding value, i.e. <diff_value> = <$value_{(t)}$> - <$value_{(t-1)}$>.

Absolute values <value> are sent the first time and when the difference is to large. An absolute value will be preceded by a value flag <value_flag>.The most significant byte (MSB) of an absolute value is sent first.

The breath phase <phase> is sent the first time and then only upon breath phase changes. It is preceded by a phase flag <phase_flag>.

When SERVO-i / SERVO-s is in standby mode this command returns ER10, i.e. it is not a valid command in standby mode.

If SERVO-i / SERVO-s is set in standby mode before the <trigger_point> is reached, this command returns ER10.

5.20 Ultra Trend UT

This command reads one of the trend channels from the trend memory, the last value is presented first. Compressed binary coded format is used (8 data bits).

Input syntax: UT<k>[<start_time>]<length><EOT>

SERVO-i / SERVO-s Normal output syntax: <time_flag><t_0><value_flag><$value_{(0)}$><$diff\_value_{(-1)}$>...

<time_flag><t_1><$diff\_value_{(-x)}$>...<value_flag><$value_{(-y)}$>...

<$diff\_value_{(-n+1)}$><end_flag>

SERVO-i / SERVO-s Output syntax in case of error: <error_flag><error><end_flag>

SERVO-s of System version 1.0 Output syntax: E00F7F
No trend data is available in SERVO-s v1.0

Parameters:

<k> = 00 – 33 (trend channel, ASCII)

<year> = 00 – 99
<month> = 01 – 12
<day> = 01 – 31
<hour> = 00 – 23
<minute> = 00 – 59
<sec> = 00 – 59

<start_time> = <year><month><day><hour><min><sec> (ASCII)

<length> = <hour><min><sec> (ASCII)

<error_flag> = $E0_{16}$
<error> = XX_{16}(binary error code)

<time_flag> = 81_{16}
<t_0>,<t_1> = <year><month><day><hour><min><sec> (binary)

<value_flag> = 80_{16}
<$value_{(0)}$>...<$value_{(-n+1)}$> = 0000_{16} – $7EFF_{16}$(MSB first)

<$diff\_value_{(-1)}$>...<$diff\_value_{(-n+1)}$> = 82_{16} – $7E_{16}$

(82_{16} = -126_{10} ; $7E_{16}$ = 126_{10})

<end_flag> = $7F_{16}$

If no <start_time> is selected, the default <start_time> will be the time of the last trend value.

The first time stamp <t_0> of the response is mandatory, in case there are any trend values to return. Subsequent time stamps <t_1> are given in case of discontinuities in the trend, e.g. if the SERVO-i has been turned off for a while. A time stamp is preceded by a time flag <time_flag>.

Values are sent as differences <diff_value> when possible in order to save bandwidth, where <diff_value> is the difference between the current and the succeeding value, i.e. <diff_value> = <$value_{(t)}$> - <$value_{(t+1)}$>.

Absolute values <value> are sent the first time and when the difference is to large. An absolute value is preceded by a value flag <value_flag>. The most significant byte (MSB) of an absolute value is sent first.

6 Extended Commands

6.1 General

The EXTENDED commands below are according to the SV 300 CI, Version 2.0 and above (see ref. [1]).

Equipment administration commands:

Empty command	The empty command can be used for connection check.
Read Address Number, RADN	Reads the address number of the ventilator (emulated).
Read Analog Input Code, RAIC	Reads the status of the aux input, i.e. on or off, and aux. input code (emulated).
Read Battery, RBAT	Reads the internal battery voltage (emulated).
Read Channel Configuration, RCCO	Reads the channel configuration.
Read CI Type, RCTY	General call from the computer to the CIE to check the connection.
Read Software Version, RSWV	Requests technical information about the Servo Ventilator modules.
Read Text, RETX	Reads stored text strings.
Read Time, RTIM	Reads the Real Time Clock.
Read Time out, RTOU	Reads the command timeout.
Set Time, STIM	Sets the Real Time Clock (not supported).
Set Time Out, STOU	Defines the command timeout.
Store Text, STTX	Store text string.

Data acquisition commands:

Set Data Acquisition Definition, SDAD	Defines which channels to be read by the command Read Acquired Data.
Read Data Acquisition Definition, RDAD	Reads the Data Acquisition channel definition table defined by the instruction Set Data Acquisition Definition.
Read Acquired Data, RADA	Read data stream.
Read Acquired Data Continuously, RADC	Read combined data stream continuously.
Read Sampling Time, RSTI	Reads the sampling time in milliseconds.
Set Sampling Time, SSMP	Sets the sampling time in milliseconds.
Read Alarm Output, RALO	Requests alarm status.

Patient administration commands:

Admit Patient, ADMP	Stores the patient id with the time when the command was received. Optionally, a specific time may be entered (not supported).
Discharge Patient, DISP	Removes the patient id from the active patient field and stores the patient information, patient id, admittance time and discharge time in the patient history table (not supported).
Read Patient Info, RPAI	Reads the patient information from the active patient field. Optionally, the patient history table may be retrieved.

6.2 Empty command

CIE responds to the empty command in extended mode.

Input syntax: <EOT>

Output syntax: *<CHK><EOT>

6.3 Admit Patient ADMP

This command is not supported by CIE, and hence CIE returns ER10 if this command is received.

6.4 Discharge Patient DISP

This command is not supported by CIE, and hence CIE returns ER10 if this command is received.

6.5 Read Acquired Data RADA

This command reads the data, i.e. curve-, breath-, settings-, trend- or alarm data, according to the channel table setup via the command Set Data Acquisition Definition. Each type of RADA command is described in detail in the subsections below.

6.5.1 Curve Data

Input syntax: RADA<curve_parameters><CHK><EOT>

Normal Output syntax:
<phase_flag><phase><value_flag><$value_{(1,1)}$>
[<value_flag><$value_{(2,1)}$><value_flag><$value_{(3,1)}$>
<value_flag><$value_{(4,1)}$>]<$diff\_value_{(1,2)}$>
[<$diff\_value_{(2,2)}$><$diff\_value_{(3,2)}$><$diff\_value_{(4,2)}$>]...
<phase_flag><phase><$diff\_value_{(1,X)}$>[<$diff\_value_{(2,X)}$>
<$diff\_value_{(3,X)}$><$diff\_value_{(4,X)}$>]...
<value_flag><$value_{(1,Y)}$>[< $diff\_value_{(2,Y)}$>< $diff\_value_{(3,Y)}$>
< $diff\_value_{(4,Y)}$>]...
<$diff\_value_{(1,n)}$>[<$diff\_value_{(2,n)}$><$diff\_value_{(3,n)}$>
<$diff\_value_{(4,n)}$>]
<end_flag><CHK>

Output syntax in case of error: <error_flag><error><end_flag><CHK>

Parameters: <curve_parameters> = UC<n>[<trigger_point>][<end_trigger_point>]

n = 0001 – 1500 (number of samples, ASCII)

<trigger_point> = { 0 (free run, ASCII),
1 (start insp, ASCII) – default
2 (end insp, ASCII),
3 (start exp, ASCII),
4 (end exp, ASCII)}

<end_trigger_point> = {0 (free run, ASCII),
1 (start insp, ASCII)
2 (end insp, ASCII),
3 (start exp, ASCII),
4 (end exp, ASCII)}

<phase_flag> = 81_{16}

<phase> = { 10_{16} (insp time),
20_{16} (pause time),
30_{16} (exp time)}

<error_flag> = $E0_{16}$

<error> = XX_{16}(binary error code)

<value_flag> = 80_{16}

<$value_{(1,1)}$>...<$value_{(4,n)}$> = 0000_{16} – $7EFF_{16}$ (MSB first)

<$diff\_value_{(1,2)}$>...<$diff\_value_{(4,n)}$> = 82_{16} – $7E_{16}$

(82_{16} = -126_{10} ; $7E_{16}$ = 126_{10})

<end_flag> = $7F_{16}$

During Nasal CPAP:

<trigger_point> ignored and treated as 0 (free run)

<phase> will always be 30_{16} (exp time)

If no <trigger_point> selected, the default value 1 (start insp.) applies.

If no <end_trigger_point> selected, <n> samples will be transmitted.

If <end_trigger_point> selected, <trigger_point> must also be selected. In this case the command transmits samples until the trigger condition <end_trigger_point> is true or a maximum of <n> samples are transmitted.

Values are sent as differences <diff_value> when possible in order to save bandwidth, where <diff_value> is the difference between the current and the preceding value, i.e. <diff_value> = <$value_{(t)}$> - <$value_{(t-1)}$>.

Absolute values <value> are sent the first time and when the difference is too large. An absolute value will be preceded by a value flag <value_flag>.The most significant byte (MSB) of an absolute value is sent first.

The breath phase <phase> is sent the first time and then only upon breath phase changes. It is preceded by a phase flag <phase_flag>.

When SERVO-i / SERVO-s is in standby mode, this command returns the binary error code 17.

If no curve channels are defined, this command returns the binary error code 16.

If SERVO-i / SERVO-s is set in standby mode before the <trigger_point> is reached, this command returns the binary error code 17.

6.5.2 Breath Data

Input syntax: RADA< breath_parameters ><CHK><EOT>

Output syntax: <value$_{(0)}$>...<value$_{(n)}$> <CHK><EOT>

Parameters: <breath_parameters> = B

<value$_{(0)}$>...<value$_{(n)}$> = 0000 – 9999

n = 0 – 49

When SERVO-i / SERVO-s is in standby mode, this command returns ER17.

If no breath channels are defined, this command returns ER16.

The read channel information always comes from the last completed breath channel.

6.5.3 Settings Data

Input syntax: RADA<setting_parameters><CHK><EOT>

Output syntax: <value$_{(0)}$>...<value$_{(n)}$><CHK><EOT>

Parameters: <setting_parameters> = S

<value$_{(0)}$>...<value$_{(n)}$> = 0000 – 9999

n = 0 – 49

When SERVO-i / SERVO-s is in standby mode, this command returns ER17.

If no settings channels are defined, this command returns ER16.

6.5.4 Alarm Data

Input syntax: RADA<alarm_parameters><CHK><EOT>

Output syntax: <alarm_value$_{(0)}$>...< alarm_value$_{(n)}$><CHK><EOT>

Parameters: <alarm_parameters> = A

<alarm_value$_{(0)}$>...< alarm_value$_{(n)}$> = { 0 (No Alarm)

1 (Alarm)}

n = 0 – 49

When SERVO-i / SERVO-s is in standby mode, this command returns ER17.

If no alarm channels are defined, or the alarm channels are defined with the SDADE command, this command returns ER16.

6.5.5 Alarm Data with extended output

Input syntax: RADA<alarm_parameters><CHK><EOT>

Output syntax: <alarm_value$_{(0)}$>...< alarm_value$_{(n)}$><CHK><EOT>

Parameters: <alarm_parameters> = E

<alarm_value$_{(0)}$>...< alarm_value$_{(n)}$> = { 0 (No Alarm)

1 (Alarm active)

2 (Alarm active but silenced)}

n = 0 - 49

When SERVO-i / SERVO-s is in standby mode, this command returns ER17.

If no alarm channels are defined, or the alarm channels are defined with the SDADA command, this command returns ER16.

6.5.6 Trend Data

The trend data can be retrieved in different formats—ASCII or binary, the table for them follows below.

ASCII format:

Input syntax: RADA<trend_parameters><CHK><EOT>

Output syntax:

SERVO-i / SERVO-s Breath Channels:

<t_0>,<value$_{(0)}$>,<value$_{(-1)}$>...

[;<t_1>,<value$_{(-x)}$>,...,<value$_{(-n+1)}$>]<CHK><EOT>

Settings Channels: Not available

Alarm Channels: Not available

SERVO-s of System version 1.0: ER15<CHK><EOT>
No trend data is available in SERVO-s v1.0.

Parameters: <trend_parameters> = AT<chan>[<start_time>]<length>

<chan> = 200 – 499, channel number

<start_time> = <year><month><day><hour><min><sec>

<length> = <hour><min><sec>

<t_0>,<t_1> = <year><month><day><hour><min><sec>

<year> = 00 – 99
<month> = 01 – 12
<day> = 01 – 31
<hour> = 00 – 23
<minute> = 00 – 59
<sec> = 00 – 59

<value$_{(0)}$>...<value$_{(-n+1)}$> = 0000 – 9999

If no <start_time> is selected, the default <start_time> will be the time of the last trend value.

The first time stamp <t_0> of the response is mandatory in case there are any trend values to return. Subsequent time stamps <t_1> are given in case of discontinuities in the trend, e.g. if the SERVO-i has been turned off for a while.

Since no settings- or alarm trends are available, CIE returns ER15 if such a trend is requested.

Compressed binary coded format (8 data bits):

Input syntax:	RADA<trend_parameters><CHK><EOT>
SERVO-i / SERVO-s Normal output syntax:	Breath Channels: <time_flag><t_0><value_flag><$value_{(0)}$> <$diff\_value_{(-1)}$>...<time_flag><t_1> <$diff\_value_{(-x)}$>...<value_flag> <$value_{(-y)}$>...<$diff\_value_{(-n+1)}$><end_flag><CHK> Settings Channels: Not available Alarm Channels: Not available
SERVO-i / SERVO-s Output syntax in case of error:	<error_flag><error><end_flag><CHK>
SERVO-s of System version 1.0 Output syntax:	E00F7F<CHK> No trend data is available in SERVO-s v1.0.
Parameters:	<trend_parameters > = UT<chan>[<start_time>]<length> <chan> = 200 – 499, channel number <start_time> = <year><month><day><hour><min><sec> <length> = <hour><min><sec> <year> = 00 – 99 <month> = 01 – 12 <day> = 01 – 31 <hour> = 00 – 23 <minute> = 00 – 59 <sec> = 00 – 59 <error_flag> = $E0_{16}$ <error> = XX_{16}(binary error code) <time_flag> = 81_{16} <t_0>,<t_1> = <year><month><day><hour><min><sec> <value_flag> = 80_{16} <$value_{(0)}$>...<$value_{(-n+1)}$> = 0000_{16} – $7EFF_{16}$ (MSB first) <$diff\_value_{(-1)}$>...<$diff\_value_{(-n+1)}$> = 82_{16} – $7E_{16}$ (82_{16} = -126_{10} ; $7E_{16}$ = 126_{10}) <end_flag> = $7F_{16}$

If no <start_time> is selected, the default <start_time> will be the time of the last trend value.

The first time stamp <t_0> of the response is mandatory in case there are any trend values to return. Subsequent time stamps <t_1> are given in case of discontinuities in the trend, e.g. if the SERVO-i has been turned off for a while. A time stamp is preceded by a time flag <time_flag>.

Values are sent as differences <diff_value> when possible in order to save bandwidth, where <diff_value> is the difference between the current and the succeeding value, i.e. <diff_value> = <$value_{(t)}$> - <$value_{(t+1)}$>.

Absolute values <value> are sent the first time and when the difference is to large. An absolute value will be preceded by a value flag <value_flag>.The most significant byte (MSB) of an absolute value is sent first.

Since no settings or alarm trends are available, CIE returns the binary error code 15 if such a trend is requested.

6.6 Read Acquired Data Continuously RADC

This command reads the data continuously, i.e. curve-, breath-, settings-, trend- or alarm data according to the channel table set-up via the command Set Data Acquisition Definition.

It is possible to read 1 or more curves at the same time. Up to 4 curves are allowed.

New breath data is transmitted when the breath is finished, i.e. when a new breath is started.

Breath/Setting/Alarm data package is transmitted when some of the data, according to the channel table set-up, is updated.

The curve data are transferred continuously. However, if an alarm occurs, a setting changes, new breath data are available or new one-minute trend are available, the curve data transfer will be temporarily interrupted.

If buffer overflow occurs, ESC is received or 'Stand by' mode set, the transmission stops.

Input syntax:	RADC<CHK><EOT>
Normal Output syntax:	[<settings_data><CHK>] [<alarm_data><CHK> or <alarm_data_extended><CHK>] [<curve_data><CHK>] [<breath_data><CHK>] [<trend_data><CHK>]
Output syntax in case of error:	<error_flag><error><end_flag><CHK>
Scenario:	<settings_data><CHK><alarm_data><CHK><curve_data><CHK> <breath_data><CHK><trend_data><CHK>...

Parameters:

<curve_data> =
<phase_flag><phase><value_flag><value$_{(1,1)}$>
[<value_flag><value$_{(2,1)}$><value_flag><value$_{(3,1)}$>
<value_flag><value$_{(4,1)}$>]<diff_value$_{(1,2)}$>
[<diff_value$_{(2,2)}$><diff_value$_{(3,2)}$><diff_value$_{(4,2)}$>]...
<phase_flag><phase><diff_value$_{(1,X)}$>[<diff_value$_{(2,X)}$>
<diff_value$_{(3,X)}$><diff_value$_{(4,X)}$>]...
<value_flag><value$_{(1,Y)}$>[< diff_value$_{(2,Y)}$>< diff_value$_{(3,Y)}$>
< diff_value$_{(4,Y)}$>]...
<diff_value$_{(1,n)}$>[<diff_value$_{(2,n)}$><diff_value$_{(3,n)}$>
<diff_value$_{(4,n)}$>]
<end_flag>

<error_flag> = $E0_{16}$
<error> = XX_{16}(binary error code)

<phase_flag> = 81_{16}
<phase> = { 10_{16} (insp time),
20_{16} (pause time),
30_{16} (exp time)}

<value_flag> = 80_{16}
<value$_{(1,1)}$>...<value$_{(4,n)}$> = 0000_{16} – $7EFF_{16}$ (MSB first)

<diff_value$_{(1,2)}$>...<diff_value$_{(4,n)}$> = 82_{16} – $7E_{16}$
(82_{16} = -126_{10} ; $7E_{16}$ = 126_{10})

<end_flag> = $7F_{16}$

n = 0 - ∞

<alarm_data> =
A<value$_{(0)}$>...<value$_{(n)}$><end_flag>
<value$_{(0)}$>…<value$_{(n)}$> = { 00_{16} (No Alarm)
FF_{16} (Alarm)}

<alarm_data_extended> =
E<value$_{(0)}$>...<value$_{(n)}$><end_flag>
<value$_{(0)}$>…<value$_{(n)}$> = { 00_{16} (No Alarm)
01_{16} (Alarm)
02_{16} (Alarm active but silenced)}

<breath_data> =

B<value(0)>…<value(n)><end_flag>

<value(0)>…<value(n)> = 0000_{16} – $7EFF_{16}$ (MSB first)

n = 0 – 49

<trend_data>

Breath Channels only:

T[<time_flag><t_0>]

<value(0)>...<value(n)><end_flag>

n = 0 – 49

<t_0> = <year><month><day><hour><min><sec>

<value(0)>...<value(n)> = 0000_{16} – $7EFF_{16}$ (MSB first)

<time_flag> = 81_{16}
The [<time_flag><t_0>] shall be transmitted in the first trend data transmission block.

<settings_data> =

S<value(0)>…<value(n)><end_flag>

<value(0)>..<value(n)> = 0000_{16} – $7EFF_{16}$ (MSB first)

n = 0 – 49

During Nasal CPAP <phase> will always be 30_{16} (exp time)

The CIE transmits channel data according to the channel table setup via Set Data Acquisition Definition command.

The maximum time difference between transmitted value and sampled value is less than 500 ms.

The <end_flag> is transmitted when curve data transfer is interrupted. The curve data transfer continues, after an interrupt, from where it was interrupted. When curve data transfer continues, absolute values are sent first.

Buffer Overflow or ‘Stand by’ mode set: …<end_flag><CHK><end_flag>

When SERVO-i / SERVO-s is in standby mode, this command returns the binary error code 17.

If no curve channels are defined, this command returns the binary error code 16.

6.7 Read Address Number RADN

The CIE returns the address number of the ventilator unit (emulated).

Input syntax:	RADN[/<switch>]<CHK><EOT>
Output syntax:	<n><CHK><EOT>
Emulated Output:	00<CHK><EOT>
Parameters:	<switch> = { /I = Read current address number setup }
	<n> = 00-99

6.8 Read Alarm Output RALO

The CIE returns the summary alarm status.

Input syntax:	RALO<CHK><EOT>
Output syntax:	<value><CHK><EOT>
Parameters:	<value> = { 0 (No Alarm), 1 (Alarm active), [2 (Alarm active but silenced)]} (Note 1)

When SERVO-i / SERVO-s is in standby mode, this command returns ER17.

Note 1: Parameter value 2 only if alarm channels with extended output is configured.

6.9 Read Analog Input Code RAIC

The CIE returns the status of the aux input (emulated).

Input syntax:	RAIC<CHK><EOT>
Output syntax:	<value><CHK><EOT>
Emulated output:	255<CHK><EOT>
Parameters:	<value> = 001 – 255

The code 255 means that no device is connected.
A code in the range 128 to 254 is interpreted as if there is a device connected which is in an OFF state.

6.10 Read Battery RBAT

The CIE returns the internal battery voltage (emulated).

Input syntax:	RBAT<CHK><EOT>
Output syntax:	<status>,<value><CHK><EOT>
Emulated Output:	0,380<CHK><EOT>
Parameters:	<status> = 1 Not OK, should be replaced 0 OK
	<value> = 000 – 999 (steps of 10 mV)

Since CIE has not battery of its own within SERVO-i / SERVO-s, the emulated value 380 (3.8 V) will be returned.

6.11 Read Channel Configuration RCCO

This command reads the channel configuration, e.g. gain, offset, either for a specific channel or for all available channels.

Input syntax: RCCO[<ch>]<CHK><EOT>

Output syntax: <sampling_time>;
<ch_1>,<gain>,<offset>,<unit>,<type>,<id>;
[<ch_2>,<gain>,<offset>,<unit>,<type>,<id>;
<ch_n>,<gain>,<offset>,<unit>,<type>,<id>;]<CHK><EOT>

Parameters: <ch> = 100 – 499 , channel number
<sampling_time> = 004 – 224 (ms)(even numbers only)
<ch_1>...< ch_n > = 100 – 499 , channel

<gain> = <X>E<Y>
Interpretation: Gain = X * 10^Y
<X> = -9999 to +9999 , 5 ASCII characters
<Y> = -127 to +127 , 4 ASCII characters

< offset > = <X>E<Y>
Interpretation: Offset = X * 10^Y
<X> = -9999 to +9999 , 5 ASCII characters
<Y> = -127 to +127 , 4 ASCII characters

<unit> = 01 to 99, 2 ASCII characters

<unit>	Unit
01	ml
02	ml/s
03	ml/min
04	cmH_2O
05	ml/cmH_2O
06	breaths/min
07	%
08	l/min
09	cmH_2O/l/s
10	mmHg
11	kPa
12	mbar
13	mV
14	s
15	l/s
16	cmH_2O/l
17	l
18	Joule/l
19	µV
20	no unit
21	cmH_2O/µV
22	breaths/min/l

Parameters: (continued)	<type> = {	CU (Curve Data), BR (Breath Data), BT (Breath data, also available as trend), SD (Settings Data), AD (Alarm Data)}
	<id> = {	FFFF, (Reserved Parameter id, 4 ASCII characters } Interpretation: MAQUET internal nomenclature.

If channel is omitted in the received command, information concerning all available channels will be transferred.

The ASCII character '-' represents information not applicable.

Any CU, BR, BT, SD, ST parameter which has defined value of gain has the following
Magnitude = $\{Value_n * Gain - Offset\}$

6.12 Read CI Type RCTY

This command is a general call from the computer to check the connection.

Input syntax:	RCTY<CHK><EOT>
Output syntax:	
SERVO-i	Servo-i<status><CHK><EOT>
SERVO-s	Servo-s<status><CHK><EOT>
Parameters:	<status> = { 1 (there is an error in the internal communication) 0 (OK)}

Please see section 4.5 for further details about this command

6.13 Read Data Acquisition Definition RDAD

This command reads the channel table, setup via the command Set Data Acquisition Definition.

Input syntax:	RDAD<CHK><EOT>
Output syntax:	C[<n_{C1}>...<n_{C4}>] B[<n_{B1}>...<n_{B50}>] T[<n_{T1}>...<n_{T50}>] S[<n_{S1}>...<n_{S50}>] A[<n_{A1}>...<n_{A50}> or E[<n_{A1}>...<n_{A50}>] <CHK><EOT>
Parameters:	<n_{C1}>...<n_{C4}> = 100 – 199 , curve channel number <n_{B1}>...<n_{B50}> = 200 – 299 , breath channel number <n_{T1}>...<n_{T50}> = 200 – 299 , trend channel number <n_{S1}>...<n_{S50}> = 300 – 399 , settings channel number <n_{A1}>...<n_{A50}> = 400 – 499 , alarm channel number

6.14 Read Patient Info RPAI

This command reads the patient information from the active patient field. Optionally, the patient history table may be retrieved.

Input syntax: RPAI[<history>]<CHK><EOT>

Output syntax: If history flag is not present in the command:

<id><admittance_time><CHK><EOT>

If history flag is present in the command:

<id_1><admittance_$time_1$><discharge_$time_1$>...
<id_n><admittance_$time_n$><discharge_$time_n$><CHK><EOT>

Emulated output: If history flag is present in the command a string of 30 ASCII '-' characters will be transmitted.

Parameters: <history> = H (ASCII)

<id> = Patient id, 20 ASCII characters

<admittance_time> = <year><month><day><hour><minute>
<discharge_time> = <year><month><day><hour><minute>

<year> = 00 – 99
<month> = 01 – 12
<day> = 01 – 31
<hour> = 00 – 23
<minute> = 00 – 59

The CIE responds to the command by transmitting the active patient information, i.e. the active patient ID and the admittance time.

A string of 30 ASCII '-' characters will be transmitted if no active patient exists.

CIE returns 00 for <hour> and <minute>, since SERVO-i / SERVO-s does not store any admittance/discharge time information, only date.

6.15 Read Sampling Time RSTI

This command reads the set sampling time (in milliseconds). See further the command Set Sampling Time.

Input syntax: RSTI<CHK><EOT>

Output syntax: <value><CHK><EOT>

Parameters: <value> = 010 – 224 (ms)

6.16 Read Software Version RSWV

This command requests information about the module firmware versions, PROM checksums, language as well as module configuration and error count.

Input syntax: RSWV[<switch>]<CHK><EOT>

Output syntax:

SERVO-i

Servo-i,<lang>,<opt$_1$>,<opt$_2$>;

<module_id$_1$>,<version>,<checksum>,<date>,
<error_code>,<error_date>

[,<com_error>,<timeout>];

...

<module_id$_n$>,<version>,<checksum>,<date>

,<error_code>,<error_date>

[,<com_error>,<timeout>];<CHK><EOT>

SERVO-s

Servo-s,<lang>,<opt$_1$>,<opt$_2$>;

<module_id$_1$>,<version>,<checksum>,<date>,
<error_code>,<error_date>

[,<com_error>,<timeout>];

...

<module_id$_n$>,<version>,<checksum>,<date>

,<error_code>,<error_date>

[,<com_error>,<timeout>];<CHK><EOT>

Parameters:

<switch> = { /C = Clear error counters (Ignored)
/E = Display internal communication error counters}

<lang> = selected language, 3 ASCII characters, see channel 329 for further details

<opt_1> = '-', Not applicable
<opt_2> = 001, CI hardware version – 3 ASCII characters

<$module\_id_1$>...<$module\_id_n$> = module id =

{ 001 (Breathing system),
002 (Monitoring),
003 (Not supported),
004 (Panel),
005 (ExpFlowMeter),
006 (Computer Interface Emulator)
}

<version> = Module PROM version, ASCII character string of length 30.

<checksum> = Not implemented in current SERVO-i / SERVO-s, Module PROM checksum, ASCII character string. The ASCII character '-' is returned.

<date> = Not implemented in current SERVO-i / SERVO-s, Module PROM code date checksum, ASCII character string. The ASCII character '-' is returned.

<com_error> = 000, Emulated reply because such information cannot be retrieved from the CAN controller. In the original CI, a counter was incremented when an internal communication error occurred. When the counter reached 255 it was not further updated. The <com_error> field could be 000 – 255.

<timeout> = 000, Emulated reply because such information cannot be retrieved from the CAN controller.
In the original CI, a counter was incremented when an internal communication timeout occurred. When the counter reached 255 it was not further updated. The <timeout> field could be 000 – 255.

<error_code> = 00000 – 99999. Emulated {00000} because the information is not available in SERVO-i / SERVO-s.

<error_date> = {YYYYMMDDHHMMSS}, date that last error occurred. A string of 14 ASCII '-' characters will be transmitted because the information is not available in SERVO-i / SERVO-s.

The ASCII character '-' represents information not applicable or available.

6.17 Read Text RETX

The CIE responds to the command by transmitting the text string from the battery backuped wraparound buffer of at least 1600 characters. This command may be transmitted from a terminal and no checksum is used.

Input syntax: RETX<EOT>

Output syntax: <text><EOT>

Parameters: <text> = 0 – 1600 characters

6.18 Read Time RTIM

This command reads the Real Time Clock.

Input syntax: RTIM<CHK><EOT>

Output syntax: <year><month><day><hour><minute><sec><CHK><EOT>

Parameters:

<year>	= 00 – 99
<month>	= 01 – 12
<day>	= 01 – 31
<hour>	= 00 – 23
<minute>	= 00 – 59
<sec>	= 00 – 59

6.19 Read Time out RTOU

The CIE returns the set character timeout. Due to serial communication, the CIE needs to receive any character within the character timeout. Otherwise the previous characters will be ignored.

Input syntax: RTOU<CHK><EOT>

Output syntax: <value><CHK><EOT>

Parameters: <value> = 001 – 250 (steps of 0.1 seconds).

6.20 Set Data Acquisition Definition SDAD

This command defines which channels to be read by the instruction Read Acquired Data or Read Acquired Data Continuously. The channels may contain curve, breath, trend, settings and alarm data.

Input syntax: SDADC[<n_{C1}>...<n_{C4}>]<CHK><EOT> or

SDADB[<n_{B1}>...<n_{B50}>]<CHK><EOT> or

SDADT[<n_{T1}>...<n_{T50}>]<CHK><EOT> or

SDADS[<n_{S1}>...<n_{S50}>]<CHK><EOT> or

SDADA[<n_{A1}>...<n_{A50}>]<CHK><EOT> or

SDADE[<n_{A1}>...< n_{A50}>]<CHK><EOT>

Output syntax: *<CHK><EOT>

Parameters: [<n_{C1}>...<n_{C4}>] = 100 – 199 , curve channel number

[<n_{B1}>...<n_{B50}>] = 200 – 299 , breath channel number

[<n_{T1}>...<n_{T50}>] = 200 – 299 , trend channel number

[<n_{S1}>...<n_{S50}>] = 300 – 399 , settings channel number

[<n_{A1}>...<n_{A50}>] = 400 – 499 , alarm channel number

The CIE shall set up a Data acquisition table in memory of channels to be read by the command. The max number of curve channels that can be set is 4. For breath, trend, settings and alarm data, the max number of channels is 50 for each category. The definition shall be valid until next time the command Set Data Acquisition Definition is issued.

If no channel parameters are given, the corresponding data acquisition table is cleared.

If alarm channels are set up with the command SDADA, any channels previously set up with SDADE are cleared and vice versa.

The new channel table will be activated within 500 ms after the variable has been set.

6.21 Set Sampling Time SSMP

This command sets the sampling time in milliseconds. The default sampling time is 20 ms. Only one sampling time can be set at a time and this is valid for all sampled channels until next time the command Change Sampling Time is received.

Input syntax: SSMP<value><CHK><EOT>

Output syntax: *<CHK><EOT>

Parameters: <value> = 004 – 224 (ms)

Odd requested sampling time is decremented by 1 ms.

The new sampling time is activated within 500 ms.

The new sampling time is shared between Basic and Extended mode, e.g. if the sampling time is changed in extended mode, the new value is applicable in both basic and extended mode.

Furthermore the sampling time is persistent, i.e. it is stored in persistent memory between ventilator sessions.

The minimum internal sampling time is 10 ms. In cases where the requested sampling time is less than 10 ms, it is set to 10 ms.

6.22 Set Time STIM (not supported)

This command is supposed to set the Real Time Clock. *It is however not supported since it affects the existing trend data.*

Input syntax: STIM<year><month><day><hour><minute><CHK><EOT>

Output syntax: ER10<CHK><EOT>

Parameters:
<year> = 00 – 99
<month> = 01 – 12
<day> = 01 – 31
<hour> = 00 – 23
<minute> = 00 – 59

6.23 Set Time Out STOU

This command defines the input character timeout. Due to serial communication, the CIE needs to receive any character within the set timeout. Otherwise the previous characters will be ignored.

Input syntax: STOU<value><CHK><EOT>

Output syntax: *<CHK><EOT>

Parameters: <value> = 001-250 (steps of 0.1 seconds)

If this command has not been received, the default timeout of 10 seconds applies.
The new timeout will be activated within 500 ms after command received.

The timeout is shared between Basic and Extended mode, e.g. if the timeout is changed in extended mode, the new value is applicable in both basic and extended mode.

6.24 Store Text STTX

This command stores a text string in a battery backuped memory wrap-around buffer. This command may be transmitted from a terminal and no checksum is used.

Input syntax: STTX<text><EOT>

Output syntax: *<EOT>

Parameters: <text> = 0 – 80 ASCII characters

The CIE responds to the command by storing the text string appended with <CR><LF> in a wraparound buffer of at least 1600 characters.

7 Checksum Calculation

7.1 General

A checksum byte is included in transmission messages while in EXTENDED mode. The checksum is based on the exclusive OR operation (XOR).

7.2 Formula

The checksum is calculated according to the following formula:

Data:

Chk: Checksum byte

Number_Of_Bytes: Number of bytes in the message

^ : Bitwise XOR (exclusive OR)

Formula:

```
Chk = 0;
for ( i = 0; i < Number_Of_Bytes; i++ )
{
  Chk = Chk ^ Message_Byte[i];
}
```

7.3 Checksum transmission

If Message format is ASCII, the checksum byte will be transmitted as two ASCII characters, representing the hexadecimal equivalent.

If Message format is Binary, the checksum byte will be transmitted as one byte.

7.4 Example

The command ‘Read CI Type’, RCTY will be transmitted:

RCTY1C<EOT>

Checksum byte = $1C_{16}$

1C = ASCII equivalent

8 Revision History

8.1 Reference Manual – Revision 03

8.1.1 General changes – Revision 03

Information regarding the SERVO-s Computer Interface Emulator is added throughout the Reference Manual. These changes are not included in the Revision history table below.

8.1.2 History table – Revision 03

In the table below, the following keywords are used in 'Comment' column:

- **Added**. New functionality added with System version 2.0.
- **Changed**. Changed functionality e.g. due to System version 2.0.
- **Corrected**. Corrections made due to printing errors or lack of information in the previous version of the Reference Manual.

Page	Section	Comment
7	About SCM 990 compatibility	Information regarding sampling period changed.
7	About SV 300 compatibility	Information regarding sampling period changed.
8	4.3.1 Definitions	'NIV' added.
10-11	4.6 Error message handling	Error 'Buffer full' added.
11	4.6 Error message handling, Binary commands	BASIC and EXTENDED commands error messages corrected.
12-13	4.8.1 Channel 00-99	Channels 26-28 and 31 changed.
13	4.8.2 Channel 100-199	Channel 103 corrected.
13	4.8.2 Channel 100-199	Channels 113-114 added.
14	4.8.3 Channel 200-299	Channel 225 corrected.
14-15	4.8.3 Channel 200-299	Channels 229-236 and 238-252 added.
16	4.8.4 Channel 300-399	Channel 305 corrected.
17	4.8.4 Channel 300-399	Channels 333-356 added.
18	4.8.5 Switch Parameters for channels 300 to 399	Heading corrected.
18	4.8.5 Switch Parameters for channels 300 to 399	Switch parameters for channel 310 added.
20-21	4.8.5 Switch Parameters for channels 300 to 399	Channels 337, 349 and 351 added.
21-22	4.8.6 Channel 400-499	Channels 430-437 added.
26	5.9 Firmware Version SV	Output syntax changed.
27	5.13 Read Sampling Time RS	Information regarding sampling time and parameter values changed.
28	5.16 Change Sampling Time CS	Information regarding sampling time changed.
35	6.5.2 Breath Data	Information regarding read channel information corrected.
39	6.6 Read Acquired Data Continuously RADC	Normal output syntax and Scenario corrected.
43	6.11 Read Channel Configuration RCCO	Parameters for Units 14-18 added.
45	6.15 Read Sampling Time RSTI	Information regarding sampling time and parameter values changed.
48	6.20 Set Data Acquisition Definition SDAD	Information regarding Data acquisition table corrected.
49	6.21 Set Sampling Time SSMP	Information regarding sampling time changed.

8.2 Reference Manual – Revision 04

8.2.1 History table – Revision 04

In the table below, the following keywords are used in 'Comment' column:

- **Added**. New functionality added with System version 3.0.
- **Changed**. Changed functionality e.g. due to System version 3.0.
- **Corrected**. Corrections made due to printing errors or lack of information in the previous version of the Reference Manual.

Page	Section	Comment
10	4.5 Signal Handshake protocol	Information regarding computers with automatic Xon/Xoff control corrected.
10	4.6 Error handling	Error code ER12 corrected.
11	4.6 Error handling	Error code 0C16 corrected.
11	4.8.1 Channel 00-99	Information regarding Y-piece measurement added.
13	4.8.2 Channel 100-199	Information regarding Y-piece measurement added.
14	4.8.2 Channel 100-199	Channels 115-117 added.
14	4.8.3 Channel 200-299	Information regarding Y-piece measurement added.
15	4.8.3 Channel 200-299	Channels 253 and 254 added.
16	4.8.4 Channel 300-399	Channel 312 and 328 added.
17	4.8.4 Channel 300-399	Channel 356 changed.
17	4.8.4 Channel 300-399	Channel 357-360 added.
18	4.8.5 Switch Parameters for channels 300 to 399	Switch parameter for channel 310 added (Nasal CPAP).
21	4.8.5 Switch Parameters for channels 300 to 399	Switch parameters for channel 360 added.
22	4.8.6 Channel 400-499	Channels 438-440 added.
27	5.12 Read Curve RC	Information regarding Nasal CPAP added.
30	5.19 Ultra Curve UC	Information regarding Nasal CPAP added.
34	6.6 Read Acquired Data RADA	Information regarding Nasal CPAP added.
41	6.6 Read Acquired Data Continuously RADC	Information regarding Nasal CPAP added.

8.3 Reference Manual – Revision 05

8.3.1 History table – Revision 05

In the table below, the following keywords are used in 'Comment' column:

- **Added**. New functionality added with System version 3.2.
- **Changed**. Changed functionality e.g. due to System version 3.2.
- **Corrected**. Corrections made due to printing errors or lack of information in the previous version of the Reference Manual.

Page	Section	Comment
4	General information	Text changed due to System version 3.2.
4	Equipment combinations	Text corrected.
5	1 Introduction	Text changed due to System version 3.2
8	4.3.1 Definitions	Edi and NAVA added.
14	4.8.2 Channel 100-199	Channels 115-117 corrected.
14	4.8.2 Channel 100-199	Channel 118 added.
15	4.8.3 Channel 200-299	Channel 253 corrected.
15-16	4.8.3 Channel 200-299	Channels 255-258 added.
16	4.8.4 Channel 300-399	Channel 312 corrected.
17	4.8.4 Channel 300-399	Channels 358-359 corrected.
18	4.8.4 Channel 300-399	Channels 361-362 added.
19	4.8.5 Switch Parameters for channels 300 to 399	Switch parameters for channel 310 added (# 15 NAVA).
23	4.8.6 Channel 400-499	Channels 439-440 corrected.
23	4.8.6 Channel 400-499	Channels 441-443 added.
44	6.11 Read Channel Configuration RCCO	Unit parameters 19-21 added.

8.4 Reference Manual – Revision 06

8.4.1 History table – Revision 06

In the table below, the following keyword is used in 'Comment' column:

- **Corrected**. Corrections made due to lack of information in the previous version of the Reference Manual.

Page	Section	Comment
7	To consider when writing a CIE driver	Corrected: Text inserted.
21	Switch Parameters for channels No. 300 to 399	Corrected: Channel 330: Notes 1 and 2 inserted.
22	Switch Parameters for channels No. 300 to 399	Corrected: Notes 1 and 2 inserted.

8.5 Reference Manual – Revision 07

8.5.1 History table – Revision 07

In the table below, the following keywords are used in 'Comment' column:

- **Added**. New functionality added with System version 4.0.
- **Changed**. Changed functionality e.g. due to System version 4.0.
- **Corrected**. Corrections made due to printing errors or lack of information in the previous version of the Reference Manual.

Page	Section	Comment
4	General information	Text changed due to System version 4.0.
5	1. Introduction	Text changed due to System version 4.0.
7	About SV 300 compatibility	Corrected: Number of commands with emulated response.
8	4.3.1 Definitions	Added: Extended Alarm.
9	4.3.3 Common acronyms	Corrected: AT and ST deleted (not available).
11-12	4.6 Error handling	Corrected: Error descriptions in tables and table notes.
14	4.8.2 Channel 100-199	Corrected: % in channel 103.
15	4.8.2 Channel 100-199	Added: Channel 119.
16	4.8.3 Channel 200-299	Corrected: % in channel 225.
16	4.8.3 Channel 200-299	Changed: Note 4 in channel 246.
17	4.8.3 Channel 200-299	Added: Channels 259 – 260.
17	4.8.4 Channel 300-399	Changed: Note 4 in channels 313 and 314.
17	4.8.4 Channel 300-399	Corrected: % in channels 316 and 317.
18	4.8.4 Channel 300-399	Corrected: Parameter name on channel 322.
18	4.8.4 Channel 300-399	Changed: Channel 330 activated.
19	4.8.4 Channel 300-399	Added: Channels 363 – 367.
20-22	4.8.5 Switch Parameters for Channels 300-399	Corrected: Information in the table clarified.
22	4.8.5 Switch Parameters for Channels 300-399	Added: Channel 363.
24	4.8.6 Channel 400-499	Added: Channels 444 – 446.
25	4.8.6 Channel 400-499	Added: Alarm status information/tables.
28	5.12 Read Curve RC	Changed: Note regarding standby mode and trigger_point.
30	5.18 Trend Output TO	Corrected: SERVO-i / SERVO-s output syntax.
32	5.19 Ultra Curve RC	Changed: Note regarding standby mode and trigger_point.
36	6.5.1 Curve Data	Changed: Note regarding standby mode and trigger_point.
37	6.5.4 Alarm Data	Changed: Note regarding SDADE.
37	6.5.5 Alarm Data with extended output	Added: New RADA command.
38	6.5.6 Trend Data	Corrected: Breath Channels syntax.
38-40	6.5.6 Trend Data	Corrected: Settings and Alarm Channels syntax deleted (not available).
41	6.6 Read Acquired Data Continuously RADC	Corrected: Introduction clarified.
41	6.6 Read Acquired Data Continuously RADC	Added: Extended alarm data output syntax.
42	6.6 Read Acquired Data Continuously RADC	Added: Alarm data extended syntax.
44	6.8 Read Alarm Output RALO	Added: Parameters, value 2.

45	6.11 Read Channel Configuration RCCO	Added: Parameters, unit 22 (breaths/min/l).
46	6.11 Read Channel Configuration RCCO	Corrected: Parameters type AT and ST deleted (not available).
46	6.13 Read Data Acquisition Definition RDAD	Added: Extended alarm (E) output syntax.
50	6.17 Read Text RETX	Corrected: Parameters, 0 characters can be read.
50-51	6.20 Set Data Acquisition Definition SDAD	Added: SDADE (extended alarms) input syntax including note.
52	6.24 Store Text STTX	Corrected: Parameters, 0 characters can be stored. Note clarified.

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