capnostream™20

Capnostream Data Transfer Protocols

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Chapter 1

Introduction

This document describes the communication protocols used for data transfer by the Capnostream monitor. It is intended for use by computer programmers and other experts who wish to access binary data from the Capnostream monitor.

The document covers data transfer in the following cases:

- Data transfer using the RS-232 protocol, in the case where a computer is used in the monitoring configuration, for example, for the purposes of medical research, or for transferring the data to a nursing station. In this case, after the monitor and computer are connected and turned on, commands are sent as described in Using RS-232: Communication Modes on page 7.
- USB binary data transfer, for monitoring configurations where a flash memory stick is used, with the intent of transferring the data to a computer at a later point. This is described in the final chapter. In this case, after the monitor is turned on, and a flash memory stick is installed, data is transferred using screen commands as described in USB Binary Data Transfer on page 20.

In this document, transmitted data is represented in hexadecimal format, using the C programming language convention for hexadecimal numbers. Under this convention, a hexadecimal number is displayed with the prefix 0x.

A description of the procedure for data transfer using the RS-232 protocol can be found in Setting Up Communication with RS-232 on page 7. A description of the procedure used for transfering data with the USB binary data transfer method can be found in USB Binary Data Transfer Procedures on page 20.

For transfer of patient data in .csv (comma separated value) format for use with Excel files, refer to *Capnostream™ 20 Patient Data Transfer Application Note*. Compared to the binary formats described in this document, use of the .csv format is a less complex method of downloading patient data for analysis and research, and is recommended for non-technical personnel.

Both this document and the *Capnostream™ 20 Patient Data Transfer Application Note* are available on the Capnostream™ 20 Operator's Manual CD.

Chapter 2

Using RS-232: Communication Modes

Setting Up Communication with RS-232
Enabling Communication Protocol
Real-time Communication
Trend Download Communication
Hand Shake

Setting Up Communication with RS-232

The Capnostream monitor can be connected to a PC for data collection purposes by connecting a user-supplied RS-232 cable to the 9-pin D-type connector at the rear of the monitor at one end and to the PC at the other end. The monitor does not need to be set manually for RS-232 communication; when the Enable Communication Protocol command described below is sent from the PC, the monitor automatically switches to RS-232 communication mode. When the Disable Communication Protocol command is sent, the monitor will switch off the RS-232 communication mode. The cable can then be removed from the monitor.

The baud rate can be changed manually using monitor screens (see the Capnostream 20 Operator's Manual, Appendix 1 Institutional Settings). The monitor is shipped with the default of automatic baud rate selection. To use automatic baud rate selection, the computer must repeat the Enable Communication Protocol Command multiple times, until the monitor sends the expected response.

Enabling Communication Protocol

The monitor enables this communication protocol after receiving the RS-232 Enable Communication Protocol command. Then, the first message to be sent by the monitor to the computer is the Device ID and Software Version message.

The monitor disables this communication protocol after receiving the Disable Communication Protocol command.

Real-time Communication

The monitor starts real-time communication after receiving the Start Real-time Communication command.

The monitor periodically transmits the following types of messages:

- A CO_2 Wave message once every 50 milliseconds.
- A Numerics message once every second.
- A Patient ID message when the patient ID is changed from the monitor's menu.

Real-time communication can be stopped by sending the Stop Communication command.

Trend Download Communication

The monitor starts trend download after receiving the Start Long Trend Download command. Real-time communication is automatically disabled before starting the trend download.

The monitor transmits the following messages for each patient's trend data:

- A New Patient Information Download message at the beginning of the download.

- One or more Long Trend Patient Data Download messages.

Trend Download communication can be aborted by sending the Stop Long Trend Download command.

Hand Shake

The monitor can handle only one command at a time. The monitor's response time to a command is a maximum of 1 second.

Chapter 3

Using RS-232: Serial Communication Parameters

Serial Communication Parameters

Parameter	Description
Transmission rate	Selectable from the Institutional Defaults menu in the monitor: Automatic, 9600, 19.2K, 57.6K, or 115.2K. The Capnostream leaves the factory set to Automatic.
Format	1 start bit, 8 data bits, 1 Stop bit, No parity
Transmit data format	Binary

Chapter 4

Using RS-232: Message Format

Message Format

The message format consists of message header, message length, message body, and checksum byte. The message body starts with the message code and optional message data.

		Message body		
Header	Length	Code	Data	Checksum

Message header	0x85
Message length	Number of bytes in the message body
Message code	See details below
Message data	According to message code
Checksum	XOR of the message bytes (excluding the header)

If one of the message bytes (length, code, data or checksum) is either 0x85 or 0x80, then the byte is split into two bytes, one of 0x80, and the other is the remainder, for example:

0x85 → 0x80 0x05

0x80 → 0x80 0x00

For the purposes of the message length field in the message body above, even if a byte is split into two bytes, it is still counted as one.

Chapter 5

Using RS-232: Host Commands and Data

Enable Communication Protocol
Disable Communication Protocol
Inquire Numeric Item
Start Real-time Communication
Stop Real-time Communication
Inquire Patient ID
Inquire Events List
Start Long Trend Download
Stop Long Trend Download

Enable Communication Protocol

Parameter	Value
Message length	1
Message code	1
Message data	None

Disable Communication Protocol

Parameter	Value
Message length	1
Message code	2
Message data	None

Inquire Numeric Item

Parameter	Value
Message length	2
Message code	3
Byte#1	Data Item: 1 = $EtCO_2$ 2 = $FiCO_2$ 3 = Respiration rate 4 = SpO_2 value 5 = Pulse rate

Start Real-time Communication

Parameter	Value
Message length	1
Message code	4
Message data	None

Stop Real-time Communication

Parameter	Value
Message length	1
Message code	5
Message data	None

Inquire Patient ID

Parameter	Value
Message length	1
Message code	11
Message data	None

Inquire Events List

Parameter	Value
Message length	1
Message code	21
Message data	None

Start Long Trend Download

Parameter	Value
Message length	1
Message code	54
Message data	None

Stop Long Trend Download

Parameter	Value
Message length	1
Message code	55
Message data	None

Chapter 6

Using RS-232: Monitor Data and Status

Real-time Communication
Download Communication

Real-time Communication

CO_2 Wave Message

Parameter	Value
Reply to	None. This message is sent in time intervals of 50 milliseconds
Message length	5
Message code	0
Byte #1	Wave message number - Cyclic counter for time-based alignment
Byte #2-3	Instantaneous CO_2 value - in current Capnostream CO_2 units (where the first byte is the integer part and the second part is the fraction part in 1/256 units. - i.e. 080 hex = 0.5) • In case of mmHg the value will be expressed in mmHg. • In case of Vol% the value will be expressed in Vol%/10. • In case of kPa the value will be expressed in kPa/10.
Byte #4	Fast status (bitwise mapping, 1 = true) xxxx xxxd - Invalid CO_2 value xxxx xxdx – Initialization xxxx xdxx - Occlusion in gas input line xxxx dxxx - End-of-breath indication xxxd xxxx - SFM in progress (formerly called AZ in progress) xxdx xxxx - Purging in progress xdxx xxxx - FilterLine® not connected dxxx xxxx - CO_2 malfunction

Numerics Message

Parameter	Value
Reply to	None. This message is sent in time intervals of 1 second
Message length	28
Message code	1
Bytes #1-#4:	Time stamp (the number of seconds since midnight (GMT) on January 1, 1970).
Byte #5	$EtCO_2$ value (in current Capnostream CO_2 units) (FFh for invalid value)*
Byte #6:	$FiCO_2$ value (in current Capnostream CO_2 units) (FFh for invalid value)*
Byte #7	Respiration rate value (Breaths per minute) (FFh for invalid value)
Byte #8	SpO_2 value (FFh for invalid value or if not supported)
Byte #9	Pulse rate value (FFh for invalid value or if not supported)
Byte #10:	Slow Status (bitwise mapping) xxxx xxxd –Patient type (0=Adult, 1=Neonatal) xxxx xxdx – Temporary alarm silence (1 = silenced) xxxx xdxx – All alarms are silenced (1 = silenced) xxxx dxxx – High priority alarm is active and audible (1 = audible) xxxd xxxx – Low priority alarm is active and audible (1 = audible) xxdx xxxx – Advisory is active and audible (1 = audible) xdxx xxxx – Pulse beeps are silenced (1 = silenced) dxxx xxxx – Reserved
Byte #11-13:	Events' index (in user defined events: 1 to 30, FFh for a quick event, 0 if none)
Byte #14:	CO_2 Active alarms (bitwise mapping, 1 = true) xxxx xxxd –No Breath xxxx xxdx –$EtCO_2$ High xxxx xdxx –$EtCO_2$ Low xxxx dxxx –RR High xxxd xxxx –RR Low xxdx xxxx –$FiCO_2$ High xdxx xxxx –Reserved dxxx xxxx –Reserved
Byte #15:	SpO_2 Active alarms (bitwise mapping, 1 = true) xxxx xxxd –Pulse Not Found xxxx xxdx –SpO_2 High xxxx xdxx –SpO_2 Low xxxx dxxx –Pulse Rate High xxxd xxxx –Pulse Rate Low xxdx xxxx –SpO_2 Sensor Off Patient xdxx xxxx –SpO_2 Sensor Disconnected dxxx xxxx –Reserved
Byte #16:	"No Breath" period (seconds)
Byte #17:	$EtCO_2$ alarm – high limit (in current Capnostream CO_2 units)*
Byte #18:	$EtCO_2$ alarm – low limit (in current Capnostream CO_2 units)*
Byte #19:	Respiration rate alarm – high limit (breaths-per-minute)
Byte #20:	Respiration rate alarm – low limit (breaths-per-minute)
Byte #21:	$FiCO_2$ alarm – high limit (according to monitor's setup units)
Byte #22:	SpO_2 alarm – high limit (%)
Byte #23:	SpO_2 alarm – low limit (%)
Byte #24:	Pulse rate alarm – high limit (bpm)

Byte #25:	Pulse rate alarm – low limit (bpm)
Byte #26:	Current Capnostream CO_2 units: 1 = mmHg 2 = kPa 3 = Vol%
Byte #27:	Extended CO_2 status: xxxx xxxd – Check calibration xxxx xxdx – Check flow xxxx xdxx – Pump off dddd dxxx – Reserved: always 0.

* The numeric value in current Capnostream CO_2 units will be expressed as folows:

- In case of mmHg the value will be expressed in mmHg.
- In case of Vol% the value will be expressed in Vol%/10.
- In case of kPa the value will be expressed in kPa/10.

Patient ID Message for Non-Unicode Languages

Languages that require Unicode characters in Capnostream device currently include only Russian.

Parameter	Value
Reply to	This message is sent when a patient is admitted or discharged, and as a reply to the Inquire Patient ID command.
Message length	29
Message code	2
Bytes #1-#4	Time stamp -- the number of seconds since midnight (GMT) on January 1, 1970.
Bytes #5-#28	Patient ID (24 ASCII characters padded with blanks). In case of discharge, or when no patient is connected, all bytes are 0.

Patient ID Message for Unicode Languages

Languages that require Unicode characters in Capnostream device currently include only Russian.

Parameter	Value
Reply to	This message is sent when a patient is admitted or discharged, and as a reply to the Inquire Patient ID command.
Message length	53
Message code	12
Bytes #1-#4	Time stamp -- the number of seconds since midnight (GMT) on January 1, 1970.
Bytes #5-#52	Patient ID (24 Unicode 2-byte characters padded with blanks). In case of discharge, or when no patient is connected, all bytes are 0.

Events List Message for Non-Unicode Languages

Languages that require Unicode characters in Capnostream device currently include only Russian.

Parameter	Value
Reply to	Inquire Events List command. This message will be re-transmitted for each of the 30 events.
Message length	13
Message code	21
Bytes #1	Event Number
Bytes #2-#12	Event Description (11 ASCII characters padded with blanks).

Events List Message for Unicode Languages

Languages that require Unicode characters in Capnostream device currently include only Russian.

Parameter	Value
Reply to	Inquire Events List command. This message will be re-transmitted for each of the 30 events.
Message length	24
Message code	22
Bytes #1	Event Number
Bytes #2-#12	Event Description (11 Unicode 2-byte characters padded with blanks).

Numeric Item Message

Parameter	Value
Reply to	Inquire Numeric Item command.
Message length	2
Message code	3
Byte #1	Numeric item value according to Inquiry: Et CO_2 -- Et CO_2 value (mmHg) (0xFF for invalid value) FiCO_2 -- Fi CO_2 value (mmHg) (0xFF for invalid value) Respiration rate -- Respiration rate value (Breaths per minute) (0xFF for invalid value) SpO_2 value -- SpO_2 value (0xFF for invalid value, 0x00 if not supported) Pulse rate value -- Pulse rate value (0xFF for invalid value, 0x00 if not supported)

Device ID and Software Version Message

Parameter	Value
Reply to	This message is sent once after communication is activated by the Enable Communication Protocol command.
Message length	31
Message code	4
Message data	"Vxx.xx mm/dd/yyyy zzrrnnnnnn "
Notes:	1. xx.xx is the software version number 2. mm/dd/yyyy is the software release date (optional – may be filled with blanks) 3. zz = Code for the product (B2) 4. rr = Revision in order to identify a major (or minor) revision 5. nnnnnn = Number 6. The string is padded with two blank spaces at the end.

Download Communication

Long Trend Patient Data Download Message

Parameter	Value
Reply to	Long Trend Download command. A sequence of long-trend Patient Data download messages is sent. Message period is no longer than 500 milliseconds. A New Patient Information Download message is sent at the beginning of each sequence of a patient's data messages.
Message length	3 + N x 9 where N is the total number of trend data points in the current message.
Message code	55
Message	The numeric $EtCO_2$ and $FiCO_2$ values will be expressed according to the Capnostream CO_2 units setup at the beginning of the trend download, as folows: • In case of mmHg the value will be expressed in mmHg. • In case of Vol% the value will be expressed in Vol%/10. • In case of kPa the value will be expressed in kPa/10. For Capnostream products that do not store the $FiCO_2$ trend, the $FiCO_2$ value will be FFh. Byte #1: Trend message number -- Cyclic counter for consistency. Byte #2: Trend CO2 unit: • 1 = mmHg • 2 = kPa • 3 = Vol% Byte #(9*i+3)- #(9*i+6): Time stamp (the number of seconds since midnight (GMT) on January 1, 1970). Byte #(9 x i + 7): Next $EtCO_2$ according to setup units (from oldest to newest). Byte #(9 x i + 8): Next $FiCO_2$ according to setup units (from oldest to newest). Byte #(9 x i + 9): Next Respiration Rate (from oldest to newest). Byte #(9 x i + 10): Next SpO_2 level (from oldest to newest). Byte #(9 x i + 11): Next Pulse Rate (from oldest to newest). Where: $0 \le i \le N$ $0 \le N \le 25$ (if N = 0 message consists of 2 bytes only and contains no data).

	Value of FEh in all bytes of the trend point, indicates end of patient data download. This terminator is sent as the last trend point in the last Long Trend Patient Data Download Message for the patient. Value of FDh in $EtCO_2$ byte indicates that the next bytes represent recorded events (index in user defined events: 1 to 30, FFh for a quick event, 0 for none). Value of FCh in $EtCO_2$ byte indicates that the next bytes represent recorded alarms using the following codes:

Code	Alarm /Equipment Events
None	0
No Breath	1
$EtCO_2$ high	2
$EtCO_2$ low	3
RR high	4
RR low	5
SpO_2 high	6
SpO_2 low	7
Pulse Rate high	8
Pulse Rate low	9
$FiCO_2$ high	10
Battery low	13
CO_2 only[1]	23
CO_2 not available[2]	50
SpO_2 not available[3]	51

[1] Not available

[2] The following equipment events are indicated by the CO_2 not available code (50):
CO_2 Warmup, SFM, Occlusion, Purging, FilterLine® not connected, Pump off, and CO_2 Fail.

[3] The following equipment events are indicated by the SpO_2 not available code (51):
Pulse Not Found, SpO_2 Sensor off Patient, SpO_2 Sensor Disconnected, and SpO_2 Fail.

New Patient Information Download Message for Non-Unicode Languages

Languages that require Unicode characters in Capnostream device currently include only Russian.

Parameter	Value
Reply to	This message is sent at the beginning and end of each sequence of patient data during Long Trend Download.
Message length	29
Message Code	57
Message Data	Bytes #1-#4: Patient start time stamp (the number of seconds since midnight (GMT) on January 1, 1970). Bytes #5-#28: Patient ID (24 ASCII characters (padded with blanks)). In case of discharge or when no patient is connected, all bytes are 0.

New Patient Information Download Message for Unicode Languages

Languages that require Unicode characters in Capnostream device currently include only Russian.

Parameter	Value
Reply to	This message is sent at the beginning and end of each sequence of patient data during Long Trend Download.
Message length	53
Message Code	58
Message Data	Bytes #1-#4: Patient start time stamp (the number of seconds since midnight (GMT) on January 1, 1970). Bytes #5-#28: Patient ID (24 ASCII characters (padded with blanks)). In case of discharge or when no patient is connected, all bytes are 0.

Chapter 7

USB Binary Data Transfer Procedures

Full Binary Continuous Transfer
Full Binary Trend Transfer

The USB binary data transfer procedures give the user the same results as certain sequences of communications carried out with RS-232 protocols. These procedures are used when the user wants to record data using a flash memory stick, rather than recording directly onto a computer. The data on the flash memory stick can then be downloaded to a computer at the user's convenience. The formats of the data are the same as those described previously, according to the type of data transfer (continuous or trend).

Full Binary Continuous Transfer

Full Binary Continuous Transfer allows real-time data recording. This is equivalent to using RS-232 communications to send the Enable Communications Protocol command, (see Using RS-232: Communication Modes on page 7), and then the Start Real-time Communication command. When a case is started, the associated patient ID is sent. If the case is already underway, the patient ID is sent immediately when the recording begins. The messages transferred are described in Real-time Communication on page 7.

Note: TO START FULL BINARY CONTINUOUS DATA TRANSFER

1. Turn on the monitor.
   The Home screen is displayed.
2. Insert a USB flash memory stick into the USB connector on the rear of the monitor.
3. Verify that the USB symbol is displayed in the upper right corner of the monitor screen.
4. Use the control knob to select ***System*** from the menu bar.
   The System Setup screen is displayed.
5. Use the control knob to select ***Data Output*** from the menu bar.
   The Data Output screen is displayed.
6. Select ***Full Binary Continuous Transfer*** on the screen.
7. Select ***Start USB*** from the menu bar.
8. To discontinue data transfer, select ***Stop USB*** from the menu bar.

Full Binary Trend Transfer

Full Binary Trend Transfer allows a dump of the monitor's trend memory. This is equivalent to using RS-232 communications to send the Enable Communications Protocol command, (see Using RS-232: Communication Modes), and then the Start Long Trend Download command. When a case is started, the associated patient ID is sent. If the case is already underway, the patient ID is sent immediately when the recording begins. The messages transferred are described in the Trend Download Communication section. This transfer ends when the entire trend memory is transferred.

Note: TO START FULL BINARY TREND DATA TRANSFER

1. Turn on the monitor.
   The Home screen is displayed.
2. Insert a USB flash memory stick into the USB connector on the rear of the monitor.
3. Verify that the USB symbol is displayed in the upper right corner of the monitor screen.
4. Use the control knob to select ***System*** from the menu bar.
   The System Setup screen is displayed.
5. Use the control knob to select ***Data Output*** from the menu bar.
   The Data Output screen is displayed.
6. Select ***Full Binary Trend Transfer*** on the screen.
7. Select Start USB from the menu bar.
8. To discontinue data transfer, select ***Stop USB*** from the menu bar.