



SBC Communication Protocol

Component of the Pioneer Set

Intended Use

The hardware and software components of the EIT Pioneer Set are intended for laboratory applications, exclusively. They must not be used on humans! Set-up and use of the components is the sole responsibility of the user.

Specifications

The Ethernet connection allows to set the parameters of the SensorBeltConnector and to measure data from the SensorBelt.

A block diagram and definitions for the SensorBeltConnector can be found in the appropriate data sheet.

Commands

Commands are being sent (host to SBC) and answers are received (SBC to host) on TCP/IP port 10000.

Command parameters are transmitted and received in little-endian byte order.

The command structure is an ASCII string. Commands and parameters are case sensitive.

Command line syntax, with „Name“ being the parameter name and „Value“ being the parameter value:

```
<STX><Command><Name><Value><LRC><ETX>
```

Response line syntax:

```
<STX><Command><Name><Value><Error Code><LRC><ETX>
```

LRC: XOR calculation of frame, excluding STX, ETX and LRC itself.

Swisstom AG

The vision of Swisstom AG is to become a globally active and leading provider of life saving, non-invasive medical technology for patient monitoring – to the benefit of patients, physicians, caregivers and society.

Swisstom AG was founded in Landquart (Switzerland) in September 2009 by Josef X. Brunner, Stephan H. Böhm and Peter Seitz. Swisstom AG develops innovative medical devices for the monitoring of lung and heart function in ICU patients and patients undergoing general anesthesia. End-users include physicians (primarily intensivists and anesthesiologists) and other health care professionals.

Unlike traditional tomographic methods, Swisstom's imaging is driven by electrical impedance tomography (EIT). This technology will serve Swisstom as a platform for future product developments.



TECHNICAL DATA SHEET

List of commands

The following table list all available commands.

Command	Available during ac-	Description
get	yes	Get parameter value
raw	no	Raw acquisition
set	no	Set parameter value.
sta	no	Start acquisition
sto	yes	Stop acquisition
ver	yes	Firmware and hardware version
upd	no	Firmware Update
rst	no	Softreset of all parameter values to factory default.

Please note: DAC sampling frequency is calculated as follows and can be adjusted by changing N (N being an integer):

$$DAC_FQ = \frac{1}{(36 + N) \cdot 10ns}$$

Error codes

There are two kind of error codes: one as a response of a command frame and the other as errors who arise during the data acquisition.

Command error codes:

Data error codes

Number	Description	Comments
0000	No Error	--
0001	Unknown parameter name	No parameter value in response
0002	Parameter value out of range	--
0004	CRC check failed	--

Number	Description	Comments
0000	No Error	--
0001	Error codes	Internal coding only

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List of parameters

The following Table defines the values to be used with the „set“ and „get“ commands.

Parameter	Description	Type	Range	Value size x	Default value	Preliminary range
PGA0_G	PGA 0 gain	Integer	[0, 3]	1	0	{1, 2, 5, 10}
PGA1_M	PGA 1 mode	Integer	[0, 2]	1	0	{normal, calibration, shutdown}
PGA1_G	PGA 1 gain	Integer	[0, 9]	1	0	{1, 10, 20, 30, 40, 60, 80, 120, 157, 0.2}
PGA1_O	PGA 1 offset	Integer	[0, 15]	2	0	{1, 1.3, 2.5, 3.8, 4.9, 6.1, 7.3, 8.4, 10.6, 11.7, 12.7, 13.7, 14.7, 15.7, 16.7, 17.6}
NCO_FQ	NCO Frequency	Integer	[0, 20]	2	5	[50, 250] kHz @ 10 kHz (resolution)
DAC_GA	DAC Gain	Integer	[1, 256]	3	256	[2-8, 1.0] @ 2-8
DAC_FQ	DAC sampling freq.	Integer	[0, 255]	3	7	~[343 kHz, 2.78 MHz]
STIDTA	Current generation scan table	String	Length = [1, 32] Chars in {“G”, “I”, “N”}	32	“INNNNNNN NNNNNNNN NNNNNNNN NNNGNNNN”	-
STMDTA	Measure scan table	String	Length = [1, 32] Chars in {“1”, “2”, “N”}	32	“1NNNNNNN NNNNNNNN NNNNNNNN NNN2NNNN”	-
N_MEAS	Number of periods per measurement window	Integer	[1, 4096]	4	1	[1, 4096]
T_ICLK	ICLK delay	Integer	[0, 2047]	4	0	[0, 20.47] μs @ 10 ns
T_MCLK	MCKL delay	Integer	[0, 2047]	4	0	[0, 20.47] μs @ 10 ns
N_IGNR	Number of periods to ignore	Integer	[0, 4095]	4	0	[0, 4095]
T_IGNR	Additional delay	Integer	[0, 2047]	4	0	[0, 20.47] μs @ 10 ns
N_SMPL	Number of samples	Integer	[1, 65536]	5	1	[1, 65536]
T_SMPL	Additional inter-sample delay	Integer	[0, 1023]	4	0	[0, 10.23] μs @ 10 ns
TP_RAW	Trigger position for raw acquisition	Integer	[0, 1023]	4	0	[0, 1023]
T_REFR	Demodulator reference, sample delay	Integer	[0, 2047]	4	0	[0, 20.47] μs @ 10 ns
FCT_I0	I0 factor	Integer	[0, 7]	1	0	[0, 7]
FCT_Q0	Q0 factor	Integer	[0, 7]	1	0	[0, 7]
FCT_I1	I1 factor	Integer	[0, 7]	1	0	[0, 7]
FCT_Q1	Q1 factor	Integer	[0, 7]	1	0	[0, 7]
RAW_MD	Data collection mode for raw acquisition	Integer	[0, 2]	1	0	{0: ADC0, sine, 1: ADC1, sine, 2: ADC0, ADC1}

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Example 1: general ASCII command to SBC

	STX	Command			Parameter Name						Parameter value			LRC	ETX
Index	0	1	2	3	4	5	6	7	8	9	10	...	10+x	11+x	12+x

Where x is the size of the parameter value.

Answer from SBC follows the following structure:

	STX	Command			Parameter Name						Parameter value			Error Code				LRC	ETX
Index	0	1	2	3	4	5	6	7	8	9	10	...	10+x	11+x	12+x	13+x	14+x	15+x	16+x

Example 2: set the PGA1 gain to 40

	STX	Command			Parameter Name						Parameter value		LRC	ETX
ASCII	^B	's'	'e'	't'	'P'	'G'	'A'	'1'	'_'	'G'	'0'	'5'	'.'	^C
Hex	0x02	0x73	0x65	0x74	0x50	0x47	0x41	0x31	0x5F	0x47	0x30	0x35	0x55	0x03

Answer of SBC:SBC answers with the parameter value.

	STX	Command			Parameter Name						Parameter value		Error Code				LRC	ETX		
ASCII	^B	's'	'e'	't'	'P'	'G'	'A'	'1'	'_'	'G'	'0'	'5'	'0'	'0'	'0'	'0'	'0'	'0'	'^'	^C
Hex	0x02	0x73	0x65	0x74	0x50	0x47	0x41	0x31	0x5F	0x47	0x30	0x35	0x30	0x30	0x30	0x30	0x30	0x30	0x5E	0x03

Example 3: erroneous command

Request with wrong parameter name, 'o' instead of 'O'

	STX	Command			Parameter Name						Parameter value		LRC	ETX
ASCII	^B	's'	'e'	't'	'P'	'G'	'A'	'1'	'_'	'o'	'0'	'5'	'n'	^C
Hex	0x02	0x73	0x65	0x74	0x50	0x47	0x41	0x31	0x5F	0x6F	0x30	0x35	0x6E	0x03

The SBC responds with an error „wrong parameter name“

	STX	Command			Parameter Name						Parameter value		Error Code				LRC	ETX
ASCII	^B	's'	'e'	't'	'P'	'G'	'A'	'1'	'_'	'o'	'0'	'5'	'0'	'0'	'0'	'1'	'N'	^C
Hex	0x02	0x73	0x65	0x74	0x50	0x47	0x41	0x31	0x5F	0x6F	0x30	0x35	0x30	0x30	0x30	0x31	0xD1	0x03



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Specification of data from SBC

Data is sent from the SBC in two parts: as header (fixed size) and as variable data (variable size). The header (Table below) specifies the content and size of the variable data (Table on next page).

Fixed size part or „data header“

Data	Symbol	Size [byte]	Comments
Decoder code	DEC	4	This is a 32 bit Integer that indicates how the data buffer should be interpreted. The data buffer described in this document: 0
Total packet size	TPS	4	This is a 32 bit Integer indicating the overall buffer size in bytes.
Timestamp	TS	4	See right column
Reserve	STATUS	4	n.a.
Error Code	ERROR	4	Error conditions of SBC while measuring.
Reserve	NEC	4	n.a.
Reserve	NST	4	n.a.
Reserve	NBE	4	n.a.
Position data size	NPO	4	This is a 32 bit Integer that gives the size of bytes of the position sensor data
Scanning pattern code size	NSPC	4	This is a 32 bit Integer that gives the size of bytes of scanning pattern code data.
Voltage at injection site data size	NVI	4	See explanation on the right
IQ data size	NIQ	4	Size of the image data.
Reserve	NEXT	4	n.a.

Data communication

All measured data, including I and Q values used for image reconstruction, are sent by the SBC to the host on TCP/IP port 10001. One complete data buffer is sent over the network each time a complete scan is performed. The rate (frame rate) at which this buffer is sent depends on the image rate set.

Time stamp

The timestamp is a 32 bit Integer that gives the start time of the image acquisition. The timestamp is given in milli with 1 millisecond resolution. Timer can be reset by host computer (Port 10000 command).

Voltage at injection site

This is a 32 bit Integer that gives the size of bytes of the voltages measured at the injecting electrodes. This size is usually equal to the number of electrodes with- in the belt (i.e. 32) times 8 (2 x 32 bit samples)

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Variable size part of data

Data	Sym- bol	Size [byte]	Comments
Reserve	ECP	NEC	n.a.
Reserve	STP	NST	n.a.
Reserve	BEP	NBE	n.a.
Position payload	POP	NPO	Position as measured by the accelerometer or the gravity sensor inside the SensorBeltConnector
Scanning pattern code payload	SPC	NSPC	This is the scanning pattern code used for this frame in the format used in STMDTA.
Voltage at injection site payload	VIP	NVI	All voltages measured at a given electrode while this electrode was injecting current.
IQ payload	IQP	NIQ	Image data. Each measurement takes 8 byte (4 byte for I and 4 byte for Q), i.e. 2 integers 32 bit each.
Reserve	EXTCn	4	n.a.
Reserve	NEXTn	4	n.a.
Reserve	EXTPn	NEXTn	n.a.

For more information

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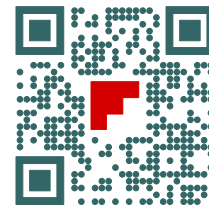
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