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S2C Underwater Acoustic Modem Guide: Standard Version 1.7.D

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Revision History

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1.7.B	April 3, 2014	1st revision: minor corrections. Firmware v1.7.9.
1.7.C	June 10, 2014	2nd revision: new sections on Positioning added. Firmware v1.7.10.
1.7.D	August 25, 2014	3rd revision: power amplifier errors added, battery voltage status modified. Firmware v.1.7.14.
1.7.D1	September 30, 2014	4th revision: Support section added.

Contents

1 Introduction

This document describes operating and configuring the S2C Underwater Acoustic Modem/S2C USBL Underwater Communication Device.

The manual focuses solely on the firmware of the S2C-series devices. Please refer to the S2C Quick Installation Guide for hardware installation, testing and maintenance instructions.

Along with a comprehensive overview of the firmware features, this document provides detailed information about performing communication tasks and modifying settings configurations of the S2C Underwater Acoustic Modem/S2C USBL Underwater Communication Device.

Aimed at system integration specialists, this manual is intended to serve as a comprehensive guide to the low-level command set that provides full control over S2C devices. This document is not a tutorial for programming, instead, it contains detailed descriptions of each command and examples of its application.

This manual describes the Standard command set, best for raw sensor data transmissions. Refer to the S2C Underwater Acoustic Modem Guide Networking Version for the Networking command set description.

2 Device Features

The highlight of S2C communication devices is the EvoLogics' patented Sweep-Spread Carrier (S2C) Communication Technology.

S2C Technology provides significant advantages for applications in underwater acoustic channels, where dynamic parameters of the environment and multipath signal propagation challenge communication efforts. S2C communication devices achieve high data rates in underwater acoustic channels both in deep and reverberant shallow waters as adaptive algorithms adjust S2C performance to match the current channel parameters and maintain the highest bitrate possible.

In spite of the half-duplex nature of an underwater acoustic link, S2C communication devices with a proprietary data exchange protocol provide full duplex bidirectional data transmissions.

The digital stack of the device consists of the ADC (Analog-to-Digital Converter), DAC (Digital-to-Analog Converter), DSP (Digital Signal Processor) and FPGA (Field-Programmable Gate Array) that implement the physical layer S2C protocol, and an ARM processor, implementing the D-MAC data-link layer protocol.

We will describe these protocols in the sections below.

2.1 Communication protocols

2.1.1 Physical layer: the S2C protocol.

The physical layer protocol of your device implements the patented S2C (Sweep Spread Carrier) spread spectrum signal modulation technique. The S2C modulation increases speed, reliability and efficiency of data transmissions in harsh underwater environments.

The key concepts of the S2C method are implemented on the physical layer of the device's protocol stack. The physical layer protocol is implemented in the DSP (Digital Signal Processor) and the FPGA (Field-Programmable Gate Array) of the digital stack and performs the following tasks:

- evaluating the parameters of the underwater acoustic channel
- detection of data packets
- packet and symbol synchronization
- acoustic signal modulation
- acoustic signal demodulation
- acoustic positioning (for USBL-series devices)

2.1.2 Data-link layer: the D-MAC protocol.

Your device implements the D-MAC data-link layer protocol.

The key concept of the D-MAC protocol , developed by EvoLogics, is to use different media access algorithms for transmissions of small or large volumes of data.

Large volumes of data are transmitted with an efficient algorithm that uses propagation delays for interweaving data packets with their delivery acknowledgements. Transmission parameters are automatically adjusted to maintain the highest bitrate possible in current acoustic channel conditions.

Another algorithm is used to transmit short messages. Short messages of limited length are transmitted with a fixed bitrate, and can be transferred between devices even during an ongoing burst data transmission without interrupting it.

Read more about the D-MAC data delivery algorithms in section 2.1.3 below.

2.1.3 D-MAC protocol: data delivery algorithms

The D-MAC data link layer protocol combines two media access algorithms to transfer different types of data: burst data and instant messages.

Burst data. An adaptive D-MAC burst data delivery algorithm adjusts transmission parameters to maintain the highest bitrate, achievable in current conditions. It is optimal for transferring large amounts of data between two devices.

Before a burst data transmission, two devices establish a connection by performing a handshaking procedure of exchanging service messages. During the handshake, parameters of the acoustic channel are estimated, including the acoustic signal's round trip time.

Data to be transferred is buffered and dynamically split into packets. Acoustic channel parameters, measured during connection establishment and later during the data transfer define the optimal data packet size. The longest allowed duration of a data packet can be configured by the user (see more in section 5.9.9).

Data packets are grouped into packet trains (clusters of packets), and packet delivery acknowledgements are interwoven within packet trains instead of following every single train. As there is no need to wait for the acknowledgement before transferring the next train, the channel is utilized more efficiently. The size of a packet cluster is user-configurable to best-fit the particular application (see more in section 5.9.8).

A device on the receiving side then reassembles the split data into its original format and outputs it to the corresponding input-output interface of the receiver. Once the data has been transferred, the acoustic link between devices can be closed or kept online by service message exchange.

See section 5.4 for detailed instructions on sending and receiving burst data.

Instant Messages. The instant messages delivery algorithm of the D-MAC protocol provides for instant bidirectional exchange of short messages even during burst data transfers. Short instant messages (up to 64 bytes long) do not interrupt the burst data flow between communicating devices, since instant messages are delivered as service message extensions of the burst data algorithm. Instant messages can also be delivered if there is no ongoing burst data transmission.

Instant messages are transferred with a constant bitrate of 976 bps, acceptable for a wide range of acoustic channel parameters.

A connection establishment procedure is not required, moreover, broadcast messaging feature allows sending instant messages to several devices at once.

There are several types of instant messages supported:

- Instant messages.

  Instant messages (IM) are messages that are transmitted as soon as possible after a corresponding command was received. They can be transmitted with delivery acknowledgements.

- Synchronous instant messages.

  Synchronous instant messages (IMS) are messages with time-triggered transmission.

  Unlike instant messages, transmission of an IMS can be scheduled to start at a predefined time. Transmission of the IMS is controlled by upper layer protocols, that trigger the physical layer to start the transmission.

- Piggyback messages.

  Piggyback messages (PBM) are messages that can be transmitted only as attachments to other data. A PBM is not transmitted immediately or at a pre-scheduled time, instead,

it is buffered until there is other data to be transmitted. A PBM can be transmitted only along with an acknowledgement of an instant message reception or along with a service message of the burst data algorithm.

Read more about these types of instant messages in section 5.5.

2.2 Networking features

The D-MAC data-link layer protocol offers multiple features, that facilitate implementation of custom media-access control protocols and networking protocols on top of it.

The following features of the D-MAC form the basic framework for underwater acoustic networking and protocol development:

- Addressable data exchange.

  Every device has its unique address and can be easily addressed for burst data transmissions or instant message exchange. Address of the device can be changed with AT commands, see section 5.9.5.

- Backoff State.

  Collision resolution algorithms are implemented to handle conflicts between devices contending for media access.

  If a device detects an ongoing acoustic connection between other devices in the network, it goes into a **Backoff State** and for some Backoff Timeout becomes unavailable for acoustic communication. In Backoff State the device will decline any connection establishment requests and will not accept data for transmission from the input-output interface.

- Unicast or Broadcast instant messages.

  Instant messages can be transmitted either in Unicast mode, when the message is addressed to a particular device, or in Broadcast Mode, when the message is sent to every device in the network (see 5.5.1).

- Promiscuous Mode.

  Promiscuous Mode allows to overhear instant messages addressed to other devices - in Promiscuous Mode the local device will receive instant messages, addressed to other devices in the network, including messages sent in Unicast mode and addressed to one particular device.

- Synchronous instant messages.

  Synchronous instant messages - instant messages with time-triggered transmission (see 5.5.2) - allow to synchronize the upper layer protocols with the physical layer protocol. Unlike an instant message, which is transmitted as soon as possible after a corresponding command was received, transmission of an IMS can be scheduled to start at a predefined time. Transmission of the IMS is controlled by upper layer protocols, that trigger the physical layer to start the transmission.

- Extended notifications.

Extended notifications (5.11.5) provide additional information about setting modifications, as well as about signal receptions and transmissions - including notifications about the beginning and the end of acoustic transmissions. This information is necessary for some media access control algorithms, that can be implemented on top of D-MAC.

2.2.1 Developer solutions

A special series of underwater acoustic modems (S2C WiSE) and a software emulation tool extend the possibilities of application and network protocol development with S2C devices. Third party open-source frameworks (SUNSET[1], DESERT[2]) are compatible with S2C WiSE devices and offer additional opportunities for developers.

S2C WiSE modems. S2C WiSE (White Line Science Edition) underwater acoustic modems offer an open environment for network protocol developers, providing a flexible framework to test new network protocols on real hardware.

S2C WiSE acoustic modems facilitate an embedded developer sandbox of up to 32 GB. The EvoLogics WiSE toolchain allows to build custom firmware modules for S2C modems and opens opportunities for new implementations. S2C WiSE modems are an excellent testbed for new underwater network protocols, as test scenarios for performance evaluation can run on real hardware in real-world conditions.

The NS-2 framework is preinstalled on all S2CR WiSE modems. NS-2, a widely used network simulator, supports simulation of TCP, routing and multicast protocols over communication networks. Moreover, the sandbox includes Bash, Expect and TCL scripting language interpreters installed, as well as the C/C++ cross-toolchain for compiling applications for S2CR WiSE modems.

An S2CR-WiSE modem provides all the features of standard EvoLogics S2CR underwater acoustic modem: it allows connecting to TCP ports to send or receive data over the acoustic channel, as well as configuring the modem settings.

Please refer to **EvoLogics S2C WiSE User Guide** for more information and S2CR WiSE-specific instructions.

D-MAC emulator. EvoLogics communication and positioning emulator is a hardware-free framework that allows to configure and run a network of virtual underwater acoustic modems on EvoLogics server.

A network of virtual underwater acoustic modems on EvoLogics server can be accessed remotely and provides a great solution for development and training. Any code, written and run on the modem emulator, can be later run on the actual modem hardware without any modifications, offering a time-saving solution that minimizes development costs for upper layer network protocols and simplifies integration of acoustic modems into underwater infrastructure.

[1]Read more about SUNSET framework online.
[2]Read more about DESERT framework online.

2.3 Wake-Up Module

The Wake Up Module is an optional integrated electronic unit that can turn parts of the device off to save power.

The Wake Up Module helps optimize power consumption for battery-powered deployments. It checks for incoming acoustic signals and incoming data from a serial input-output interface and turns the rest of the device on only when such a signal is detected. Once the device completes receiving or transmitting data, everything but the Wake Up Module is switched off.

The Wake Up Module always reacts on incoming data on the RS-232 input-output interface. It initializes a wake-up procedure that turns the rest of the device on and buffers all incoming data until the device is ready to proceed (for about 5 seconds). Data is then transferred to the device that transmits it over the acoustic channel.

To save energy, the Wake Up Module monitors the acoustic channel in an on/off toggle cycle - it does not permanently monitor the acoustic channel, instead, it cycles between active monitoring and idle phases. It reacts on incoming acoustic signals only when it is active. An idle Wake Up Module does not detect incoming acoustic signals. The cycle parameters can be easily adjusted to meet the requirements for average energy consumption. Read more about configuring the acoustic channel monitoring cycle in section 5.10.

Please note: the upper limit for baudrate of a serial interface is 19200 bps when a Wake Up Module is installed.

The Wake Up Module is incompatible with Ethernet interfaces.

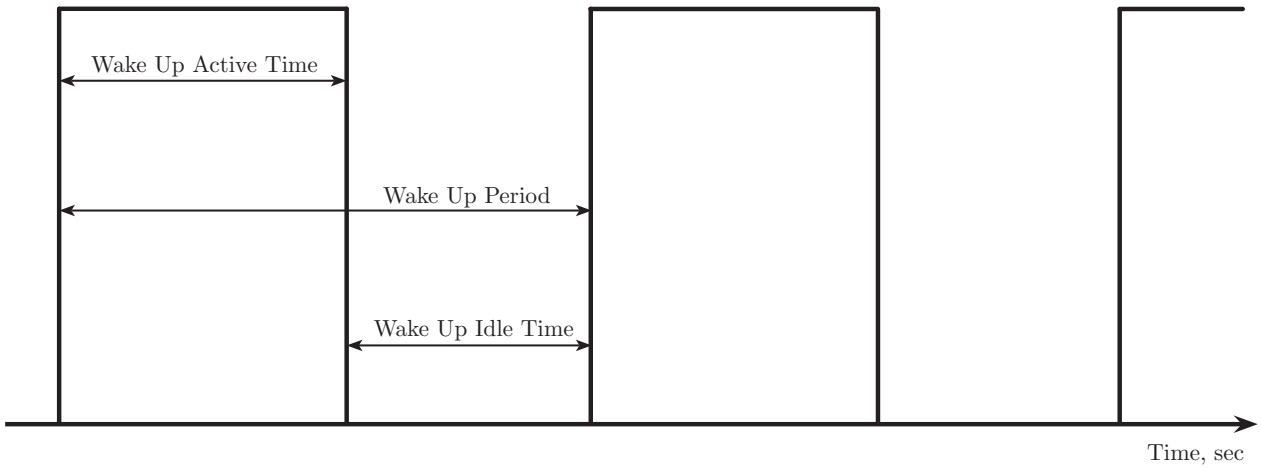

Figure 1: The Wake Up toggle cycle

2.4 USBL positioning

Acoustic USBL (Ulta-Short Baseline) positioning is a feature, available only for S2C USBL-series devices.

S2C USBL-series communication and positioning devices provide 3D position tracking simultaneously with data transmissions. A time–, cost– and energy–saving solution, the S2C USBL device does not switch between communication mode and positioning mode, instead, positioning data is calculated during acoustic communication between two devices.

Therefore, an S2C USBL device can be used as a transceiver for USBL positioning, where acoustic signals are used to determine the distance and bearing to a transponder - an S2C underwater acoustic modem, attached to a tracking target.

The USBL transceiver measures the time from transmission of its acoustic signal until an acoustic reply from the transponder is detected, and converts it to distance to the transponder. Containing several transducers separated by a short distance (the ultra-short baseline antenna), the transceiver calculates the angle to the transponder.

Moreover, S2C USBL devices can be optionally combined with an internal AHRS (Attitude and Heading Reference System) to provide pitch, roll and yaw compensation of the USBL antenna movements.

See section 5.13 for more information and instructions on USBL positioning.

3 Device Interfaces

An S2C Underwater Acoustic Modem/S2C USBL Underwater Communication Device can be equipped with serial (RS-232, RS-485/RS-422) and Ethernet input-output interfaces.

Up to 8 input-output interfaces can be configured on one S2C device.

We recommend the **PuTTY** software tool for connecting to devices over serial interface, and **netcat**[3]for connecting over Ethernet.

3.1 Data Channels

The D-MAC data-link layer protocol allows to create and configure a maximum of 8 virtual channels for burst data exchange - the data channels - within the acoustic communication link.

Each input-output interface of a device is mapped to a particular data channel, so data channels are used to direct data from an input-output interface of the transmitter to a certain input-output interface of the receiver.

Up to 8 data channels share the acoustic communication link, where burst data packets from different data channels are multiplexed into packet trains according to channel priorities (see section 3.1.1 below for more information).

Each data channel has an identification number - the `Channel number`, so upon reception burst data packets from different data channels are identified and directed to the correct input-output interface of the receiver - the receiver's input-output interface with the matching `Channel number`.

A list of `Channel number`s and corresponding input-output interfaces of the local device can be viewed with a specific command. With another command, an input-output interface of the local device can be reassigned to another data channel, so burst data will be directed to another input-output interface of the remote device (see 5.9.14).

If an Ethernet interface is available to access the device, the channel list can also be edited with the web-based Configuration Utility (see A.1 for details).

[3]**netcat** official page: http://nc110.sourceforge.net/, **netcat** for Windows download: lab.evologics.de/share/soft/windows/netcat/nc.exe.

3.1.1 Channel Priority

As up to 8 virtual data channels share the acoustic link, one packet train can contain packets from up to 8 different channels. The data channels are prioritized, so for every channel its channel priority value defines the number of its packets in a shared packet train.[4]

If an Ethernet interface is available to access the device, channel priorities can be modified with the web-based Configuration Utility (see Appendix A.1 for details).

If the device is only accessible over RS-232, channel priorities can be reassigned with a Firmware Update Utility. Contact EvoLogics for more information.

[4]For every channel i, its priority p_i defines the number of the channel's packets n_i in a shared packet train:

$$\begin{aligned} N_0 = N, n_0 = 0 \\ N_i = max(0, N_{i-1} - n_{i-1}) \\ n_i = min(\lceil p_i N_i \rceil, m_i) \\ i = 1...k \end{aligned}$$

Here N is `Cluster Size` – the overall number of packets in a train (see section 5.9.8 for details), k is the `Channel Number`, an identifier assigned to the i-th channel, m_i - the number of packets in the transmission buffer of the i channel.

3.2 Interface configuration: the `Interface String`

An `Interface String` is a text string that describes the configuration of an input-output interface. The string defines the interface type, interface parameters and filters – data pre-processing programs – applied to the data stream.

Commands described in section 5.9.14 allow to view the list of input-output interfaces and the corresponding data channels. The list of interfaces is displayed in the following format:

`<Channel Number> <Interface String>`

The `Channel Number` and the `Interface String` of the assigned interface are separated by a space.

In general, the `Interface String` format is following:

`<interface type>://<interface parameters>|<filters>`

- Interface types - `serial` for RS-232 or `tcp` for Ethernet - and their specific parameters are described in sections 3.2.1 and 3.2.2 that follow.

  Interface type and interface parameters are separated by a `://` combination. The default interface parameters can be omitted in the `Interface String`.

- A pipe symbol `|` separates the filters. Similar to Unix and Unix-like systems, a filter is a program that gets data from the data stream, processes it, and outputs its results back to the data stream. Read more about available filters in section 3.2.3.

If an Ethernet interface is available to access the device, `Interface Strings` can be edited with the web-based Configuration Utility (see appendix A.1 for details).

If the device is only accessible over RS-232, `Interface Strings` can be edited with a Firmware Update Utility. Contact EvoLogics for more information.

Configuring input-output interfaces is an advanced procedure and may require additional support from EvoLogics. We recommend consulting EvoLogics before modifying interface configurations.

3.2.1 RS-232 Interface

The `Interface String` format for a serial input-output interface is:

`serial://<interface name>:B<baudrate>:<data bits><parity><stop bits>|<filters>`

Here `<interface name>` is the symbolic name of the serial port. S2C devices use Linux-like naming for serial ports `/dev/ttyS*` where * represents the port number.

The port name is listed in the Factory certificate of your device.

See the table below for detailed descriptions of other parameters:

Parameter	Options	Description
`B<baudrate>`	50 .. 115200	Baudrate, bps. Default value: 19200 bps. Possible values: 50, 75, 110, 134, 150, 200, 300, 600, 1200, 1800, 2400, 4800, 9600, 19200, 38400, 57600, 115200 The maximum baudrate for devices with a Wake Up Module is 19200 bps.
`<data bits>`	5 .. 8	Data bits. Default value: 8. Possible values: 5, 6, 7, 8
`<parity>`	`N`	The parity bit is set to none. Default value.
	`E`	The parity bit is set to even.
	`O`	The parity bit is set to odd.
`<stop bits>`	1..2	Stop bits. Default value: 1. Possible values: 1, 2

The default configuration of a serial input-output interface is:

`serial:///dev/ttyS1:B19200:8N1|<filters>`

The default interface parameters can be omitted, as shown below:

`serial:///dev/ttyS1|<filters>`

If your device features a serial input-output interface, it is set up to a recommended configuration with a command interpreter `<filter>` (either `at` or `net`) enabled for the RS-232 interface.

See section 3.2.3 for detailed description of the filters (pre-processing programs) and filter parameters, as well as their recommended configurations.

3.2.2 Ethernet Interface

The `Interface String` format for an Ethernet input-output interface is:

`tcp://<ip address>:<port number>:<client/server>:<disable buffering>|<filters>`

See the table below for detailed descriptions of the interface parameters:

Parameter	Options	Description
`<ip address>`		IP address for TCP/IP connection. Default value: `0.0.0.0`
`<port number>`		Port number for TCP/IP connection. Default value: 9200
`<client/server>`	`lr`	Server mode: listen-respawn. The device is a server - it listens for requests from `<ip address>:<port number>`. It will attempt to restore a lost connection.
	`ls`	Server mode: listen-single. The device is a server - it listens for requests from `<ip address>:<port number>`. It will not attempt to restore a lost connection.
	`c`	Client mode: connect. Default mode. The device is a client - it will send requests to `<ip address>:<port number>`.
`<disable buffering>`	`n`	Disable data buffering.

If `<ip address>` is 0.0.0.0, the device listens on all IP address in the subnet.

By default, the device is configured in the subnet `192.168.0.0/24`. The default IP address of your device is listed in its Factory Certificate. The IP address and the network mask of the device can be edited with the web-based Configuration Utility (see A.1 for details).

If your device features an Ethernet input-output interface, it is set up to a recommended configuration:

`tcp://0.0.0.0:9200:lr|<filters>`

The recommended configuration includes a command interpreter `<filter>` (either `at` or `net`) enabled for the Ethernet interface.

See section 3.2.3 for detailed description of the filters (pre-processing programs) and filter parameters, as well as their recommended configurations.

3.2.3 Data pre-processing: filters overview

Filters are software modules that process data from the input-output interface and output the results back to the data stream. Several filters can be enabled for an input-output interface, so data can undergo several stages of processing before being output to the data channel and transmitted over the acoustic link.

Enabling and disabling filters for the input-output interface is performed by editing the `Interface String` (see section 3.2 above). The default filter syntax is:

```
|<filter name> <filter parameter 1> <filter1 parameter 1 value>
<filter1 parameter 2> <filter1 parameter 2 value>|<filter2>
```

Different filters are separated by the pipe symbol `|`. The `<filter name>`, `<filter parameters>` and their corresponding values are separated by optional spaces. Default filter parameters and corresponding values can be omitted.

The pipe `|` in the `Interface String` signifies that the output of the interface or a filter to the left is passed as input to the filter on the right. Therefore, the filters are order-sensitive. For example, if a `zlib` data compressing filter would precede a command interpreter `at`, as shown below:

```
serial:///dev/ttyS1:B19200|zlib|at
```

data would be compressed before being passed to the command interpreter, which would fail to parse commands from the compressed data. The correct order of filters in the example above would be:

```
serial:///dev/ttyS1:B19200|at|zlib
```

Data, output by the command interpreter `at` would be passed to `zlib` for compression.

Read more about supported filters below.

3.2.4 Command interpreter: `at` filter or `net` filter.

Command interpreters are software modules that parse the data from the input-output interface to recognize and execute AT commands, supported by S2C devices.

S2C devices support two modes of operation: the **Data Mode** and the **Command Mode**:

- In **Data Mode** all incoming host data is treated as burst data to be immediately transmitted over the acoustic channel. All burst data, received from the remote side, is routed directly to the corresponding input-output interface. Read more about the **Data Mode** in section 4.2.
- In **Command Mode** all incoming data from the input-output interface is treated as commands to the local device. Read more about the **Command Mode** in section 4.3.

Two types of command interpreters exist for S2C devices:

- The `at` filter is a command interpreter that supports both operating modes - the **Data Mode** and the **Command Mode**. `at` filter also supports the Time Independent Escape Sequence (see 4.2.2) that allows commands to be executed without leaving the **Data Mode**. The `at` filter parses and executes commands from the Standard AT command set of S2C devices, described in this manual.
- The `net` filter supports only **Command Mode**. It parses and executes commands from the Networking AT command set of S2C devices, described in the **S2C Underwater Acoustic Modem Guide Networking Version**. The Networking command set is slightly different from the Standard command set. It includes separate commands for transferring burst data, but does not support the **Data Mode** and the Time Independent Escape sequence.

Only one command interpreter - either `at` or `net` - can be enabled for an input-output interface. If your device has more than one input-output interface, only one type of command interpreter - either `at` or `net` - can be enabled for several interfaces. Different command interpreters for different interfaces are not allowed.

If no command interpreter is enabled for an interface, it will operate in **Data Mode**, so all incoming data will not be parsed for commands - it will be immediately routed for an acoustic transmission as burst data. AT commands and actions they perform will not be available. Sending and receiving instant messages, synchronous instant messages or piggyback messages will not be possible, as they require a command interpreter as well.

See the table below for the `at` filter and the `net` filter parameters:

Parameter	Options	Description
`-p <protocol ID>`	0 .. 7	Protocol ID. Default value: 0. Read more in section 3.2.5 below.
`-l "<end-of-line>"`		End-of-line marker, a character or sequence of characters signifying the end of a line. Default value: `\r` (**carriage return**).
`-u <option>`	1	Positioning data output enabled. Default value, if `Protocol ID` is 0. The device generates positioning strings and outputs them to the input-output interface. Positioning data output can be enabled/disabled with a command - read more in section 5.11.4.
	0	Positioning data output disabled. Default value, if `Protocol ID` is non-zero.
`-x <option>`	1	Extended notifications enabled. The device generates extended notifications. Extended notifications can be enabled/disabled with a command - read more in section 5.11.5.
	0	Extended notifications disabled. Default value.
`-o <option>`	1	Optocoupler control enabled. Optocoupler control is an experimental feature. Contact EvoLogics for more information on optocoupler control.
	0	Optocoupler control disabled. Default value.

- An example of an `Interface String` with the `at` filter in default configuration enabled for a RS-232 interface, would look like:

  ```
  serial:///dev/ttyS1:B19200|at -p 0 -l "\r" -u 1 -x 0 -o 0
  ```

  In this example, incoming data from the RS-232 interface will be parsed for commands from the Standard AT command set, the `Protocol ID` is 0, the end-of-line market is carriage return, positioning data output is enabled, extended notifications are disabled, optocoupler control is disabled.

  With default parameters omitted, the same string would look like this:

  ```
  serial:///dev/ttyS1:B19200|at
  ```

- An example of an `Interface String` with the `net` filter enabled for an Ethernet interface, would look like:

  ```
  tcp://0.0.0.0:9200:lr|net -p 1 -l "\n" -u 0 -x 0 -o 0
  ```

  In this example, incoming data from the Ethernet interface will be parsed for commands from the Networking AT command set, the `Protocol ID` is 1, the end-of-line market is line feed, positioning data output is disabled, extended notifications are disabled, optocoupler control is disabled.

  With default parameters omitted, the same string would look like this:

  ```
  tcp://0.0.0.0:9200:lr|net -p 1 -l "\n"
  ```

3.2.5 Command interpreter: the Protocol ID parameter

The `Protocol ID` is an important parameter of the command interpreter. It performs two functions:

- `Protocol ID` signifies, if the interpreter executes control commands that modify global device settings. These commands are described in section 5.9.

  If `Protocol ID` is 0, the interpreter will execute control commands that modify global device settings.

  If `Protocol ID` is 1..7, the interpreter will not execute commands that modify global device settings.

- `Protocol ID` is an identifier for transmitting instant messages, synchronous instant messages and piggyback messages.

  Since the data-layer protocol uses a different algorithm for transferring messages, than the burst data algorithm that uses data channel numbers for directing data to a particular interface, the messages are directed to the destination interface according to the `Protocol ID`.

  For example, a message sent from an interface with `Protocol ID` 6 will be transmitted over the acoustic channel and directed to the `Protocol ID` 6 input-output interface of the receiver. If the receiver does not have an interface with a command interpreter having `Protocol ID` 6, the message will be lost.

All input-output interfaces with an enabled command interpreter (either `at` or `net`) must have different `Protocol IDs`. `Protocol ID` duplication on different interfaces is not allowed, since it may lead to unpredictable behaviour of your device! Therefore, only one input-output interface can have `Protocol ID` 0, so all commands to modify global settings must be input through that interface only.

Please note that your device was shipped with recommended interface configuration, contact EvoLogics before proceeding with `Protocol ID` manipulation!

The `AT?PID` command (see more in section 5.7.2) allows to view the `Protocol ID` of the current input-output interface - the interface used to access the device.

3.2.6 Data Compression: the `zlib` filter.

The device can compress data before transmitting it over the acoustic channel to speed up the data transfer. Data compression and decompression is performed by `zlib` - a data compression filter (pre-processing software module), and can be enabled for any input-output interface of the device.

See the table below for the `zlib` parameters:

Parameter	Options	Description
`-z <compression level>`	0 .. 9	Compression level. Default value: 9.
`-b <block size>`	up to 8192 B	Block size, in B. Default value: 4096 B.
`-n <option>`	1	Disable timeout.
	0	Enable timeout. Default value.
`-t <timeout>`		Timeout, in s, floating point value. Default value: 1 s.

`zlib` compresses data in blocks of `<block size>` B. When timeout is enabled, `zlib` waits `<timeout>` seconds to receive the full block of data from the input-output interface and compress it. During the timeout, once the full block (`<block size>` B) of data is received, it is compressed. Once the timeout expires, `zlib` compresses data, even if it received less than `<block size>` B from the input-output interface.

If timeout is disabled, `zlib` only compresses data when a full block (`<block size>` B) is available. If there is not enough data, `zlib` will wait for the full block to compress it.

An example of the `zlib` data compression filter with default parameters, enabled for a serial input-output interface would look like:

```
serial:///dev/ttyS1|zlib -z 9 -b 4096 -n 0 -t 1
```

The default filter parameters can be omitted, as shown below:

```
serial:///dev/ttyS1|zlib
```

Please remember, that if burst data is compressed before being transmitted over the acoustic channel, the receiving side must correctly decompress it. To ensure correct compression and decompression of the data, both communicating devices must have the `zlib` filter enabled with identical compression parameters on the corresponding input-output interfaces!

4 Device operation

4.1 AT Commands

S2C devices are controlled by a specific command language - a set of AT commands. AT commands are short text strings that instructs the device to perform an action. The AT command set contains commands for all communication operations, commands for viewing, modifying and saving device settings, commands for tracking communication parameters, position tracking etc. See section 5 for detailed information on AT command syntax and individual command descriptions.

To input and execute AT commands, a command interpreter must be enabled for the input-output interface used to access the device. It is enabled by default for one of the input-output interfaces. The command interpreters and their parameters are described in detail in section 3.2.3.

If the `at` command interpreter is enabled for the input-output interface (3.2.4), your device supports 2 operating modes - the **Data Mode** and the **Command Mode**. This manual describes the Standard AT command set, supported by the `at` command interpreter.

4.2 Data Mode

Data Mode, the default mode of S2C devices, is best for transferring raw sensor data. In **Data Mode** all incoming host data is treated as burst data to be immediately transmitted over the acoustic channel. All burst data, received from the remote side, is sent directly to the corresponding input-output interface.

The device starts in **Data Mode** by default. To use AT commands, one must switch the device into **Command Mode** with a Guard Time Escape Sequence (see 4.2.1 below) or use the Time Independent Escape Sequence (see 4.2.2 below) to execute commands without leaving the **Data Mode**.

4.2.1 Guard Time Escape Sequence

The **Guard Time Escape Sequence** (GTES) is a control sequence – a series of characters that switches the device into Command Mode.

The GTES control sequence is `+++`.

To make sure the sequence is distinguished from burst data, a 1 second data-free timeout (Guard Time) must precede and follow the control sequence. Only a pause - `+++` - pause sequence, encountered in the stream of burst data, will be recognized as the GTES.

Please note, that for a device with a Wake Up Module, it can take up to 6 seconds to switch unto Command Mode. Increase the Guard Time to 6 seconds if you are using a device with a Wake Up Module installed.

The device will respond with an `OK` once it has entered Command Mode. Every input data is from then on treated as commands (see section 5 for command syntax and descriptions).

Several AT commands switch the device back to Data Mode - see sections 5.3.1 and 5.3.8.

Please note, that GTES is not recommended for Ethernet interfaces, as the TCP/IP protocol can not guarantee holding the guard time interval before and after the TIES.

4.2.2 Time Independent Escape Sequence

Time Independent Escape Sequence (TIES) is a text string that allows to execute AT commands without leaving the **Data Mode**:

`+++<AT command>`

The control sequence `+++` begins the TIES string and invokes an alternative interpretation of subsequent characters - it alerts the command interpreter, that the characters to follow are to be parsed as an AT command. The end-of-line marker of the AT command terminates the TIES string.

Which end-of-line marker - **line feed** (`LF`, `\n`, `0x0A`) or **carriage return** (`CR`, `\r`, `0x0D`) - ends a command string depends on the interface and the terminal software used to access the device. Read more about end-of-line markers in section 5.1.2.

All data following the end-of-line marker of the AT command will be treated as burst data. No guard time is necessary for the TIES to be distinguished from burst data, as the control sequence in the beginning of TIES triggers AT command execution. **For the string to be recognized as TIES, intervals between TIES-characters must not exceed 1 second!** TIES strings containing AT commands in wrong format are treated as burst data and will be transmitted to the remote device.

4.2.3 Back Escape Sequence

In Data Mode, the device outputs **Back Escape Sequence**s (BES) – text strings that contain various notifications or responses to AT commands (read more about command responses and notifications in section 5.1.1).

In Data Mode, notifications (5.1.4) will be output as BES strings in the following format:

`+++AT:<length>:<notification><end-of-line>`

Here `<length>` is the length (B) of the `<notification>` string. The `<notification>` can contain binary data.

Command responses (5.1.3) will be output as BES strings in the following format:

`+++<AT command>:<length>:<command response><end-of-line>`

Here `<AT command>` is the command the device responds to, `length` is the length (B) of the `<command response>`.

The BES strings generated by your device end with a combination of control characters - **carriage return** followed by **line feed** (`CR+LF`, `\r\n`, `0x0D0A`) as the `<end-of-line>` marker. Read more about end-of-line markers in section 5.1.2.

4.3 Command Mode

In **Command Mode** all incoming data from the input-output interface is treated as commands to the local device that must be executed immediately. The Command Mode was designed as an interface for software programming and manual operations.

To switch into Command Mode, use the GTES or a TIES with the specific command (see 5.3.1). Use another command (5.3.2) to switch back to Data Mode.

Please note, that while the device is in Command mode, any incoming burst data is buffered and only sent to the input-output interface after the device switches back to Data Mode.

5 Commands

5.1 Introduction

The AT command set controls every aspect of device operation. A similar Hayes command set is the industry standard for modem communications.

AT commands allow modifying, applying and storing device settings and setting configurations. The device supports AT commands for transmitting various types of data, tracking communication parameters and estimating positioning data.

This section contains general notes about AT command syntax. Individual commands are described in detail in sections that follow.

5.1.1 AT Command syntax

An AT command is a short text string that instructs the device to perform an action.

All command statements begin with an `AT` prefix, where "AT" stands for "ATtention code". The device is thus signalized that a command is to follow.

A command character and/or letters and numerical values complete the command string.

- In general commands, used to switch between different modes of operation, establish or close an acoustic connection etc., a capital letter follows the `AT` prefix.
- In data control commands, used to send burst data and instant messages, an asterisk `*` follows the `AT` prefix.
- In settings management commands, used to store settings profiles, an ampersand `&` follows the `AT` prefix.
- In requests, used to view setting values and acoustic channel parameters, a question mark `?` follows the `AT` prefix.
- In commands to edit global device settings, an exclamation mark `!` follows the `AT` prefix.
- In command to edit settings, specific to the current data channel, the at symbol `@` follows the `AT` prefix. Read more about data channels in section 3.1.
- In help commands, corresponding command characters and a dollar sign `$` follow the `AT` prefix.

The AT command syntax is case-sensitive. Only upper-case characters are accepted.

Command length is limited to 1054 characters. An error message is generated if this limit is exceeded.

In command descriptions that follow, `n` at the end of an `AT!` command designates command options. `n` is a numerical value, the corresponding value ranges are defined in individual command descriptions.

Please note: you can skip `0` at the end of a command. The device treats `AT!L` and `AT!L0` as the same statement.

5.1.2 End–of–line markers

Each AT command ends with a control character - an end-of-line marker that terminates a command statement.

The standard terminal software used to access the device automatically adds an end-of-line marker to the command string when you press `Enter`.

The end-of-line is a syntactical element and does not appear in the command line of the standard terminal.

Which end-of-line marker - **line feed** (`LF`, `\n`, `0x0A`) or **carriage return** (`CR`, `\r`, `0x0D`) - ends a command string depends on the interface and the terminal software used to access the device.

Ethernet terminals usually use the **line feed** (`\n`), serial terminals - the **carriage return** (`\r`). The Ethernet interface of your device is by default configured for a **line feed** (`\n`) end-of-line marker, an RS-232 interface – for a **carriage return** (`\r`).

All messages generated by your device end with a combination of control characters - **carriage return** followed by **line feed** (`CR+LF`, `\r\n`, `0x0D0A`) as the end-of-line marker.

Make sure the software used to access the device is properly configured with correct end-of-line marker settings!

5.1.3 Command Responses and Error messages

The local device generates an immediate response to a command it received. The only exception is the ATO command that switches the device into Data Mode (see 5.3.2).

Wait for the command response before sending another command to the device! Characters, input between a command and the corresponding response, might be ignored, leading to unpredictable behaviour.

Command responses terminate with a \r\n combination of command characters.

Command responses include:

- Confirmations that a command to change a setting or perform an action is accepted for execution.

  When an acoustic connection to a remote device is established, some setting changes cannot be executed immediately. Execution of these commands is postponed, until the connection is closed (the acoustic link status is OFFLINE READY or INITIATION LISTEN, read more about the acoustic link statuses in section 5.7.5).

  If command execution is deferred, the command confirmation response is preceded by a prefix - an asterisk enclosed in square brackets [*]. This prefix means, that the command will be executed as soon as the acoustic link status becomes OFFLINE READY or INITIATION LISTEN.

Confirmations	Description
OK	The command is accepted and will be executed immediately.
[*]OK	The command is accepted and will be executed when the acoustic link status becomes OFFLINE READY or INITIATION LISTEN.

- Requested values or value lists if the command was a request.

  When an acoustic connection to a remote device is established, some local device settings cannot be changed. Until the connection is closed, execution of a setting change is postponed. In this case, requesting the setting value will display the deferred new value.

  When requested, deferred setting values are displayed with a prefix - an asterisk enclosed in square brackets [*]. This prefix means, that the displayed value will be applied as soon as the acoustic link status becomes OFFLINE READY or INITIATION LISTEN state.

Request responses	Description
<Setting value>	The current setting value.
[*]<Setting value>	The value is deferred and will be applied when the acoustic link status becomes OFFLINE READY or INITIATION LISTEN.

- Error messages and busy messages.

  Error messages alert about syntax errors, invalid input values, inability to perform the requested action, internal errors etc.

  See the table below for a full list of errors that can be generated as a response to an AT command:

Error message	Description
`ERROR EFAULT`[1]	Acoustic transmission failed: the power amplifier is either not powered or has been damaged. Check power wiring if your device is in OEM configuration. Try again and contact EvoLogics if the problem persists.
`ERROR OVERLOAD`[1]	Acoustic transmission failed: the power amplifier is overloaded. This occurs: – If a high-power transmission was attempted in air or in shallow water. Try again using a lower `Source Level` setting (see 5.9.5). – If your device is overvoltaged: the input voltage exceeds the upper limit. Please refer to the Quick Test Guide supplied with your device for the highest input voltage allowed! Make sure that the input voltage is within allowed range and try again. Contact EvoLogics if the problem persists.
`ERROR PHY OFF`	The command cannot be executed since the physical layer is off. Physical layer must be on for this command's execution.
`ERROR CONFIGURATION NOT STORED`	Storing the settings configuration failed. Try again, contact EvoLogics if the error persists.
`ERROR NOT ACCEPTED`	The new setting was not applied.
`ERROR WRONG DESTINATION ADDRESS`	The transmission's `<destination address>` matches the local address.
`ERROR UNKNOWN COMMAND`	The entered string was not recognized as a valid AT command.
`ERROR WRONG FORMAT`	The command contains syntax errors.
`ERROR BUFFER IS NOT EMPTY`	The current data channel's buffer is not empty, attempted setting modification is not allowed.
`ERROR BUFFERS ARE NOT EMPTY`	The buffers are not empty, attempted setting modification is not allowed.
`ERROR BUFFER FULL`	Incoming data from the host cannot be transmitted - the buffer is full.
`ERROR OUT OF RANGE`	Attempted setting modification is not allowed - new value is out of range.
`ERROR PROTOCOL ID`	Attempted setting modification is not allowed - the `Protocol ID` is not 0.
`ERROR PROTOCOL ID DUPLICATION`	`Protocol ID` duplication is not allowed, check the interface string configuration.
`ERROR INTERNAL <code>`	An internal system error occurred. Please contact EvoLogics and submit the error `<code>`.

[1]This error message is supported by physical layer protocol version `0x<XXXX>4001` and higher. Use `ATIn` to view device firmware information (5.3.9).

Busy messages alert about media access being temporarily not available. The busy messages are described in the table below:

Busy message	Description
`BUSY DELIVERING DATA TO <destination address>`	The channel is busy with data being delivered.
`BUSY RECEIVING DATA FROM <source address>`	The channel is busy with data being received.
`BUSY CLOSING CONNECTION WITH <destination address>`	The channel is busy with a connection being closed.
`BUSY DELIVERING INSTANT MESSAGE TO <destination address>`	The channel is busy with an instant message delivery.
`BUSY RECEIVING INSTANT MESSAGE FROM <source address>`	The channel is busy with an instant message reception.
`BUSY BACKOFF STATE`	The channel is busy, the local device is in Backoff state (see `AT?S`, section 5.7.5).

5.1.4 Notifications

Notifications are strings the local device generates to inform about:

- Receiving instant messages over the acoustic channel.

  The notification includes the message itself and the transmission parameters.

  See sections 5.5.6, 5.5.7 and 5.5.8 for detailed descriptions.

- Successful or failed instant message deliveries.

  Delivery reports are generated either upon receiving a delivery acknowledgement from the remote device, or if delivery was not acknowledged after a certain number of retries.

  See section 5.5.4 for detailed descriptions.

- Position of the remote device.

  A S2C USBL (Ultra-Short Baseline) device can output a string with the target's position (or the direction towards the target) and signal acoustic parameters.

  Read more about positioning data in sections 5.13.1 and 5.13.2.

  These notifications can be turned on of off for the current data channel (see section 5.11.4).

- Automatic setting adjustments, status of acoustic transmissions and other events.

  These extended notifications can be turned on and off for the current data channel (see section 5.11.5).

  Section 5.11.5 provides the full list of extended notifications and their detailed descriptions.

All notifications end with a `\r\n` combination of command characters as the end of line marker.

Please note, that notifications are independent reports and can appear between a local command and the corresponding command response.

5.2 Help commands

5.2.1 AT? or AT$: See all Help sections

Use AT? or AT$ to see the full help list.

5.2.2 AT*$: See Data Control Help sections

Use AT*$ to see a list of Data Control commands for sending data and instant messages.

5.2.3 AT&$: See Settings management Help sections

Use AT&$ to see a list of commands, used to manage settings profiles.

5.2.4 AT?$: See Requests Help sections

Use AT?$ to see a list of all settings requests.

5.2.5 AT!$: See Settings Help sections

Use AT!$ to see a list of commands for modifying settings.

5.2.6 AT@$: See Data stream Help sections

Use AT@$ to see a list of commands, specific to current data channel.

5.2.7 AT<keyword>$: Search Help sections

Use AT<keyword>$ to search Help sections for a <keyword>. Please mind that the search is not case-sensitive.

See an example in the table below:

	Example AT<keyword>\$
+++	Switch to Command Mode
OK	
ATnoise$	Search commands for keyword "noise"
AT?NOISE raw noise data sample (in noise state)	First search result.
ATN set noise mode	Second search result.

5.3 General commands

5.3.1 ATC: Switch to Command Mode

ATC switches the device into Command Mode.

This command is an alternative to the Guard Time Escape Sequence (GTES). When used as a part of a Time Independent Escape Sequence (TIES, see section 4.2.2), it spares the guard time intervals that a GTES demands.

The device replies with an OK after having switched to Command Mode.

	Example ATC
+++ATC	TIES with the command.
OK	Command response, the device is in Command Mode.
AT*SENDIM,4,2,ack,test	Send IM to address 2.
DELIVEREDIM,2	The IM was delivered.
ATO	Switch to Data Mode.

5.3.2 ATO: Switch to Data Mode

Use ATO to switch the device from Command Mode into Data Mode, where all input data is treated as burst data.

The device does not respond to this command, it switches into Data Mode and is ready to transmit data.

	Example ATO
+++	Guard Time Escape Sequence, switching to Command Mode.
OK	Success confirmation, the device is in Command Mode.
ATI7	View device manufacturer (see 5.3.9).
EvoLogics GmbH	Device manufacturer.
ATO	Switch to Data Mode.

5.3.3 ATS: Switch to Deaf State

In **Deaf State** the device does not receive any incoming signals and only operates as a transmitter.

This mode is useful, for example, if an upper layer protocol specifies scheduled transmissions with strict time intervals between them. Switching the receiver off in this case ensures the channel will never be occupied by incoming data. Therefore, incoming data will not compromise the outgoing transmissions schedule, defined by an upper layer protocol.

Use ATS to switch your device into **Deaf State**. The receiver unit will be shut down.

The device will respond with INITIATION DEAF.

To quit **Deaf State**, use ATA (see 5.3.5) or ATD (see 5.3.6).

	Example `ATS`
`+++`	Switch to Command Mode.
`OK`	
`ATS`	Switch to Deaf State.
`INITIATION DEAF`	The device is entering Deaf State.

5.3.4 `ATN`: Switch to Noise State

Electromagnetic interference or environmental noise (acoustic noise from the vessel, underwater vehicle or other machinery) in close proximity of the device can couple into its sensitive preamplifier circuits and significantly degrade its performance.

To analyse and identify the sources of noise, your device can switch into noise measurement mode – the **Noise State**.

In **Noise State**, acoustic communication is not possible, instead, several specific commands are available to analyse the analog input noise:

- Use the `AT?E` command (see 5.12.3) to request the RMS value of the noise.
- Use `AT?NOISE` (see 5.12.8) to obtain the raw noise data sample.

Use `ATN` to switch the device into **Noise State**.

The device will respond with `INITIATION NOISE`.

To quit **Noise State**, use `ATA` (see 5.3.5) or `ATD` (see 5.3.6).

We recommend to perform a noise test before deploying your device during system integration:

Perform a dry test:

- Install the device and all components of the system it is integrated with in air. Turn the system on.
- In **Noise State**, measure the RMS value of the noise (see section 5.12.3 for details).
- If RMS value of the noise exceeds -80, the noise interferes with your device's performance - a further investigation is recommended.

  This limit can vary between different typed of devices, please contact EvoLogics for a specific recommendation for your device.
- To investigate the sources of noise, obtain the noise sample - an time-vector of analog input noise (see section 5.12.8 for details).
- Perform spectral analysis or use other methods to identify the sources of noise.

After analysing and eliminating sources of noise in lab environment, repeat the steps described above to perform an underwater test.

5.3.5 ATA: Switch to Listen State

ATA switches your device into its default state - the **Listen State**, when the device is ready to accept a connection establishment request or instant messages.

Use ATA to switch back into **Listen State** from **Noise State** or **Deaf State**.

The device will respond with INITIATION LISTEN.

	Example ATA
+++ATC	Switch to Command Mode.
OK	
ATN	Switch to Noise State.
INITIATION NOISE	The device is in Noise State.
ATA	Switch to Listen State.
INITIATION LISTEN	The device is in Listen State.

5.3.6 ATD: Establish an acoustic connection

Use ATD to establish an acoustic connection to a remote device.

The device will respond with INITIATION ESTABLISH.

It will send a connection establishment request to an address, specified by the Remote Address setting of your device (read more about Remote Address in section 5.9.6).

Use this command when you need to establish an acoustic connection to a remote device, but there is no burst data to be transmitted at the moment. This is useful when, in absence of burst data, you need to check the parameters of the acoustic channel, awake a remote device with a Wake Up Module (read more in section 5.10.4), or establish the acoustic link for other diagnostic purposes.

If the Remote Address setting is 0 (read more in 5.9.6), the remote device to connect to is undefined, so an error report will be generated.

	Example ATD
+++AT?S	Check the Acoustic Link Status (see 5.7.5).
+++AT?S:29:INITIATION LISTEN 32000 32768	Acoustic Link Status: the device is in Listen State.
+++ATD	Establish an acoustic connection.
+++ATD:20:INITIATION ESTABLISH	The device is establishing the acoustic connection.

5.3.7 `ATHn`: Close an acoustic connection

Use `ATHn` to close or terminate an acoustic connection to a remote device.

See the table below for command options.

Command	Options		Description
`ATHn`	`n`	0	Close an acoustic connection. Graceful disconnect - a service message will notify the remote device about the connection being closed.
		1	Terminate an acoustic connection. Force disconnect - the remote device is not notified about the connection being closed.

5.3.8 ATZn: Reset the device, drop data and/or instant messages.

Use ATZn to:

- reset the device
- drop burst data from the transmission buffer and close the acoustic connection
- drop instant messages from the transmission buffer
- clear all data from the transmission buffer

See the table below for command options.

Command	Options		Description
ATZn	n	0	Reset the device to stored settings and restart it. No command response. Any open TCP connections will be closed. The device will restart in Data Mode.
		1	Drop burst data and terminate the acoustic connection.
		2	Reserved for future use.
		3	Drop instant messages.
		4	Clear the transmission buffer – drop burst data and instant messages.

If extended notifications are turned on for the current data channel (see 5.11.5),

```
PHYOFF
```

and

```
+++PHYON
```

strings will be generated when the physical layer (the transducer unit) is turned off and on again during system reset. Please note, that as the device restarts in its default Data Mode, the +++PHYON notification includes the Back Escape Sequence (see section 4.2.3). You can turn extended notifications off with the AT@ZXn command, see more in section 5.11.5.

	Example ATZ1
test data test data	Send burst data.
+++ATZ1	Drop burst data and terminate the connection.
+++ATZ:2:OK	

5.3.9 ATIn: View firmware information

ATIn requests the current firmware version, or the physical layer protocol and the data-link layer protocol versions.

See the table below for command options.

Command	Options		Description
ATIn	n	0	View <Firmware Version Number>
		1	View <Physical Layer Protocol>,<Data-Link Layer Protocol> versions
		2-6	Reserved for future use, device will generate an error report
		7	View <device manufacturer> information

	Example ATI
+++	Switch to Command Mode.
OK	
ATI0	Request the current firmware version
1.7	Firmware version number
ATI1	Request the physical and data–layer protocol versions
phy: 0x40803016, mac: v1.7.1	
ATI5	The n is out of range
ERROR OUT OF RANGE	
ATI?	
ERROR WRONG FORMAT	

5.4 Data control: send and receive burst data

5.4.1 Send burst data

When in Data Mode, any data sent to the input-output interface will be transmitted to a particular remote device as burst data. The network address of the remote device is defined by the `Remote Address` setting (see section 5.9.6).

Before sending data make sure that:

- You are sending data to the correct data channel - the channel mapped to the desired input-output interface of the receiver. Make sure the `Channel Number` (see section 5.9.14) of the source input-output interface matches the `Channel Number` of the destination input-output interface.
- An acoustic connection can be established - the `Carrier Waveform ID` identifiers of the local and the remote devices match one of the allowed combinations (see `Carrier Waveform ID`, section 5.9.4).
- The maximum length of a data packet is identical for both communicating devices (see `Packet Time`, section 5.9.9).
- The `Highest Address` settings of the devices match (see section 5.9.7).
- Data compression is either disabled on both the source input-output interface and the destination input-output interface, or enabled with identical compression parameters (see section 3.2.6).

If `Remote Address` value is 0, the local device is ready to establish an acoustic connection with any device on the network, but unable to send data to one particular device (5.9.6).

If `Remote Address` value is 0, data sent to the input-output interface will be dropped. A corresponding notification will be generated:

```
DROPCNT,<dropped bytes count>
```

Here `<dropped bytes count>` is the size of dropped data in bytes.

5.4.2 Receive burst data

Receiving burst data in Data mode is automatic - all incoming data is sent directly to the input-output interface.

If burst data is received while the device is in Command mode, the data is buffered and sent to the input-output interface after the device switches to Data Mode.

5.4.3 AT?ZE: Burst data delivery counter

The device counts all delivered burst data bytes upon receiving corresponding acknowledgements from the remote side.

Use AT?ZE to request the overall delivered bytes count.

The local device will return the current value:

View Value	Response	Example	
AT?ZE	<delivered burst data bytes>	+++	Switch to Command Mode.
		OK	
		AT?ZE	Get the current value.
		0	
		AT!E	
		ERROR WRONG FORMAT	

5.5 Data control: send and receive instant messages

5.5.1 AT*SENDIM: Send instant messages

An instant message (IM) is transmitted as soon as possible after the corresponding command was received. Its transmission is triggered by the D-MAC protocol.

Before sending an instant message make sure that:

- You are sending data to the desired input-output interface of the receiver: make sure the Protocol ID (see section 5.7.2) of the source input-output interface matches the Protocol ID of the destination input-output interface.
- An acoustic connection can be established - the Carrier Waveform ID identifiers of the local and the remote devices match one of the allowed combinations (see section 5.9.4).
- The Highest Address settings of the devices match (see section 5.9.7).

Use AT*SENDIM to send an instant message:

AT*SENDIM,<length>,<destination address>,<flag>,<data>

Here an instant message in form of a binary data array <data> of length <length> bytes is to be delivered to a remote device with an address <destination address>.

See the parameter descriptions in the table below.

		Parameter Description
<data>		The instant message – a binary data array
<length>		Message length - the data array length, max. 64 bytes
<destination address>		Network address of the remote device
Unicast Mode	1..Highest Address	The message will be sent to a particular address
Broadcast Mode	255	The message will be sent to all network devices
	0	Reserved for future use
<flag>	ack	The local device requests an instant message delivery acknowledgement. If the remote side does not acknowledge successful instant message delivery, the local device will transmit the message again. Set the number of retries with AT!RI, see IM Retry Count, section 5.9.18 View the current IM Retry Count with AT?RI Message delivery cannot be acknowledged in Broadcast Mode, the noack setting must be used.
	noack	The local device does not request an instant message delivery acknowledgement. The instant message will be transmitted once. A delivery report will not be generated.

Please note: if flag is ack in broadcast mode, a syntax error message will be generated.

See section 5.9.7 for the `Highest Address` description.

In Unicast Mode the instant message will be delivered to a particular remote device.

In Broadcast Mode the instant message will be addressed to all communication devices in the network. To send a message in Broadcast Mode, simply enter the broadcast address as the message destination address.

You can define whether the remote device should acknowledge a successful unicast message delivery. Please note that broadcast messages, sent to all communication devices in the network, cannot be acknowledged.

You can use the `AT?DI` request to check the status of a message delivery (see section 5.5.5 for details).

	Example `SENDIM`
`+++`	Switch to Command Mode
`OK`	
`AT?S`	Request the acoustic connection status
`INITIATION LISTEN 16384`	
`AT*SENDIM,4,10,ack,test`	Send IM to address 10 with acknowledgement request
`OK`	
`DELIVEREDIM,10`	Data was successfully delivered
`AT*SENDIM,4,10,noack,test`	Send IM to address 10 without acknowledgement
`OK`	request
`AT*SENDIM,4,11,noack,test`	Sending an IM to address 11 fails – the destination
`ERROR WRONG DESTINATION ADDRESS`	address matches the local address
`AT*SENDIM,4,12,ack,test`	Send IM to address 12
`BUSY BACKOFF STATE`	The device is in Backoff State

5.5.2 AT*SENDIMS: Send synchronous instant messages

Synchronous instant messages (IMS) are instant messages with time-triggered transmission. Unlike an IM, which is transmitted as soon as possible after a corresponding command was received, transmission of an IMS can be scheduled to start at a predefined time.

Start time of an IMS transmission is defined by a timestamp of the `System Clock`, a 32 bit microseconds counter. Read more about the `System Clock` in section 5.9.16. Transmission of the IMS is controlled by upper layer protocols, that trigger the physical layer to start the transmission.

Please note, that due to the scheduled nature of the IMS, transmissions of IMS are incompatible with transmissions of burst data, instant messages or piggyback messages. An IMS cannot be transmitted during an ongoing burst data, IM and PBM transmission, and no burst data, IM and PBM transmission is possible, until the physical layer has transmitted the scheduled IMS.

An IMS is transmitted once without a delivery acknowledgement. The IMS length is limited to 64 bytes.

Before sending an IMS make sure that:

- You are sending data to the desired input-output interface of the receiver: make sure the `Protocol ID` (see section 5.7.2) of the source input-output interface matches the `Protocol ID` of the destination input-output interface.
- An acoustic connection can be established - the `Carrier Waveform ID` identifiers of the local and the remote devices match one of the allowed combinations (see section 5.9.4).
- The `Highest Address` settings of the devices match (see section 5.9.7).

Use `AT*SENDIMS` to send a synchronous instant message:

`AT*SENDIMS,<length>,<destination address>,<timestamp>,<data>`

Here transmission of an IMS in form of a binary data array `<data>` of length `<length>` bytes to a `<destination address>` is to start at a `System Clock` `<timestamp>`.

See the IMS parameter descriptions in the table below.

		Parameter Description
`<data>`		The IMS – a binary data array
`<length>`		Message length - the data array length, max. 64 bytes
`<destination address>`		Network address of the remote device
Unicast Mode	1..`Highest Address`	The IMS will be sent to a particular address
Broadcast Mode	255	The IMS will be sent to all network devices
	0	Reserved for future use
`<timestamp>`	0..`<timestamp>`	**System clock** timestamp of the IMS transmission start
	empty	The IMS is to be transmitted immediately

To send an IMS as soon as possible, leave the `timestamp` field empty, as shown below:

`AT*SENDIMS,<length>,<destination address>,,<data>`

The device will generate a notification as soon as the IMS transmission is completed:

`SENDEND,<destination address>,ims,<timestamp>,<duration>`

Here the `ims` lasting `<duration>` us was transmitted to `<destination address>` at `System Clock <timestamp>`.

To interrupt a scheduled IMS transmission, for example, if you need to send burst data or an IM immediately, you must reset the device with the `ATZ0` command (see 5.3.8).

	Example `SENDIMS`
`+++AT*SENDIMS,4,2,,test`	Send IMS as soon as possible.
`+++AT*SENDIMS:2:OK`	The command is accepted for execution.
`+++AT:24:SENDSTART,2,ims,182272,0`	Extended notification (see 5.6): IMS transmission started.
`+++AT:31:SENDEND,2,ims,3011750843,182272`	The IMS transmission is completed.
`+++AT*SENDIMS,4,2,3090000000,test`	Send IMS at 3090000000 `System Clock` time.
`+++AT*SENDIMS:2:OK`	The command is accepted for execution.
`+++AT:31:SENDSTART,2,ims,182272,72428143`	Extended notification (see 5.6): physical layer protocol received the command to start the IMS transmission.
`+++AT:31:SENDEND,2,ims,3090000000,182272`	The IMS was transmitted at 3090000000 `System Clock` time.

5.5.3 AT*SENDPBM: Send piggyback messages

Piggyback messages (PBM) are messages that can be transmitted only as attachments to other data. A PBM is not transmitted immediately or at a pre-scheduled time, instead, it is buffered until there is other data to be transmitted. A PBM can be transmitted only along with an acknowledgement of an instant message reception or along with a service message.

Such messages are, for example, a useful tool to add information about the remaining battery voltage when transmitting measurement data from a sensor.

A PBM is transmitted once without a delivery acknowledgement. The PBM length is limited to 64 bytes.

Before sending a PBM make sure that:

- You are sending data to the desired input-output interface of the receiver: make sure the `Protocol ID` (see section 5.7.2) of the source input-output interface matches the `Protocol ID` of the destination input-output interface.
- An acoustic connection can be established - the `Carrier Waveform ID` identifiers of the local and the remote devices match one of the allowed combinations (see section 5.9.4).
- The `Highest Address` settings of the devices match (see section 5.9.7).

Use `AT*SENDPBM` to send a piggyback message:

`AT*SENDPBM,<length>,<destination address>,<data>`

Here a PBM in form of a binary data array `<data>` of length `<length>` bytes is to be transmitted to the `<destination address>` combined with other payload data.

See the PBM parameter descriptions in the table below.

		Parameter Description
`<data>`		The PBM – a binary data array
`<length>`		Message length - the data array length, max. 64 bytes
`<destination address>`		Network address of the remote device
Unicast Mode	1..`Highest Address`	The PBM will be sent to a particular address
Broadcast Mode	255	The PBM will be sent to all network devices
	0	Reserved for future use

Example SENDPBM	
+++	Switch to Command Mode
OK	
AT*SENDPBM,4,1,test	Send a PBM message.
OK	
RECVSTART	Extended notification (see 5.6): incoming acoustic signal detected.
RECVEND,3205823269,155648,-40,120	Extended notification (see 5.6): incoming acoustic signal successfully demodulated.
RECVIM,1,1,2,ack,155648,-40,120,0.1000,-	IM with delivery acknowledgement received.
SENDSTART,1,pbm|imack,198656,110000	Extended notification (see 5.6): transmission of the IM acknowledgement with the attached PBM started.
SENDEND,1,pbm|imack,3206088137,198656	Extended notification (see 5.6): transmission of the IM acknowledgement with the attached PBM finished.

5.5.4 Instant message notifications

The local device generates notifications that include message delivery reports, message cancellation reports and message expiration reports. Read more about these notifications below.

- Delivery reports

When sending instant messages with the AT*SENDIM command, you can request a delivery acknowledgement by setting the corresponding flag to ack (see section 5.5.1).

In this case, if the remote device receives the message, it sends back an acknowledgement of its reception. When the local device receives the acknowledgement, it generates a delivery report - a notification about successful message delivery:

Delivery Reports	
DELIVEREDIM,<destination address>	Instant message delivery was successful.
FAILEDIM,<destination address>	Instant message delivery was not acknowledged. A FAILEDIM report means the local device **did not receive a delivery acknowledgement**. The instant message may actually be delivered.

- Cancellation reports

For all input-output interfaces, messages of any type (instant messages, synchronous instant messages or piggyback messages) are not queued. Therefore, a message transmission is cancelled if you send another message from any input-output interface:

- before the acknowledgement of instant message reception was received - if such an acknowledgement was requested by the AT*SENDIM command
- before the scheduled synchronous instant message was transmitted to the remote side
- before the buffered piggyback message was transmitted to the remote side

The device will finish an existing transmission, even if the message being transmitted was cancelled with another message. A cancellation report will be generated, although the cancelled

message may actually be delivered. If extended notifications (5.6) are enabled for the selected data stream, this transmission can be tracked with `SENDSTART` and `SENDNEND` notifications.

If a message transmission was cancelled, the local device generates a corresponding notification:

	Cancellation reports
`CANCELLEDIM,<destination address>`	Instant message was cancelled.
`CANCELLEDIMS,<destination address>`	Synchronous instant message was cancelled.
`CANCELLEDPBM,<destination address>`	Piggyback message was cancelled.

- Expiration reports

If a synchronous instant message could not be transmitted at the pre-scheduled time, such message expires and is discarded.

If a synchronous instant message has expired, the local device generates a corresponding notification:

	Expiration report
`EXPIREDIMS,<destination>`	Synchronous instant message has expired.

- IMS transmitted report

Once the pre-scheduled synchronous instant message was transmitted, the local device generates a corresponding notification:

	IMS transmitted report
`SENDEND,<destination address>, ims,<timestamp>,<duration>`	Transmission of an IMS completed.

Here transmission of an `ims` to a `<destination address>` started at `System Clock` `<timestamp>` and lasted `<duration>` us.

5.5.5 AT?DI: Message delivery status

Use AT?DI to request the status of an instant message, synchronous instant message or piggyback message delivery.

The local device will respond with the current message delivery status.

Request		Message delivery status
AT?DI	EMPTY	No messages are being delivered.
	DELIVERING,<type>,<pid>	Delivery of a <type> message is pending. Here <type> is im for instant message, ims for synchronous instant message and pbm for piggyback message.
	FAILED,im,<pid>	Delivery of an instant message failed.
	EXPIRED,ims,<pid>	A synchronous instant message has expired.

Here <pid> is the Protocol ID, described in detail in section 5.7.2.

Example AT?DI	
+++AT?DI	Get the current delivery status
+++AT?DI:5:EMPTY	No messages are being delivered
+++AT*SENDIM,4,12,ack,test	Send IM to address 12
+++AT*SENDIM:2:OK	
+++AT?DI	
+++AT?DI:15:DELIVERING,im,0	The IM is being delivered
+++AT*SENDIM:14:DELIVEREDIM,12	Notification – the delivery report
+++AT?DI	Request the delivery status
+++AT?DI:5:EMPTY	No messages are being delivered

5.5.6 RECVIM: Receive instant messages

Upon successful IM reception, the device automatically generates a RECVIM notification:

RECVIM,<length>,<source address>,<destination address>,<flag>,
<duration>,<rssi>,<integrity>,<velocity>,<data>

Here an instant message in form of a binary data array <data> of length <length> bytes was received from a remote device with an address <source address>.

See the parameter descriptions in the table below.

		Parameter Description
<data>		The instant message – a binary data array
<length>		Packet length - data array length, max. 64 bytes
<source address>	1..Highest Address	Network address of the remote device
	0	Reserved for future use
<destination address>		Network address of the remote device
Unicast Mode	1..Highest Address	Network address of the recipient
Broadcast Mode	255	Broadcast: the IM was sent to all network devices
<flag>	ack	The remote device requested an instant message delivery acknowledgement.
	noack	The remote device did not request an instant message delivery acknowledgement.
<duration>		Duration of the transmission, in us.
<rssi>		Received Signal Strength Indicator. See section 5.12.3. Signed number
<integrity>		Incoming signal integrity level. See section 5.12.4.
<velocity>		Relative velocity of the devices, in m/s. See section 5.12.6. Signed number

See section 5.9.7 for the Highest Address description.

If Promiscuous Mode is on, the local device will receive instant messages, addressed to any device in the network, not just the ones addressed to the local device in particular. In this case the <destination address> differs from the local address. Turn Promiscuous Mode on/off with AT!RP, see 5.9.19.

5.5.7 RECVIMS: Receive synchronous instant messages

Upon successful reception of a synchronous instant message (IMS), the device automatically generates a RECVIMS notification:

RECVIMS,<length>,<source address>,<destination address>,<timestamp>,
<duration>,<rssi>,<integrity>,<velocity>,<data>

Here an IMS in form of a binary data array <data> of length <length> bytes was received from a remote device with an address <source address>.

See the parameter descriptions in the table below.

		Parameter Description
<data>		The IMS – a binary data array.
<length>		Packet length - data array length, max. 64 bytes.
<source address>	1..Highest Address	Address of the remote device.
	0	Reserved for future use.
<destination address>		Network address of the remote device.
Unicast Mode	1..Highest Address	The IMS was sent to a particular address.
Broadcast Mode	255	The IMS was sent to all devices.
	0	Reserved for future use.
<timestamp>		System Clock timestamp of the IMS reception start.
<duration>		Duration of the transmission, in us.
<rssi>		Received Signal Strength Indicator. See section 5.12.3. Signed number.
<integrity>		Incoming signal integrity level. See section 5.12.4.
<velocity>		Relative velocity of the devices, in m/s. See section 5.12.6. Signed number.

See section 5.9.7 for the Highest Address description.

If Promiscuous Mode is on, the local device will receive instant messages, addressed to any device in the network, not just the ones addressed to the local device in particular. In this case the <destination address> differs from the local address. Turn Promiscuous Mode on/off with AT!RP, see 5.9.19.

	Example RECVIMS
+++AT:9:RECVSTART	Extended notification (see 5.6): incoming acoustic signal detected.
+++AT:33:RECVEND,3349740860,182272,-40,120	Extended notification (see 5.6): incoming acoustic signal successfully demodulated.
+++AT:51:RECVIMS,4,1,2,3349740860,182272,-40,120,0.1000,test	IMS received.

5.5.8 RECVPBM: Receive piggyback messages

Upon successful reception of a piggyback message (PBM), the device automatically generates a RECVPBM notification:

RECVPBM,<length>,<source address>,<destination address>,
<duration>,<rssi>,<integrity>,<velocity>,<data>

Here a PBM in form of a binary data array <data> of length <length> bytes was received from a remote device with an address <source address>.

See the parameter descriptions in the table below.

		Parameter Description
<data>		The PBM – a binary data array.
<length>		Packet length - data array length, max. 64 B.
<source address>	1..Highest Address	Network address of the remote device.
	0	Reserved for future use.
<destination address>		Address of the remote device.
Unicast Mode	1..Highest Address	The PBM was sent to a particular address.
Broadcast Mode	255	The PBM was sent to all network devices.
	0	Reserved for future use.
<duration>		Duration of the transmission, in us.
<rssi>		Received Signal Strength Indicator. See section 5.12.3. Signed number.
<integrity>		Incoming signal integrity level. See section 5.12.4.
<velocity>		Relative velocity of the devices, in m/s. See section 5.12.6. Signed number.

See section 5.9.7 for the Highest Address that defines the highest address of a device.

If Promiscuous Mode is on, the local device will receive instant messages, addressed to any device in the network, not just the ones addressed to the local device in particular. In this case the <destination address> differs from the local address. Turn Promiscuous Mode on/off with AT!RP, see 5.9.19.

	Example RECVPBM
+++	Switch to Command Mode
OK	
AT*SENDIM,1,2,ack,-	Send an IM with delivery acknowledgement to address 2.
OK	
SENDSTART,2,im,155648,0	Extended notification (see 5.6): transmission of the IM started.
SENDEND,2,im,3204826761,155648	Extended notification: transmission of the IM finished.
RECVSTART	Extended notification: incoming acoustic signal detected.
RECVEND,3207084553,198656,-40,120	Extended notification: the acoustic signal was successfully demodulated.
DELIVEREDIM,2	Delivery acknowledgement: the IM was delivered to address 2.
RECVPBM,4,2,1,198656,-40,120,0.1000,test	A PBM was received along with the IM acknowledgement from address 2.

5.6 Data control: extended notifications

If extended notifications are turned on for the current data channel (see 5.11.5), the device will generate additional notifications about receiving and sending acoustic signals. Read more about these notifications below.

Notification	Description
`RECVSTART`	The local device detected an incoming acoustic signal and is attempting to demodulate it.
`RECVFAILED,<velocity>, <rssi>,<integrity>`	The device has failed to demodulate the incoming signal.
`RECVEND,<timestamp>, <duration>,<rssi>,<integrity>`	The incoming acoustic signal was successfully demodulated.
`SENDSTART,<destination address>, <type>,<duration>,<delay>`	Transmission of a `<type>` started.
`SENDEND,<destination address>, <type>,<timestamp>,<duration>`	Transmission of a `<type>` completed.

Detailed parameter descriptions are listed in the table below:

	Parameter Description
`<timestamp>`	`System Clock` timestamp of the reception/transmission start. Read more about `System Clock` in section 5.9.16.
`<velocity>`	Relative velocity of the devices, in m/s, signed number.
`<duration>`	Duration of the transmission, in us.
`<delay>`	Delay of the transmission, in us, non-zero for IMS only.
`<rssi>`	Received Signal Strength Indicator, signed number. See section 5.12.3 for more information.
`<integrity>`	Incoming signal's integrity level. See section 5.12.4 for more information.
`<destination address>`	Network address of the remote device.
`<type>`	Transmission type:
`burst`	Burst data packet.
`service`	Service message (SM). See section 2.1.3 for more information.
`service|im`	SM and an instant message (IM).
`service|imack`	SM and an IM acknowledgement.
`service|im|imack`	SM, IM and an IM acknowledgement.
`service|pbm`	SM and a piggyback message (PBM).
`service|pbm|imack`	SM, PBM and an IM acknowledgement.
`im`	IM.
`imack`	IM acknowledgement.
`im|imack`	IM and an IM acknowledgement.
`ims`	Synchronous instant message (IMS).
`pbm|imack`	PBM and an IM acknowledgement.

All extended notifications can be disabled with the `AT@ZXn` command (see 5.11.5) with one important exception: the `SENDEND` notification

`SENDEND,<destination address>,ims,<timestamp>,<duration>`

is part of basic notifications set and is **always enabled for IMS**.

	Example Extended notifications
`+++`	Switch to Command Mode
`OK`	
`SENDSTART,2,service,155648,110000`	Transmission of a service message started.
`SENDEND,2,service,3517411902,155648`	Transmission of a service message is finished.
`RECVSTART`	Incoming acoustic signal detected.
`RECVEND,3519669614,141312,-40,120`	The incoming acoustic signal was successfully demodulated.

5.7 Status requests

5.7.1 AT?MODE: Command interpreter

AT?MODE requests the command interpreter type (see 3.2.4), enabled for the input-output interface.

The at interpreter supports the Standard command set and two operating modes - the **Data Mode** and the **Command Mode** (see section 4). The net interpreter supports the Networking command set and the Command operating mode.

The device will respond with the value requested:

Value	Description
AT	at interpreter, Standard command set.
NET	net interpreter, Networking command set.

	Example AT?MODE
+++	Switch to Command Mode
OK	
AT?MODE	Request the enabled command interpreter type.
AT	at command interpreter, Standard command set.
AT!MODE	
ERROR WRONG FORMAT	

5.7.2 AT?PID: Protocol ID

`Protocol ID` is a parameter of the command interpreter, enabled for the input-output interface.

`Protocol ID` defines, if global device settings can be edited through an interface (only possible for `Protocol ID 0`), and also serves as an identifier for instant message communication, directing messages from the input-output interface of the transmitter to the receiver's input-output interface with the same `Protocol ID` (read more in section 3.2.5).

Therefore, for instant message communication, the `Protocol ID` of the transmitter's input-output interface must match the `Protocol ID` of the receiver's destination interface.

Use `AT?PID` to view the `Protocol ID` of the interface, used to access the device.

Request	`Protocol ID`	
`AT?PID`	`0`	Global device settings can be edited through the current interface.
	`1..7`	Global device settings cannot be edited through the current interface.

	Example `AT?PID`
`+++`	Switch to Command Mode.
`OK`	
`AT?PID`	View the `Protocol ID`.
`0`	The `Protocol ID` is 0.
`AT!AL4`	Set the `Local Address` (5.9.5) to 4.
`OK`	The command is executed - since `Protocol ID` is 0, global settings can be modified.

5.7.3 AT?PHY: Physical layer status

Use AT?PHY to request if the physical layer of the local device is turned on or off.

The local device will respond with the current physical layer status.

Request		Response
AT?PHY	ON	The physical layer is on
	OFF	The physical layer is off

Example AT?PHY

5.7.4 AT?BV: Battery Voltage

Use AT?BV to request the current battery voltage (in mV).

The device will respond with the current voltage of either its built-in battery or the external power source (depending on its configuration).

View Value	Response	Example	
AT?BV	<Battery voltage>	+++	Switch to Command Mode.
		OK	
		AT?BV	Get the value.
		25110	The voltage is 25110 mV.
		AT!BV	
		ERROR WRONG FORMAT	

5.7.5 AT?S: Acoustic Connection Status request

Use AT?S to get the current acoustic connection status.

The local device will generate a response:

<acoustic link status> <pool status>

<pool status> is a space-separated list of available free transmission buffer space (in bytes). Size of a data channel's transmission buffer can be viewed or modified with a corresponding command - see section 5.11.1.

Free buffer space is counted for every data channel. Entries of the <pool status> correspond to data channels, they are not sorted by channel numbers, but match the fixed positions of the interfaces in the Interface List (see 3.2). Use AT?ZSL to see the Interface List with Interface Strings and corresponding Channel Numbers.

Please note, the buffer might contain compressed data, the values can differ from those based on the input data size.

The <acoustic link status> is described in the table below.

Parameter		Description
Acoustic Link Status	OFFLINE READY	Initial state after switching on/reset.
	OFFLINE CONNECTION FAILED	Acoustic connection failed.
	OFFLINE TERMINATED	Acoustic connection failed or has been terminated.
	OFFLINE ALARM	Internal error has occurred, reset the device.
	INITIATION LISTEN	The device is ready for immediate connection initiated by the remote side.
	INITIATION ESTABLISH	The device attempts to establish an acoustic connection with the remote side.
	INITIATION DISCONNECT	Acoustic connection is being closed.
	ONLINE	Acoustic connection established and active.
	BACKOFF	An acoustic connection between other network nodes is detected. Local device will stay in Backoff state for for a random Backoff Timeout interval.
	NOISE	The device is in Noise State, an acoustic connection is impossible. Read more about **Noise State** in section 5.3.4.
	DEAF	The device is in Deaf State, receiving incoming transmissions is impossible. Read more about **Deaf State** in section 5.3.3.

	Example AT?S
+++AT?S	Request the acoustic connection status.
+++AT?S:29:INITIATION LISTEN 32000 32768	The device is ready for immediate connection initiated by the remote side.

5.8 Settings management

5.8.1 AT&V: Get current settings

Use AT&V to view a list of current device settings.

The local device will respond with a list of settings and their current values, see the table below for details:

Setting	Description
Source Level	The transmission's SPL, dB re 1 uPa.
Source Level Control	Source level control mode.
Gain	Input amplifier gain.
Carrier Waveform ID	Carrier waveform identifier.
Local Address	Network address of the local device.
Cluster Size	Maximum number of packets in a packet train.
Packet Time	Maximum duration of a data packet, ms.
Retry Count	Number of connection establishment retries.
Retry Timeout	Acoustic connection establishment retry timeout, ms.
Wake Up Active Time	Active interval of the acoustic channel monitoring cycle, s.
Wake Up Period	Total duration of the acoustic channel monitoring cycle, s.
Promiscuous Mode	Receive instant messages, addressed to any network device.
Sound Speed	Speed of sound in water, m/s.
IM Retry Count	Instant message delivery retries.
Pool size	Transmission buffer size, b.
Drop Counter	Dropped bytes counter, b.
Overflow Counter	Bytes dropped due to buffer overflow, b.
Hold Timeout	Shutdown after transmission timeout, s.
Idle Timeout	Closing an idle acoustic connection timeout, s.

Please remember, that some settings cannot be changed unless the acoustic link is either in OFFLINE READY or INITIATION LISTEN state. These settings are listed with a [*] mark. Applying a new value is deferred until the acoustic link status becomes OFFLINE READY or INITIATION LISTEN.

Example `AT&V`

`test data test data`	Send burst data.
`+++`	Switch to Command Mode
`OK`	
`AT&V`	View the list of current settings.
`Source Level: 3`	
`Source Level Control: 0`	
`AT&V`	
`Source Level: 3`	
`Source Level Control: 0`	
`Gain: 0`	
`Carrier Waveform ID: 2`	
`Local Address: 11`	
`Cluster Size: 10`	
`Packet Time: 1000`	
`Retry Count: 10`	
`Retry Timeout: 2500`	
`Wake Up Active Time: 1`	
`Wake Up Period: 12`	
`Promiscuous Mode: 1`	
`Sound Speed: 1500`	
`IM Retry Count: 1`	
`Pool Size: 16384 8192`	
`Drop Counter: 0 0`	
`Overflow Counter: 0 0`	
`Hold Timeout: 0`	
`Idle Timeout: 60`	
`AT!L2`	Set `Source Level` to 2.
`[*]OK`	The setting is deferred.
`AT&V`	View the list of current settings.
`[*]Source Level: 2`	The setting is deferred as the device is `ONLINE` while delivering data.
`Source Level Control: 0`	
`Gain: 0`	
`Carrier Waveform ID: 2`	
`Local Address: 11`	
`Cluster Size: 10`	
`. . .`	a few rows are skipped
`Pool Size: 16384 8192`	
`Drop Counter: 0 0`	
`Overflow Counter: 0 0`	
`Hold Timeout: 0`	
`Idle Timeout: 60`	

5.8.2 AT&W: Store settings profile

All current settings of the device - the current settings profile - can be saved to the non-volatile memory of the device. All unsaved settings will be lost after reset or shutdown - they will be restored to the values, saved in the non-volatile memory.

Use AT&W to store the current set of settings into the non-volatile memory of the device. These values will be applied after reset or shutdown.

Please note, that the System Time value will not be saved to a profile. See section 5.9.15 for more information on System Time.

If the set of settings contains deferred values, these deferred new values will be stored to the profile. Values with deferred changes only remain valid until the acoustic link status becomes OFFLINE READY or INITIATION LISTEN and will not be saved.

Please remember, that storing setting values to a profile does not mean applying them immediately. Deferred settings remain deferred.

The device will respond with a success confirmation or an error report (see section 5.1.3).

	Example AT&W
+++	Switch to Command Mode
OK	
AT?L	View the current Source Level
3	Source Level is 3.
AT!L1	Change Source Level to 1.
[*]OK	The setting will be deferred.
AT?L	View the current Source Level.
[*]1	The deferred Source Level setting is 1.
AT&W	Store settings profile.
OK	
AT!L2	Change Source Level to 2.
[*]OK	The setting will be deferred.
AT?L	View the current Source Level.
[*]2	The deferred Source Level setting is 2.
ATZ	Restart the device.
OK	
AT&V	View the setting list.
Source Level: 1	The Source Level is 1. This setting was stored to profile and applies after reset
Source Level Control: 0	
Gain: 0	
. . .	a few rows are skipped
Overflow Counter: 0 0	
Hold Timeout: 0	
Idle Timeout: 60	

5.8.3 AT&F: Restore factory settings

Use AT&F to restore the device's settings to factory defaults and reset it.

	Example AT&F
+++	Switch to Command Mode
OK	
AT?L	View the current Source Level
3	Source Level is 3.
AT!L0	Change Source Level to 1.
[*]	The setting will be deferred.
AT&V	View the setting list.
[*]Source Level: 0	The Source Level is 0. This setting was stored to profile and applies after reset
Source Level Control: 0	
Gain: 0	
. . .	Rows omitted
Idle Timeout: 60	
AT&F	Reset to factory settings profile
+++AT:5:PHYON	Device switched to Data mode after reset, BES: the physical layer is on.
+++ATC	Switch to Command Mode.
OK	
AT&V	View the settings list.
Source Level: 3	The Source Level is 3 - the setting value was restored to factory default.
. . .	Rows omitted
Idle Timeout: 60	

5.9 Settings and Requests

This section describes viewing and changing global device settings with AT commands.

Use the commands listed below to view or change individual settings. Please note, that some settings cannot be changed when an acoustic connection is active. These changes apply after a communication link is closed (see the following chapters).

After modifying some settings, you can save them to a settings profile. A saved profile of device settings does not change after reset or shutdown. Any changes you made before reset or shutdown, but did not save to a profile, are lost. After shutdown or reset, the unsaved settings are automatically restored to those saved in a settings profile.

New values are valid until the device is reset or turned off. To use a set of settings after reset, store it to non-volatile memory with `AT&W` (see 5.8.2).

NOTE: Some settings cannot be changed unless the acoustic link is either in `OFFLINE READY` or `INITIATION LISTEN` state. These settings are displayed with a `[*]` prefix. Applying a new value is deferred until the acoustic link status becomes `OFFLINE READY` or `INITIATION LISTEN`.

5.9.1 `AT?L and AT!Ln`: Source Level

`Source Level` defines the sound pressure level (SPL) in transmission mode.

View Setting	Change Setting	Options		Description
`AT?L`	`AT!Ln`	`n`	0	Maximum SPL.
			1	Maximum – 6 dB.
			2	Maximum – 12 dB.
			3	Maximum - 20 dB.

Refer to the Factory Certificate of the device for the maximum SPL value. The maximum SPL depends on the type of the S2C device, see the example below:

	`Source Level`	SPL, dB re 1 uPa
S2CR 48/78 Underwater Acoustic Modem	0	184 The Factory Certificate value
	1	178
	2	172
	3	164

A deferred `Source Level` setting is automatically applied before a burst data or instant message transmission.

Example AT?L and AT!Ln

test data test data	Send burst data.
+++	Switch to Command Mode
OK	
AT?L	Request the current Source Level.
2	The current Source Level is 2.
AT!L3	Set Source Level to 3
[*]OK	The setting is deferred.
AT?L	Get current Source Level.
3	The current Source Level is 3 - the setting was applied once the device has left ONLINE state.
AT!L4	
ERROR OUT OF RANGE	

5.9.2 AT?LC and AT!LCn: Source Level Control

Source Level Control defines if the Source Level value of the local device can be changed remotely over an acoustic link.

If Source Level Control value is 0, the local device will transmit data with an SPL defined by the Source Level value. Source Level in this case can be changed only with a specific command (see 5.9.1).

If Source Level Control is set to 1, the local device will adopt the Source Level value of a remote device during connection establishment, when the remote device has burst data to send to the local device. In this case, Source Level value of the local device will automatically change to match the Source Level of the remote device.

If Source Level Control is set to 1, new Source Level setting, adopted from the remote device, will be automatically stored to the local non-volatile memory (to the settings profile, see 5.8.2).

If extended notifications are turned on for the current data channel (see 5.11.5), a

SRCLEVEL,<Source Level>

string will be generated once a new Source Level value was adopted from the remote device during connection establishment.

You can turn extended notifications off with the AT@ZXn command, see more in section 5.11.5.

We recommend to check the Source Level Control setting of your device prior to its deployment, making sure the device will behave as desired.

View Setting	Change Setting	Options		Description
AT?LC	AT!LCn	n	0	The local Source Level setting cannot be changed by a remote device.
			1	The local device's Source Level setting can be changed by a remote device. The local device will adopt the remote device's Source Level setting during connection establishment when the remote device sends burst data.

Example AT?LC and AT!LCn

+++	Switch to Command Mode
OK	
AT?LC	Get the current Source Level Control.
0	The current Source Level Control is 0.
AT?L	Get the current Source Level.
3	The current Source Level is 3.
AT!LC1	Set Source Level Control to 1.
OK	
AT?LC	
1	
ATO	Switch to Data Mode.
+++AT?L	Get the current Source Level
+++AT?L:1:2	The local device adopted the Source Level value of the remote device during data transmission.

5.9.3 AT?G and AT!Gn: Gain

Use the Gain setting to adjust the input amplifier gain. The low gain setting is recommended for short-distance communication or for short-distance testing of the device.

View Setting	Change Setting	Options		Description
AT?G	AT!Gn	n	0	Normal gain, corresponds to high sensitivity.
			1	Low gain, corresponds to -20dB reduced sensitivity. Recommended for short distances or testing purposes.

A deferred Gain setting is automatically applied before a burst data or instant message transmission.

Example AT?G and AT!Gn

test data test data	Send burst data.
+++	Switch to Command Mode
OK	
AT?G	Get the current Gain setting.
0	
AT!G1	Set Gain to 1.
[*]OK	The setting is deferred.
AT?G	The new Gain setting is now applied.
1	
AT!G2	
ERROR OUT OF RANGE	
AT?G1	
ERROR WRONG FORMAT	

5.9.4 AT?C and AT!Cn: Carrier Waveform ID

Each device has a Carrier Waveform ID - an identifier used for acoustic connection establishment.

It defines the unique properties of the acoustic signal's waveform.

An acoustic link can only be established between devices with specific Carrier Waveform ID combinations. These are:

- 0-1
- 2-2

We recommend using the 0 - 1 combination for communications between 2 devices and the 2 - 2 combination for networking.

View Setting	Change Setting	Options	Range
AT?C	AT!Cn	n	0..3

A deferred Carrier Waveform ID setting is automatically applied before a burst data or instant message transmission.

Example AT?C and AT!Cn

test data test data	Send burst data.
+++	Switch to Command Mode
OK	
AT?C	Get the current <Carrier Waveform ID>.
2	
AT!C3	Set the <Carrier Waveform ID> to 3.
[*]OK	The setting is deferred.
AT?C	The new <Carrier Waveform ID> setting is now applied.
3	
AT!C4	
ERROR OUT OF RANGE	
AT?C2	
ERROR WRONG FORMAT	

5.9.5 AT?AL and AT!ALn: Local Address

`Local Address` is the address of the local device.

The highest address the device can take up is defined by the corresponding `Highest Address` parameter. Request its value with `AT?AM`, see section 5.9.7.

View Setting	Change Setting	Options	Range
AT?AL	AT!ALn	n	1..Highest Address

Example AT?AL and AT!ALn

test data test data	Send burst data.
+++	Switch to Command Mode
OK	
AT?AL	Get the current `Local Address`.
12	
AT!AL2	Set the `Local Address` to 2.
[*]OK	The setting is deferred.
AT?S	Get the `Acoustic Connection Status`
ONLINE 19254	
AT?S	
INITIATION LISTEN 20000	
AT?AL	
2	The new `Local Address` setting is applied.
AT?AL3	
ERROR WRONG FORMAT	
AT!AL16	
ERROR OUT OF RANGE	

5.9.6 AT?AR and AT!ARn: Remote Address

Remote Address is the address of a remote device that the local device communicates with. This setting defines the destination (remote address) of burst data transmissions - in Data Mode, all data the local device receives on the host input-output interface will be transmitted to a device with the Remote Address. Changing the Remote address setting changes the destination of burst data transmissions.

The highest possible Remote Address value is defined by the Highest Address parameter that limits the highest possible address in a network. Request its value with AT?AM, see section 5.9.7 for more information on available addresses.

- If Remote Address is a non-zero value, the local device will initiate and accept connection requests, and establish an acoustic link with only one particular device. Burst data will be transmitted and received exclusively to/from a device with Remote Address.
- If Remote Address is set to 0, the local device will accept a connection establishment request from any device to receive data from it, but is itself unable to initiate a connection for data transfer to any device in particular, as transmission destination is in this case undefined.

  The local device will receive incoming data from any remote device, and automatically adopt that device's address as a new Remote Address value. After a new Remote Address was adopted from a remote device, i.e. the Remote Address became a non-zero value, the local device will communicate to that device exclusively.

  If while Remote Address is 0, data arrives at the input-output interface, it will not be transmitted, as its destination is unspecified. This data will be dropped, and a corresponding notification will be generated (as mentioned in 5.4.1):

  DROPCNT,<dropped bytes count>

If extended notifications are turned on for the current data channel (see 5.11.5) and the local device had received data from a remote device, applying its address as the new Remote Address value, it will generate an notification about the new Remote address:

RADDR,<Remote Address>

You can turn extended notifications off with the AT@ZXn command, see more in section 5.11.5.

Use AT?AR to view the current Remote Address value, and AT!AR to change it:

View Setting	Change Setting	Options	Range
AT?AR	AT!ARn	n	0..max address

	Example AT?AR and AT!ARn
+++ATC	Switch to Command Mode
AT!AR12	Set Remote Address to 12.
OK	A new value is applied.
AT?AR3	
ERROR WRONG FORMAT	
AT!AR16	
ERROR OUT OF RANGE	

5.9.7 AT?AM and AT!AMn: Highest Address

The Highest address value defines the address range and limits the possible number of devices in a network. It represents the highest address available for a device, therefore, a device's address can only take up values that range from 1 up to Highest Address (inclusive).

Highest Address values must match for all communicating devices.

See table below for the range of possible Highest Address values.

View Setting	Change Setting	Options	Possible values
AT?AM	AT!AMn	n	2, 6, 14, 30, 62, 126, 254

	Example AT?AM and AT!AMn
+++	Switch to Command Mode
OK	
AT?AM	Get the max address value.
14	The max address is 14.
AT!AM2	
OK	
AT!AM254	
OK	
AT!AM10	
ERROR OUT OF RANGE	
AT!AM	
ERROR OUT OF RANGE	
AT?AM14	
ERROR WRONG FORMAT	

5.9.8 AT?ZC and AT!ZCn: Cluster Size

To transmit data, the device formats it into packets. They are then transmitted in packet trains (clusters).

Use `Cluster Size` to define the number of packets in a train.

The system throughput is higher when packet trains are long (large `Cluster Size`). On the other hand, longer packet trains slow down the algorithms that adapt the bitrate to the dynamics of the acoustic channel. A slow adaptation can reduce the net bitrate. It is recommended to set the `Cluster Size` to a lower value (less than 10) for communications between moving objects. In stationary cases the `Cluster Size` may be essentially higher (up to 32).

View Setting	Change Setting	Options	Range
AT?ZC	AT!ZCn	n	1..255

Example AT?ZC and AT!ZCn

test data test data	Send burst data.
+++	Switch to Command Mode
OK	
AT?ZC	Get the current `Cluster Size`.
10	
AT!ZC15	Set the `Cluster Size` to 15.
[*]OK	The setting is deferred.
AT?ZC	The new `Cluster Size` setting is applied.
15	
AT?ZC20	
ERROR WRONG FORMAT	
AT!ZC256	
ERROR OUT OF RANGE	

5.9.9 AT?ZP and AT!ZPn: Packet Time

For every packet train, the device automatically calculates and applies the optimal packet size (and thus packet duration) based on the estimated parameters of the acoustic channel.

`Packet Time` defines the maximum duration of a data packet.

Use `AT!ZPn` to set the `Packet Time` (in ms).

Shorter `Packet Time` is recommended for challenging hydroacoustic channels with highly dynamic parameters.

Please note: `Packet Time` values must be equal for all communicating devices, establishing an acoustic connection is otherwise impossible.

View Setting	Change Setting	Options	Range
AT?ZP	AT!ZPn	n	50..1000 (ms)

Example `AT?ZP` and `AT!ZPn`

`test data test data`	Send burst data.
`+++`	Switch to Command Mode
`OK`	
`AT?ZP`	Get the current `Packet Time`.
`1000`	
`AT!ZP900`	Set the `Packet Time` to 900 ms.
`[*]OK`	The setting is deferred.
`AT?ZP`	The new `Packet Time` setting is applied.
`900`	
`AT?ZP80`	
`ERROR WRONG FORMAT`	
`AT!ZP45`	
`ERROR OUT OF RANGE`	
`AT!ZP1200`	
`ERROR OUT OF RANGE`	

5.9.10 AT?RC and AT!RCn: Retry Count

`Retry Count` is a number of connection establishment retries.

This setting defines, how many times will the device retry to establish an acoustic connection.

`Retry Count` is decremented if the device retries establishing a new acoustic connection or tries to re-establish a broken acoustic link.

After successful connection establishment `Retry Count` is reset to the initial value.

View Setting	Change Setting	Options	Range
AT?RC	AT!RCn	n	0..255

Example AT?RC and AT!RCn

test data test data	Send burst data.
+++	Switch to Command Mode
OK	
AT?RC	Get the current `Retry Count`.
10	
AT!RC11	Set the `Retry Count` to 11.
[*]OK	The setting is deferred.
AT?RC	The new `Retry Count` setting is applied.
11	
AT?RC100	
ERROR WRONG FORMAT	
AT!RC257	
ERROR OUT OF RANGE	

5.9.11 AT?RT and AT!RTn: Retry Timeout

`Retry Timeout` is the time interval (in ms) that the device waits for a response to its acoustic connection establishment request.

If the remote device does not respond during the `Retry Timeout`, the local device reattempts to establish the acoustic connection. The number of retries is defined by the `Retry Count` setting, see 5.9.10 for more details.

The `Retry Timeout` value should exceed the round-trip time that corresponds to the device's maximum operation range! For example, if the operation range of the device is 3000 m, the round-trip time is 4 s (assuming the sound speed in water is 1500 m/s), so the `Retry Timeout` should exceed 4000 ms.

View Setting	Change Setting	Options	Range
`AT?RT`	`AT!RTn`	`n`	500..12000 (ms)

Example `AT?RT` and `AT!RTn`

`test data test data`	Send burst data.
`+++`	Switch to Command Mode
`OK`	
`AT?RT`	Get the current `Retry Timeout`.
`2500`	
`AT!RT1000`	Set the `Retry Timeout` to 1000 ms.
`[*]OK`	The setting is deferred.
`AT?RT`	The new `Retry Timeout` setting is applied.
`1000`	
`AT?RT2000`	
`ERROR WRONG FORMAT`	
`AT!RT12010`	
`ERROR OUT OF RANGE`	
`AT!RT450`	
`ERROR OUT OF RANGE`	

5.9.12 AT?KO and AT!KOn: Keep Online Count

`Keep Online Count` defines the number of service message exchanges that keep a connection to the remote device online after a completed data delivery. After devices exchange service messages and delivery acknowledgements `Keep Online Count` times, they close the acoustic connection.

If `Keep Online Count` is set to `0`, the devices will keep exchanging service messages and will not close the acoustic connection without an explicit command (use `ATH` 5.3.7 or `ATZ` 5.3.8 to close or terminate the acoustic connection).

View Setting	Change Setting	Options		Description
`AT?KO`	`AT!KOn`	`n`	0	The acoustic connection will remain online.
			1..255	Number of service message exchanges keeping the connection online.

Example `AT?KO` and `AT!KOn`

`+++`	Switch to Command Mode
`OK`	
`AT?KO`	View the current `Keep Online` value.
`2`	The current `Keep Online` value is 2.
`AT!KOO`	Set the `Keep Online` to 0.
`OK`	
`AT?KO`	View the current `Keep Online` value.
`0`	The current `Keep Online` value is 0. The acoustic connection will remain online.

5.9.13 AT?ZI and AT!ZIn: Idle Timeout

`Idle Timeout` defines the timeout before closing an idle acoustic connection.

The connection can become idle due to unfavourable conditions of the acoustic channel. If no data flow was re-established during the `Idle Timeout`, the local device will close the connection after `Idle Timeout` expires.

Use `AT!ZIn` to define the `Idle Timeout` (in seconds).

If the `Idle Timeout` is set to `0`, the function is disabled. The device will not close an idle acoustic connection in the absence of a data flow.

View Setting	Change Setting	Options	Range
`AT?ZI`	`AT!ZIn`	`n`	0..3600 (s)

Example `AT?ZI` and `AT!ZIn`

`test data test data`	Send burst data.
`+++`	Switch to Command Mode
`OK`	
`AT?ZI`	Get the current `Idle Timeout`.
`60`	
`AT!ZI75`	Set the `Idle Timeout` to 75.
`OK`	
`AT?ZI`	The new `Idle Timeout` setting is applied.
`75`	
`AT?ZI500`	
`ERROR WRONG FORMAT`	

5.9.14 `AT?ZS, AT?ZSL and AT!ZSn`: Channel Number

Each of the device's input-output interfaces is assigned to a particular data channel - a virtual channel for burst data exchange. Data from the input-output interface of the transmitter is directed to the input-output interface of the receiver, that has the matching `Channel number`.

`AT?ZS` request returns the `Channel number` of the channel, associated with the interface that is currently in use to access the device.

`AT?ZSL` requests the `Channel List` that lists `Channel number`s and the `Interface String`s of the input-output interfaces, mapped to those channels (see 3.2 for more information).

Use `AT!ZS` to change the `Channel Number`, associated with the interface currently in use to access the device. The interface will be mapped to another data channel, so burst data will be directed to another input-output interface of the receiver.

If the new `Channel number` value was already assigned to another input-output interface of the local device, the local device's interfaces will swap data channels. For example, if the current interface was mapped to `Channel number` 1, and the second interface of the local device - to `Channel number` 3, when you assign the current interface to `Channel number` 3, the second interface of the local device will be assigned to `Channel number` 1.

Please note, that transferring data between different data channels is impossible!

View Setting	Change Setting	Options	Range
`AT?ZS` `AT?ZSL`	`AT!ZSn`	`n`	0..7

Example AT?ZS, AT?ZSL and AT!ZSn

+++	Switch to Command Mode
OK	
AT?ZS	Get the Channel Number of the interface in use.
0	The interface is associated with Channel Number 0.
AT?ZSL	Get the Interface List.
0 tcp://0.0.0.0:9210:lr:n|at -l "\n"	
1 tcp://0.0.0.0:9220:lr:n	
AT!ZS1	Set the current interface's Channel Number to 1.
OK	
AT?ZS	The current interface is now associated with
1	Channel Number 1.
AT?ZSL	Get the Interface List.
1 tcp://0.0.0.0:9210:lr:n|at -l "\n"	Channel Number values have swapped.
0 tcp://0.0.0.0:9220:lr:n	
AT!ZS5	Set the current interface's Channel Number to 5.
OK	
AT?ZS	The current interface is now associated with
5	Channel Number 5.
AT?ZSL	Get the Interface String.
5 tcp://0.0.0.0:9210:lr:n|at -l "\n"	
0 tcp://0.0.0.0:9220:lr:n	
AT!ZS8	
ERROR OUT OF RANGE	
AT?ZS5	
ERROR WRONG FORMAT	

5.9.15 AT?UT and AT!UTn: System Time

System Time is the internal time of the device. This parameter defines the data link layer time. A default System Time value is the number of seconds elapsed since the device has been powered on.

Use AT?UT to view the current System Time (in seconds, floating point).

Use AT!UTn to set another System Time value.

Please note, that System Time values cannot be stored to a settings profile with AT&W (Store Settings Profile) command.

A reset changes the System Time back to its default value - the number of seconds elapsed since the device has been powered on.

You can use the Network Time Protocol (NTP)[5]to synchronize the System Time with an external NTP server. With NTP synchronization, the System Time will correspond to Coordinated Universal Time (UTC).

Please note, that NTP synchronization is only available over the Ethernet interface.

The NTP synchronization parameters can be configured with the S2C Acoustic Modem Configuration Utility. Read more about using the S2C Acoustic Modem Configuration Utility in section A.1.

Important notice: if the NTP server is unreachable, once the device is turned on, the System Time will correspond to its default setting - the number of seconds elapsed since the device has been turned on.

View Setting	Change Setting	Options	Range
AT?UT	AT!UTn	n	floating point

Example AT?UT and AT!UTn

+++	Switch to Command Mode
OK	
AT?UT	Get the current System Time.
6993.456	
AT!UT1	Set the System Time to 1.
OK	
AT?UT	Get the System Time.
3,34678	The current System Time. 2 seconds have passed since it was set to 1.
AT&W	Save setting to profile.
OK	
ATZ	Reset the device.
OK	
AT?UT	Get System Time.
7020.345	The System Time was not saved to profile.
AT?UT3	
ERROR WRONG FORMAT	

[5]Read more about the Network Time Protocol online.

5.9.16 AT?CLOCK: System Clock

`System Clock` is a 32 bit microseconds counter.

`System Clock` is reset when the physical layer hardware of your device is turned off.

Use `AT?CLOCK` to view the `System Clock` value.

View Value	Range
`AT?CLOCK`	$0..2^{32}$ (microseconds)

Example `AT?CLOCK`

`+++ATC`	Switch to Command Mode
`OK`	
`AT?CLOCK`	View the `System Clock` timestamp.
`419888076`	The `System Clock` timestamp.

5.9.17 AT?CA and AT!CAn: Sound Speed

`Sound Speed` defines the sound velocity value used to evaluate the distance to a remote device.

Distance estimation is the basis for calculating the position of a remote device (see section 5.13).

The device's default `Sound Speed` value is 1500 m/s.

The actual speed of sound may take up a wide range of values that depend on water temperature, salinity and pressure. Use `AT?CA` to request or `AT!CAn` to set another `Sound Speed` value (in m/s, integer).

View Setting	Change Setting	Options	Range
`AT?CA`	`AT!CAn`	`n`	1300..1700 (m/s)

Example `AT?CA` and `AT!CAn`

`test data test data`	Send burst data.
`+++`	Switch to Command Mode
`OK`	
`AT?CA`	Get the current `Sound Speed`.
`1500`	
`AT!CA1400`	Set the `Sound Speed` to 1400 m/s.
`[*]OK`	The setting is deferred.
`AT?CA`	The new setting is applied.
`1400`	
`AT?CA1400`	
`ERROR WRONG FORMAT`	
`AT!CA1800`	
`ERROR OUT OF RANGE`	
`AT!CA1299`	
`ERROR OUT OF RANGE`	

5.9.18 AT?RI and AT!RIn: IM Retry Count

`IM Retry count` is the number of instant message delivery retries.

`IM Retry count` value defines, how many times will the device retry to deliver an instant message after a failure.

NOTE: set `IM Retry count` 255 for an unlimited number of instant message delivery retries. The device will then reattempt transmitting the instant message until it is delivered to the destination address.

View Setting	Change Setting	Options		Description
AT?RI	AT!RIn	n	0	The device will not reattempt delivering the IM.
			1..255	Number of IM delivery retries.

Example AT?RI and AT!RIn

+++	Switch to Command Mode
OK	
AT?RI	Get the current `IM Retry count`.
200	
AT!RI1	Set the `IM Retry count` to 1.
OK	
AT?RI	
1	
AT?RI1	
ERROR WRONG FORMAT	
AT!RI256	
ERROR OUT OF RANGE	

5.9.19 AT?RP and AT!RPn: Promiscuous Mode

Use Promiscuous Mode to receive overheard instant messages addressed to other devices.

In Promiscuous Mode the local device will receive instant messages, addressed to other devices in the network, including messages sent in Unicast mode.

A RECVIM message (see section 5.5.6) will be generated upon an instant message reception.

View Setting	Change Setting	Options		Description
AT?RP	AT!RPn	n	0	The local device will only receive instant messages addressed to it.
			1	The local device will receive instant messages, addressed to any device in the network, not just the ones addressed to the local device.

	Example AT?RP and AT!RPn
+++	Switch to Command Mode
OK	
AT?RP	Check Promiscuous Mode.
1	The Promiscuous Mode is enabled.
AT?AL	Check the Local Address.
2	The Local Address is 2.
RECVSTART	Extended notification (see 5.6): incoming acoustic signal detected.
RECVEND,500410194,155648,-40,120	Extended notification: incoming acoustic signal successfully demodulated.
RECVIM,1,1,3,noack,155648,-40,120,0.1000,-	IM received from address 1, addressed to 3. The local device overheard the IM, addressed to another device.
AT!RP0	Disable Promiscuous Mode.
OK	
RECVSTART	Extended notification: incoming acoustic signal detected.
RECVEND,518718101,155648,-40,120	Extended notification: incoming acoustic signal successfully demodulated. Please note, that here the device did detect an IM transmission, but did not output a notification as the Promiscuous Mode is disabled.

5.10 Wake Up Module: settings and requests

This section describes settings and requests, specific to operating devices with a Wake Up Module installed.

The Wake Up Module helps optimizing power consumption for short– or long–term deployments by checking for incoming acoustic signals or incoming data on the serial input-output interface and turning the rest of the device on only when such a signal is detected. Once the device completes receiving or transmitting data, it switches itself off.

The Wake Up Module always reacts on incoming data on the serial input-output interface. To save energy, the Wake Up Module monitors the acoustic channel in an on/off toggle cycle - instead of permanent monitoring, it cycles between active monitoring and idle phases. The Wake Up Module detects incoming acoustic signals only when it is active, signals that arrive when the Wake Up Module is idle are not received.

Use commands, described below, to adjust the acoustic channel monitoring cycle.

5.10.1 `AT?DA and AT!DAn`: Wake Up Active Time

This command has effect only on devices with the Wake Up Module installed.

`Wake Up Active Time` is the active interval of acoustic channel monitoring.

This setting defines the duration (in seconds) of an active interval, when the Wake Up Module monitors the acoustic channel for incoming signals.

NOTE: Duration of the active interval must be less than the total duration of the Wake Up cycle (the `Wake Up Period`, see section 5.10.2).

View Setting	Change Setting	Options	Range
`AT?DA`	`AT!DAn`	`n`	0..3600 (s)

A deferred `Wake Up Active Time` setting is automatically applied before a burst data or instant message transmission.

	Example `AT?DA` and `AT!DAn`
`+++`	Switch to Command Mode
`OK`	
`AT?S`	Requesting the acoustic connection status
`ONLINE 16384`	
`AT?DA`	Get the current `Wake Up Active Time`.
`10`	
`AT!DA15`	Set the `Wake Up Active Time` to 15 s.
`[*]OK`	The setting is deferred.
`ATH1`	Terminate the acoustic connection.
`AT?DA`	The new `Wake Up Active Time` setting is applied.
`15`	

5.10.2 AT?DT and AT!DTn: Wake Up Period

This command has effect only on devices with the Wake Up Module installed.

`Wake Up Period` is the period of the acoustic channel monitoring cycle.

The `Wake Up Period` value defines the total duration of an acoustic channel monitoring cycle that comprises an active interval and an idle interval.

Use this command to set the `Wake Up Period` (in seconds).

Use `AT?DA` and `AT!DAn` to view or change the duration of an active monitoring interval (see section 5.10.1).

View Setting	Change Setting	Options	Range
`AT?DT`	`AT!DTn`	`n`	0..3600 (s)

A deferred `Wake Up Period` setting is automatically applied before a burst data or instant message transmission.

Example `AT?DT` and `AT!DTn`

`+++`	Switch to Command Mode
`OK`	
`AT?S`	Requesting the acoustic connection status
`ONLINE 16384`	
`AT?DT`	Get the current `Wake Up Period`.
`9`	
`AT!DT10`	Set the `Wake Up Period` to 10 s.
`[*]OK`	The setting is deferred.
`ATH1`	Terminate the acoustic connection.
`AT?DT`	The new `Wake Up Period` setting is applied.
`10`	

5.10.3 AT?ZH and AT!ZHn: Hold Timeout

This command has effect only on devices with the Wake Up Module installed.

Having completed data transmissions, the Wake Up Module–equipped device will stay powered for a `Hold Timeout` interval.

A device turns itself off once the `Hold Timeout` interval has expired.

Use `AT!ZHn` to define the duration (in seconds) of the `Hold Timeout` interval.

View Setting	Change Setting	Options	Range
`AT?ZH`	`AT!ZHn`	`n`	0..3600 (s)

Example `AT?ZH` and `AT!ZHn`

`test data test data`	Send burst data.
`+++`	Switch to Command Mode
`OK`	
`AT?ZH`	Get the current `Hold Timeout`.
`60`	
`AT!ZH10`	Set the `Hold Timeout` to 10 s.
`[*]OK`	The setting is deferred.
`AT?ZH`	The new `Hold Timeout` setting is applied.
`10`	

5.10.4 `AT?DW and AT!DWn`: Awake Remote Mode

The **Awake Remote Mode** is a mode of connection establishment, when the local device is used to turn on a deployed device, equipped with a power-saving Wake Up Module.

The Wake Up Module turns on the deployed device only if it detects incoming acoustic signals. To save energy, it does not permanently monitor the acoustic channel, instead, it cycles between active monitoring and idle phases.

The local device in **Awake Remote Mode** sends a sequence of pulses to hit the active interval of the acoustic channel monitoring cycle and have the Wake Up Module turn on the deployed device.

To make sure the intervals between pulses are not longer than the active monitoring phase, define the duration of the active phase in the `Remote Active Time` parameter, as described in section 5.10.5.

Use `AT?DW` to check whether the **Awake Remote Mode** is on and `AT!DWn` to enable or disable it.

View Setting	Change Setting	Options		Description
`AT?DW`	`AT!DWn`	`n`	0	The **Awake Remote** mode is off.
			1	The **Awake Remote** mode is on.

5.10.5 `AT?DR` and `AT!DRn`: Remote Active Time

If using **Awake Remote Mode** (see section 5.10.4) to turn on a remote device, you must set the proper `Remote Active Time` value - the duration of the remote device's active acoustic channel monitoring interval.

Use `AT!DRn` to set the `Remote Active Time`.

View Setting	Change Setting	Options	Range
`AT?DR`	`AT!DRn`	`n`	0..3600 (s)

5.11 Data channel: settings and requests

The following commands display or modify settings, specific to the selected data channel (see section 2.1.3 for more information on data channels).

To change these settings for another data channel of your device, you must assign the current input-output interface to that channel with the `AT!ZSn` command, as described in section 5.9.14.

5.11.1 `AT?ZL and AT@ZLn`: Pool Size

`Pool Size` is the transmission buffer size (in bytes) of the selected data channel.

Use `AT?ZL` to request the current buffer size, and `AT@ZLn` to change the buffer size for the selected data channel.

Before changing the buffer size, you must empty the buffer! Use `ATZ4` to clear the transmission buffer by dropping unsent data and instant messages (see 5.3.8 for details).

View Setting	Change Setting	Options	Range	
`AT?ZL`	`AT@ZLn`	`n`	8096 .. 2097152 (B)	Pool size per data channel

5.11.2 AT?ZD and AT@ZD: Drop counter

The device drops unsent data from the transmission buffer:

- if it received a corresponding command (see 5.3.8);
- once the Idle Timeout has expired (see 5.9.13);
- if data transmission to a `Remote Address` 0 was attempted

When data is dropped after an attempted transmission to `Remote Address` 0, a corresponding notification is generated:

`DROPCNT,<dropped bytes count>`

Dropped data is counted separately for every data channel (in bytes).

Use `AT?ZD` to view the current dropped bytes count and `AT@ZD` to reset the dropped bytes counter for the selected data channel.

5.11.3 `AT?ZO` and `AT@ZO`: Overflow Counter

The size of the transmission buffer is limited.

As the acoustic channel is usually slower than the input-output interface, a buffer overflow can occur if data from the input interface is filling the transmission buffer faster, than it can be transferred over the acoustic channel. If the buffer is full, all incoming bytes are lost.

Data, lost due to buffer overflow, is counted for every data channel (in bytes).

Use `AT?ZO` to request the current lost bytes count for the selected data channel and `AT@ZO` to reset the `Overflow Counter` for the selected data channel.

Buffer overflow can be avoided by implementing flow control. You can monitor the remaining free buffer space with the Acoustic Connection Status request `AT?S` (see section 5.7.5 for details).

5.11.4 AT?ZU and AT@ZUn: Positioning Data Output

This command has effect only for USBL-series devices.

The Positioning Data Output parameter defines if the USBL device should automatically output target positions to the data interface during the mission.

If Positioning Data Output is on, the device automatically generates USBLLONG (see 5.13.1) or USBLANGLES (see 5.13.2) strings.

View Setting	Change Setting	Options		Description
AT?ZU	AT@ZUn	n	0	Off: The device will not generate positioning strings.
			1	On: The device will generate positioning strings.

	Example AT?ZU and AT@ZUn
+++	Switch to Command Mode
OK	
AT?ZU	Check Positioning Data Output.
0	Positioning data output is disabled.
AT*SENDIM,1,2,ack,-	Send IM with delivery acknowledgement to address 2.
OK	
DELIVEREDIM,2	The IM was delivered.
AT@ZU1	Enable positioning data output.
OK	
AT*SENDIM,1,2,ack,-	Send IM with delivery acknowledgement to address 2.
OK	
DELIVEREDIM,2	The IM was delivered.
USBLLONG,1377811852.499612,1377811852.365264,2,	The USBLLONG string output:
1099.5699,-1000.1375,2.3383,1000.1375,-1099.5699,	position of the target -
-2.3382,3.1416,-0.0000,-1.5708,990922,-40,120,0.0001	the device with Remote Address 2.

5.11.5 AT?ZX and AT@ZXn: Extended Notifications Control

The Extended Notifications Control allows to enable or disable extended notifications.

Extended notifications provide additional information about the status of acoustic transmissions, as well as reports on automatic setting adjustments.

See the table below for the full list of extended notifications, that can be turned on or off for the selected data channel:

Notification	Description
BITRATE,<direction>,<bitrate>	Generated once the bitrate changed in remote-to-local or local-to-remote direction. See 5.12.1 and 5.12.2 for details.
SRCLEVEL,<Source Level>	Generated once a new Source Level value was adopted from the remote device. See section 5.9.2 for details.
PHYON	Physical layer turned on. See section 5.3.8 for details.
PHYOFF	Physical layer turned off. See section 5.3.8 for details.
RECVSTART	Incoming acoustic signal detected. See section 5.6 for details.
RECVFAILED,<velocity>, <rssi>,<integrity>	The device has failed to demodulate the incoming signal.
RECVEND,<timestamp>, <duration>,<rssi>,<integrity>	The incoming acoustic signal was successfully demodulated. See section 5.6 for details.
SENDSTART,<destination address>, <type>,<duration>,<delay>	Transmission of a <type> started. See section 5.6 for details.
SENDEND,<destination address>, <type>,<timestamp>,<duration>	Transmission of a <type> completed.
RADDR,<remote address>	Remote Address adopted from the remote device. See section 5.9.6 for details.

If Extended Notifications Control is set to 1, the device will output all extended notifications.

If the Extended Notifications Control is set to 0, extended notifications will be disabled, with one important exception: the SENDEND notification for IMS is part of basic notifications set and will stay enabled.

View Setting	Change Setting	Options		Description
AT?ZX	AT@ZXn	n	0	Off: the extended notifications are disabled.
			1	On: the extended notifications are enabled.

	Example AT?ZX and AT@ZXn
+++	Switch to Command Mode
OK	
AT?ZX	Get the current Extended Notifications Control.
0	Extended notifications are disabled.
AT*SENDIM,1,2,noack,-	Send IM to address 2 without delivery notification.
OK	
AT@ZX1	Enable extended notifications.
OK	
AT*SENDIM,1,2,noack,-	Send IM to address 2 without delivery notification.
OK	
SENDSTART,2,im,155648,0	Extended notification: transmission of the IM started.
SENDEND,2,im,949154383,155648	Extended notification: transmission of the IM finished.

5.12 Acoustic channel: parameter requests

This section describes tracking communication parameters with AT commands.

Most communication parameters are measured upon incoming signal reception.

If no connection is established at the moment, the last measured values will be returned.

Initial parameter values after turning on or resetting the device are 0 as no prior data transfers occurred.

5.12.1 AT?BL: Local–to–remote bitrate

Communicating devices automatically adjust the bitrate during data transmissions to maintain the highest possible throughput values.

AT?BL requests the last transmission's raw bitrate[6]value in the local-to-remote direction.

AT?BL returns the total number of transferred bits per second, including both the useful data and the protocol overhead.

The local device will return the requested value:

View Value	Notification	Example	
AT?BL	<local-to-remote bitrate>	+++	Switch to Command Mode.
		OK	
		AT?BL	Get the last measured value.
		8461	
		AT!BL	
		ERROR WRONG FORMAT	

If extended notifications are turned on for the selected data channel (see 5.11.5), a

BITRATE,<direction>,<bitrate>

[6]http://en.wikipedia.org/wiki/Bit_rate

string will be generated once the transmission bitrate changes in either direction. Here <direction> is either local for local–to–remote or remote for remote–to–local bitrate.

You can turn extended notifications off with the AT@ZXn command, see more in section 5.11.5.

5.12.2 AT?BR: Remote–to–local bitrate

Communicating devices automatically adjust the bitrate during data transmissions to maintain the highest possible throughput values.

AT?BR requests the last transmission's raw bitrate value in the remote-to-local direction.

AT?BR returns total number of transferred bits per second, including both the useful data and the protocol overhead.

The local device will return the requested value:

View Value	Notification	Example	
AT?BR	<remote-to-local bitrate>	+++ OK AT?BR 8463 AT!BR ERROR WRONG FORMAT	Switch to Command Mode. Get the last measured value.

If extended notifications are turned on for the current data channel (see 5.11.5), a

BITRATE,<direction>,<bitrate>

string will be generated once the transmission bitrate changes in either direction. Here <direction> is either local for local–to–remote or remote for remote–to–local bitrate.

5.12.3 AT?E: RSSI

AT?E requests the RSSI (Received Signal Strength Indicator) value. RSSI indicates the received signal level in dB re 1 V and represents the relative received signal strength.

RSSI is a signed floating point number. Higher RSSI values correspond to stronger signals.

The signal strength is acceptable when measured RSSI values lie between -20 dB and -85 dB.

In **Noise State** (see section 5.3.4), AT?E returns the RMS of the noise. The communication device performs best when RSSI exceeds the noise by 6 dB.

The local device will return the requested value:

View Value	Notification	Example	
AT?E	<RSSI>	+++	Switch to Command Mode.
		OK	
		AT?E	Get the last measured value.
		-56	
		AT!E	
		ERROR WRONG FORMAT	

5.12.4 AT?I: Signal Integrity Level

AT?I requests the Signal Integrity value that illustrates distortion of the last received acoustic signal. It is calculated based on cross-correlation measurements.

Higher Signal Integrity Level values correspond to less distorted signals. An acoustic link is considered weak if the Signal Integrity Level value is less than 100.

The local device will return the requested value:

View Value	Notification	Example	
AT?I	<Signal Integrity Level>	+++	Switch to Command Mode.
		OK	
		AT?I	Get the last measured value.
		145	
		AT!I	
		ERROR WRONG FORMAT	

5.12.5 AT?T: Propagation Time

AT?T requests the acoustic signal's propagation time between communicating devices (in ms).

The propagation delay is measured during burst data exchange or upon instant message acknowledgement reception.

The local device will return the requested value:

View Value	Notification	Example	
AT?T	<Propagation Time>	+++	Switch to Command Mode.
		OK	
		AT?T	Get the last measured value.
		323586	
		AT!T	
		ERROR WRONG FORMAT	

5.12.6 AT?V: Relative Velocity

AT?V requests the relative velocity between communicating devices (in m/s).

The local device will return the requested value.

Relative velocity is a signed floating point number.

View Value	Notification	Example	
AT?V	<Relative velocity>	+++	Switch to Command Mode.
		OK	
		AT?V	Get the last measured value.
		0.0072	
		AT!V	
		ERROR WRONG FORMAT	

5.12.7 AT?P: Multipath Structure

Underwater acoustic signals are subject to multipath propagation when the signals from the transmitter are reaching the receiver by two or more paths. Geometry of the underwater acoustic channel and its reflection properties determine the number of significant propagation paths, their relative strengths and delays.

AT?P returns a table illustrating the structure of the last received acoustic signal's multipath propagation from its source to the local device.

The first 8 signal arrivals are taken into account. The command produces a table, where the left column corresponds to the timeline (in us), and the right column contains the corresponding signal integrity values of the multipath components (see section 5.12.4).

View Value	Notification	Example	
AT?P	<Multipath Structure>	+++	Switch to Command Mode.
		OK	
		AT?P	Get the last measured value.
		28 146	
		448 156	
		580 123	
		968 184	
		1380 142	
		0 0	
		0 0	
		0 0	
		AT!P	
		ERROR WRONG FORMAT	

5.12.8 AT?NOISE: Noise sample

In **Noise State** (see section 5.3.4), you can use the AT?NOISE command to obtain a sample of analog input noise.

The device will output a string in the following format:

NOISE,<size>,<sample rate>,<gain>,<rssi>,<data>

Here <data> is an array of <size>/4 floating point values taken at a <sample rate>[7].

	Parameter Description
<data>	The data array, floating point values.
<size>	Data size, in bytes.
<sample rate>	Samples per second.
<gain>	Input amplifier gain. See section 5.9.3 for details.
<rssi>	Received Signal Strength Indicator. See section 5.12.3 for details.

Please remember to switch your device into **Noise State** (see the ATN command in section 5.3.4) before using the AT?NOISE!

[7]The sample rate is 250 kHz for all S2C devices, except S2CR 7/17 and 7/17 USBL - the sample rate is 62.5 kHz for these models.

5.13 Positioning: tracking remote targets

This section describes tracking the position of a remote device with AT commands.

The following commands have effect only on S2C USBL (Ultra-short baseline) series devices that provide 3D positioning functionality simultaneously with data transmissions.

5.13.1 USBLLONG: Positioning Data Output

During the mission, the USBL device can automatically output target positions.

If `Positioning Data Output` (see 5.11.4) is enabled, the device generates a `USBLLONG` string once a successful target fix was obtained.

The `USBLLONG` string format is:

```
USBLLONG,<current time>,<measurement time>,<remote address>,
<X>,<Y>,<Z>,<E>,<N>,<U>,<roll>,<pitch>,<yaw>,
<propagation time>,<rssi>,<integrity>,<accuracy>
```

Detailed parameter descriptions are listed in the table below.

	Parameter Description
`<current time>`	Timestamp of the string output, in the local device's `System Time`, in s (s.ssssss).
`<measurement time>`	Timestamp of the target position measurement, in the local device's `System Time`, in s (s.ssssss).
`<remote address>`	The target's address.
`<X>,<Y>,<Z>`	Coordinates of the target in the local device's reference frame, in m, floating point. See section B for the local reference frame.
`<E>,<N>,<U>`	Motion-compensated coordinates of the target, in m, floating point number.
`<roll>,<pitch>,<yaw>`	Rotation angles of the local device, in radians, floating point number.
`<propagation time>`	Propagation time of the acoustic signal, in us.
`<rssi>`	Received Signal Strength Indicator, signed number. See section 5.12.3 for more information.
`<integrity>`	Signal integrity level. See section 5.12.4 for more information.
`<accuracy>`	Accuracy of the position fix, in radians.

The positioning values are calculated when the acoustic link status is either `ONLINE` or `INITIATION LISTEN`.

When the acoustic link status is `ONLINE`, positioning values are refreshed during burst data exchange between the local device and the target. When the acoustic link status is `INITIATION LISTEN`, positioning values are refreshed upon reception of instant message acknowledgements during instant message exchange between the local device and the target.

If the distance to the target was not obtained, but the direction towards it was, the device will generate a `USBLANGLES` string instead of the `USBLLONG` string.

5.13.2 USBLANGLES: Target Direction Output

If Positioning Data Output (see 5.11.4) is enabled, the USBL device can automatically output positioning data during the mission.

If the USBL device calculated the direction toward the target, but the distance to the target was not estimated, the device will generate a USBLANGLES string instead of the USBLLONG string.

USBLANGLES string contains information about the bearing and elevation of the target.

The USBLANGLES string format is:

USBLANGLES,<current time>,<measurement time>,<remote_address>,
<lbearing>,<lelevation>,<bearing>,<elevation>,<roll,>,<pitch>,<yaw>,
<rssi>,<integrity>,<accuracy>

Detailed parameter descriptions are listed in the table below.

	Parameter Description
<current time>	Timestamp of the string output, in the local device's System Time, in s (s.ssssss).
<measurement time>	Timestamp of the target position estimation, in the local device's System Time, in s (s.ssssss).
<remote address>	The target's address.
<lbearing>,<lelevation>	The target's bearing and elevation in the local device's reference frame, in radians, floating point. See section B for the local reference frame.
<bearing>,<elevation>	The target's bearing and elevation, motion-compensated, in radians, floating point.
<roll>,<pitch>,<yaw>	Rotation angles of the local device, in radians, floating point.
<rssi>	Received Signal Strength Indicator, signed number. See section 5.12.3 for more information.
<integrity>	Signal integrity level. See section 5.12.4 for more information.
<accuracy>	Accuracy, in m.

The positioning values are calculated when the acoustic link status is either ONLINE or INITIATION LISTEN.

When the acoustic link status is ONLINE, positioning values are refreshed during burst data exchange between the local device and the target. When the acoustic link status is INITIATION LISTEN, positioning values are refreshed upon reception of instant message acknowledgements during instant message exchange between the local device and the target.

5.13.3 USBLPHYD: Transducer Delays Output

During the mission, the USBL device can output additional information for advanced diagnostics of the positioning results.

If `Extended notifications` (see 5.11.5) are enabled for the current data stream, the device generates a `USBLPHYD` string following a `USBLLONG` or `USBLANGLES` string once the target position or target direction was obtained.

Acoustic signal from a transponder, attached to the tracking target, is received by the transducer array of the USBL antenna. The array of 5 elementary transducers composing the USBL antenna is shown in figure 2 below.

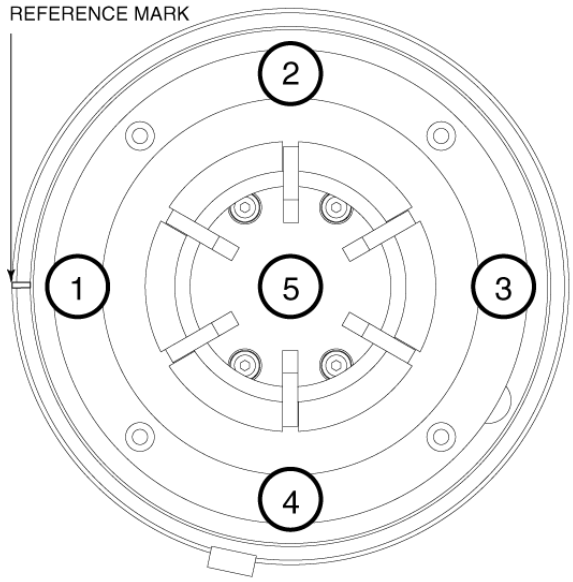

Figure 2: USBL antenna: transducer array

Signals, received by each of the 5 transducers, are delayed relative to each other. The `USBLPHYD` string contains delays between pairs of transducers (in nanoseconds).

The `USBLPHYD` string format is:

```
USBLPHYD,<current time>,<measurement time>,<remote address>,<fix type>
<delay 1-5>,<delay 2-5>,<delay 3-5>,<delay 4-5>,
<delay 1-2>,<delay 4-1>,<delay 3-2>,<delay 3-4>
```

Detailed parameter descriptions are listed in the table below.

	Parameter Description
<current time>	Timestamp of the string output, in the local device's System Time, in s (s.ssssss).
<measurement time>	Timestamp of the target position measurement, in the local device's System Time, in s (s.ssssss).
<remote address>	The target's address.
<fix type>	Type of the fix:
0	Position fix (distance and direction to target).
1	Angles fix (direction to target).
<delay 1-5>	Delay between transducers 1 and 5, in ns.
<delay 2-5>	Delay between transducers 2 and 5, in ns.
<delay 3-5>	Delay between transducers 3 and 5, in ns.
<delay 4-5>	Delay between transducers 4 and 5, in ns.
<delay 1-2>	Delay between transducers 1 and 2, in ns.
<delay 4-1>	Delay between transducers 4 and 1, in ns.
<delay 3-2>	Delay between transducers 3 and 2, in ns.
<delay 3-4>	Delay between transducers 3 and 4, in ns. See figure 2 for transducer numbering within the array.

The positioning values are calculated when the acoustic link status is either ONLINE or INITIATION LISTEN.

When the acoustic link status is ONLINE, positioning values are refreshed during burst data exchange between the local device and the target. When the acoustic link status is INITIATION LISTEN, positioning values are refreshed upon reception of instant message acknowledgements during instant message exchange between the local device and the target.

5.13.4 USBLPHYP: Coordinates Array Output

If Extended notifications (see 5.11.5) are enabled for the current data stream, the device also generates a USBLPHYP string following a USBLLONG or USBLANGLES string once the target position or target direction was obtained.

The 5 transducers of the USBL antenna are shown in figure 2 in the previous section (see 5.13.3). 6 elementary arrays of three transducers per array are used to obtain 6 estimations of target coordinates in the local reference frame (see B for the local reference frame of the device). The USBLPHYP string contains 6 sets of coordinates, estimated by 6 elementary transducer arrays.

The USBLPHYP string format is:

USBLPHYD,<current time>,<measurement time>,<remote address>,<fix type>
<X123>,<Y123>,<Z123>,<X432>,<Y432>,<Z432>,<X341>,<Y341>,<Z341>,
<X412>,<Y412>,<Z412>,<X153>,<Y153>,<Z153>,<X254>,<Y254>,<Z254>,

Detailed parameter descriptions are listed in the table below.

	Parameter Description
<current time>	Timestamp of the string output, in the local device's System Time, in s (s.ssssss).
<measurement time>	Timestamp of the target position measurement, in the local device's System Time, in s (s.ssssss).
<remote address>	The target's address.
<fix type>	Type of the fix:
0	Position fix (distance and direction to target).
1	Angles fix (direction to target).
<X123>,<Y123>,<Z123>	Coordinates of the target, in m, floating point, estimated by an array of transducers 1, 2 and 3.
<X432>,<Y432>,<Z432>	Coordinates of the target, in m, floating point, estimated by an array of transducers 4, 3 and 2.
<X341>,<Y341>,<Z341>	Coordinates of the target, in m, floating point, estimated by an array of transducers 3, 4 and 1.
<X412>,<Y412>,<Z412>	Coordinates of the target, in m, floating point, estimated by an array of transducers 4, 1 and 2.
<X153>,<Y153>,<Z153>	Coordinates of the target, in m, floating point, estimated by an array of transducers 1, 5 and 3.
<X254>,<Y254>,<Z254>	Coordinates of the target, in m, floating point, estimated by an array of transducers 2, 5 and 4. See section B for the local reference frame and figure 2 for transducer numbering within the array.

The positioning values are calculated when the acoustic link status is either ONLINE or INITIATION LISTEN.

When the acoustic link status is ONLINE, positioning values are refreshed during burst data exchange between the local device and the target. When the acoustic link status is INITIATION LISTEN, positioning values are refreshed upon reception of instant message acknowledgements during instant message exchange between the local device and the target.

5.13.5 AT?UP: Positioning

AT?UP returns the position of the remote target in the local coordinate frame of the USBL-series device[8]:

<seconds>,<remote address>,<X>,<Y>,<Z>

Here <seconds> indicates the System Time of the measurement, <X>,<Y>,<Z> (in m) are coordinates of the target - a remote device with address <remote address>.

Detailed parameter descriptions are listed in the table below.

	Parameter Description
<seconds>	Time of the measurement, in s, corresponds to the local device's System Time (see section 5.9.15).
<remote address>	The target's network address.
<X>,<Y>,<Z>	Coordinates, in m, floating point. See section B for the local coordinate reference frame.

The positioning values are calculated when the acoustic link status is either ONLINE or INITIATION LISTEN.

When the acoustic link status is ONLINE, positioning values are refreshed during burst data exchange between the local device and the target. When the acoustic link status is INITIATION LISTEN, positioning values are refreshed upon reception of instant message acknowledgements during instant message exchange between the local device and the target.

You can send an instant message with delivery acknowledgement to the remote device to track its position without establishing an acoustic link.

An example of AT?UP is listed below.

	Example AT?UP
+++	Switch to Command Mode
OK	
AT*SENDIM,4,12,ack,test	Send an instant message to address 12.
OK	
DELIVEREDIM,12	Instant message delivery acknowledged.
AT?UP	Get the position of the device with address 12.
3246,12,-1.45,4.24,26.40	

[8] see section B

5.13.6 AT?UPX: Motion-Compensated Positioning

This command has effect only on USBL-series devices with an AHRS (Attitude and Heading Reference System) sensor installed.

AT?UPX returns the position of the remote target in the local coordinate frame of the USBL-series device with roll, pitch and heading compensation.

Estimated coordinates of the remote device do not depend on the rotation of the local reference frame (see section B for the local reference frame).

A magnetic field mapping procedure is to be performed to ensure correct heading compensation. See Magnetic Mapper Guide for more information.

AT?UPX returns:

<seconds>,<remote address>,<E>,<N>,<U>

Here <seconds> indicates the System Time of the measurement, <E>,<N>,<U> are coordinates (in meters) of a remote device with address <remote address>.

Detailed parameter descriptions are listed in the table below.

	Parameter Description
<seconds>	Time of the measurement, in s, corresponds to the local device's System Time (see section 5.9.15).
<remote address>	The target's network address.
<E>,<N>,<U>	Coordinates, in m, floating point. <E>,<N>,<U> are the East, North, Up (ENU) coordinates[9], East, North, Up are directions of the object-based right-handed reference frame.

The positioning values are calculated when the acoustic link status is either ONLINE or INITIATION LISTEN.

When the acoustic link status is ONLINE, positioning values are refreshed during burst data exchange between the local device and the target. When the acoustic link status is INITIATION LISTEN, positioning values are refreshed upon reception of instant message acknowledgements during instant message exchange between the local device and the target.

You can send an instant message with delivery acknowledgement to the remote device to track its position without establishing an acoustic link.

An example of AT?UPX is listed below.

Example AT?UPX	
+++	Switch to Command Mode
OK	
AT*SENDIM,4,12,ack,test	Send an instant message to address 12.
OK	
DELIVEREDIM,12	Instant message delivery acknowledged.
AT?UPX	Get the position of the device with address 12.
14556,12,1.02,-5.76,-10.30	

[9] http://en.wikipedia.org/wiki/East_North_Up

6 Support

Please email us at **support@evologics.de** for technical support on your EvoLogics products.

Please include the following information to have your request properly processed:

- **Serial number** of your EvoLogics product (this can be found in the Factory Certificate supplied with your device).
- Detailed problem description.

Make sure your inquiry for technical support reaches us at the correct email address:

support@evologics.de.

We can not guarantee that support inquiries sent to another address will be processed, significant delays may occur.

A Appendix I

A.1 S2C Configuration Utility

If your device is equipped with an Ethernet interface, some device settings can be changed with a web-based Configuration Utility.

To access the Configuration utility:

- Connect your device to a PC over Ethernet.
- Make sure the PC and the device are in the same subnet.

  By default, the device is configured in the `192.168.0.0/24` subnet. If you have previously changed the subnet of your device with the Configuration Utility, make sure your PC is configured in the same subnet.
- Check the connection between the PC and the device (for example, use the `Ping` utility).

  The default IP address of your device is listed in its Factory Certificate. If you have previously changed the IP address of your device with the Configuration Utility, make sure you enter the correct IP address.
- Open a web-browser and go to `http://<IP Address>/`, where `<IP address>` is the IP address of your device.

The Configuration Utility main page will appear (see figure 3 below).

Figure 3: S2C Configuration Utility: main page

Go to the **IP Settings** page to change the IP address and the subnet mask of your device. The **Device Settings** page allows to modify some device settings, whereas the **Advanced Device Settings** page allows to modify input-output interface configurations and NTP synchronization parameters.

Please note: **to apply any changes you make with the Configuration Utility, you must reset the device!**

A.1.1 IP Settings

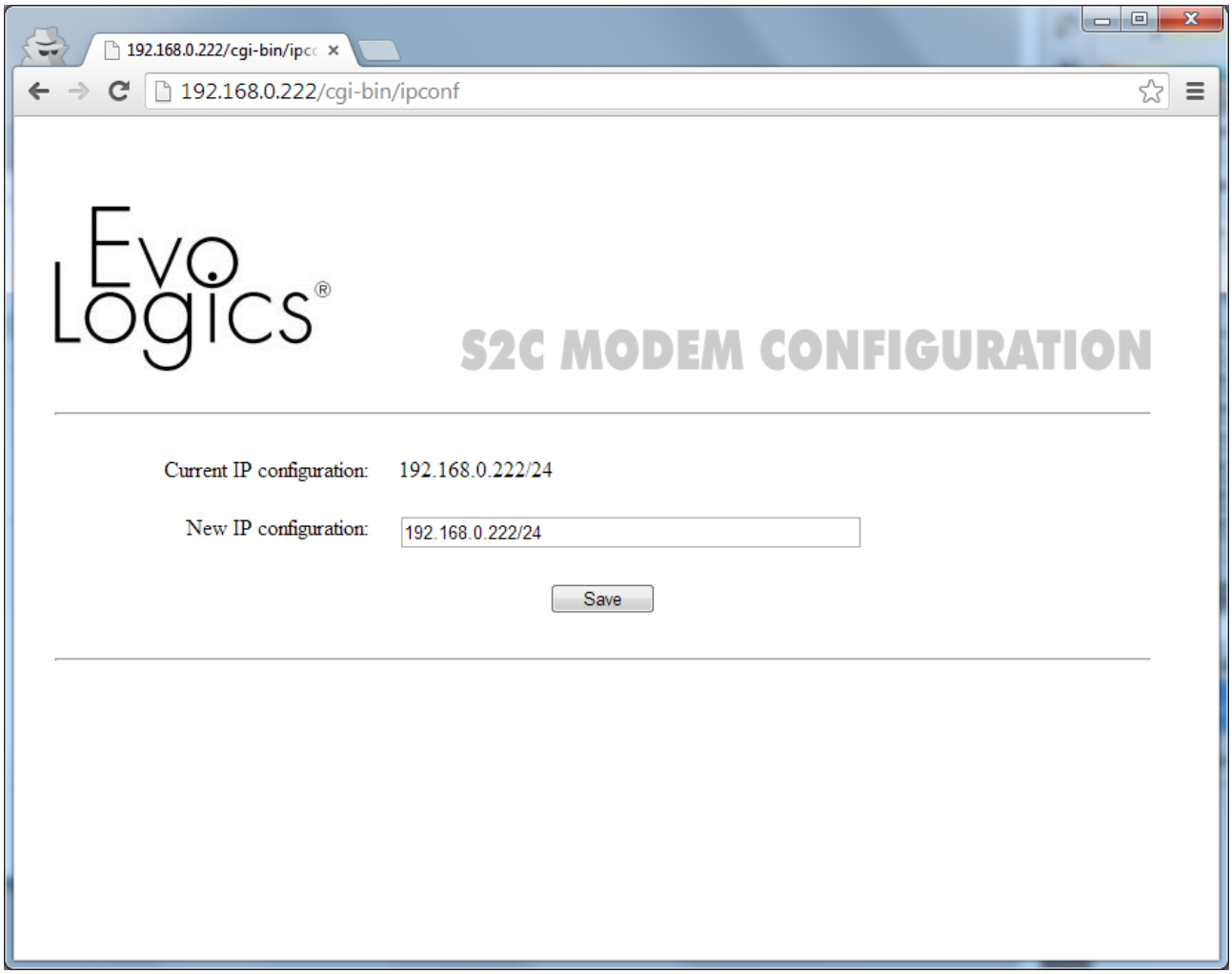

Figure 4: S2C Configuration Utility: **IP configuration** page

To change the IP address and the subnet mask of your device:

- Open the **IP Settings** page of the Configuration Utility.
- Enter the new IP configuration parameters in the following format:

  `<IP address>/<number of bits in subnet mask>`
- Press **Save**.

A success confirmation message or an error report will appear.

The new settings will be applied after the device is reset.

Reset the device to apply new settings.

A.1.2 Device Settings

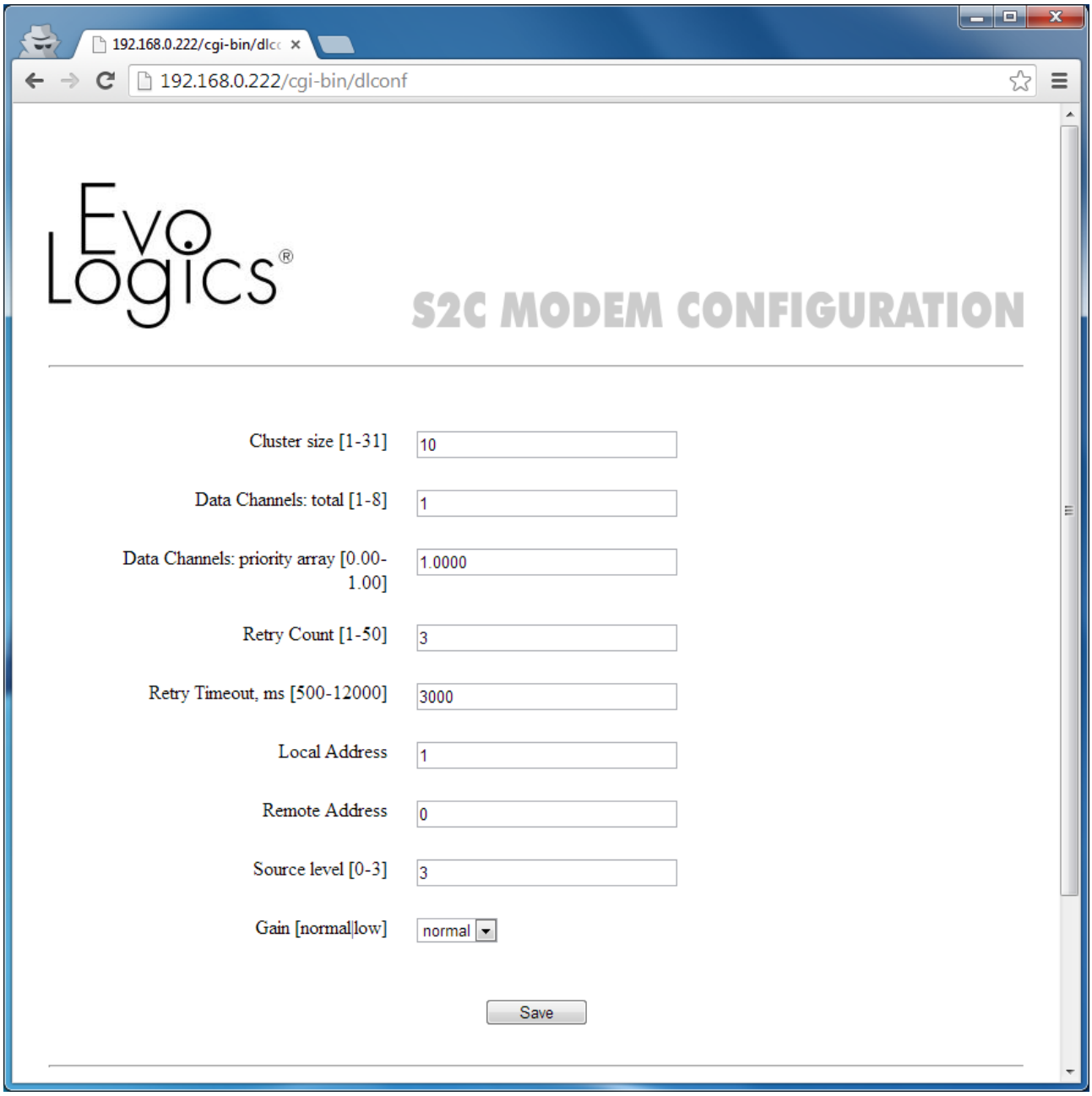

Figure 5: S2C Configuration Utility: **Device Settings** page

To change device settings:

- Open the **Device Settings** page of the Configuration Utility.
- Enter the new setting values in the corresponding fields.
- Press **Save**.

A success confirmation message or an error report will appear. The new settings will be applied after the device is reset.

Reset the device to apply new settings.

See the table below for configurable settings and their descriptions:

Parameter	Range	Description
Cluster Size	`1 .. 31`	Cluster size - number of burst data packets in a packet train (see 5.9.8).
Data Channels: total	`1 .. 8`	The total number of data channels - virtual channels for burst data exchange (see 3.1).
Data Channels: priority array	`0.00 .. 1.00`	Space-separated priorities of the data channels (see 3.1.1), floating point numbers. 1.000 for all channels by default.
Retry Count	`1 .. 50`	Number of connection establishment retries (see 5.9.10).
Retry Timeout	`200 .. 12000`	Timeout while the local device waits for a response to its connection establishment request, in ms (see 5.9.11).
Local Address		Address of the local device (see 5.9.5).
Remote Address		The address of a remote device that the local device communicates with (see 5.9.6).
Source Level	`0 .. 3`	The sound pressure level in transmission mode (see 5.9.1).
Gain	`normal, low`	Input amplifier gain (see 5.9.3).

A.1.3 Advanced Device Settings

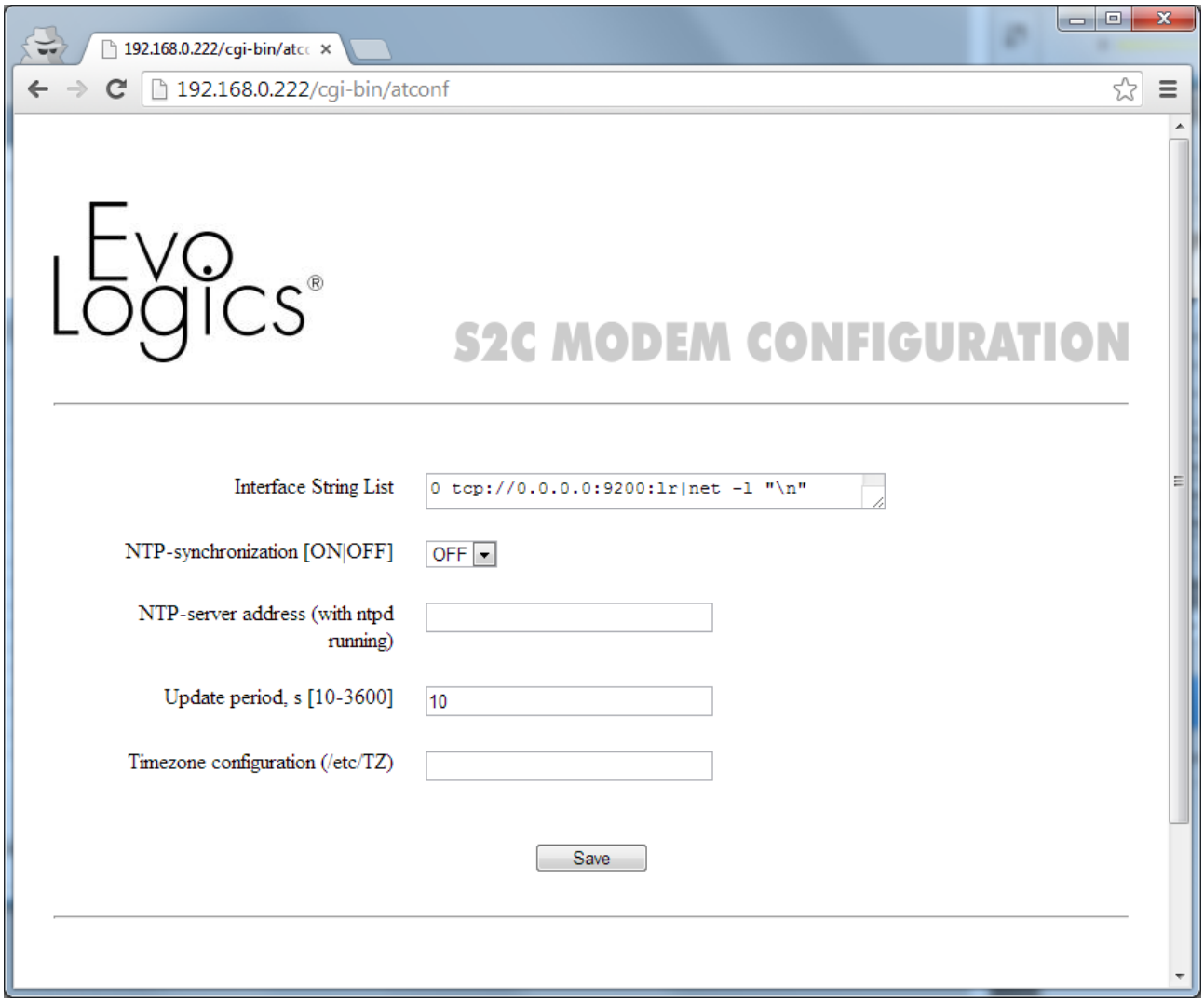

Figure 6: S2C Configuration Utility: **Advanced Device Settings** page

To change device settings:

- Open the **Advanced Device Settings** page of the Configuration Utility.
- Enter the new setting values in the corresponding fields.
- Press **Save**.

A success confirmation message or an error report will appear. The new settings will be applied after the device is reset.

Reset the device to apply new settings.

See the table below for configurable settings and their descriptions:

Parameter	Range	Description
Interface String List		The list of `Channel numbers` and assigned `Interface Strings` (see 3.2). Make sure you read section 3 before attempting to edit the interface strings! Contact EvoLogics for recommendations.
NTP synchronization	`on, off`	Enable or disable NTP (Network Time Protocol) synchronization of the `System Time` (5.9.15) with an external NTP server.
NTP-server address		IP address of the NTP-server.
Update Period	`10 .. 3600`	NTP synchronization update period, in s.
Timezone configuration		Time zone.

B Appendix II

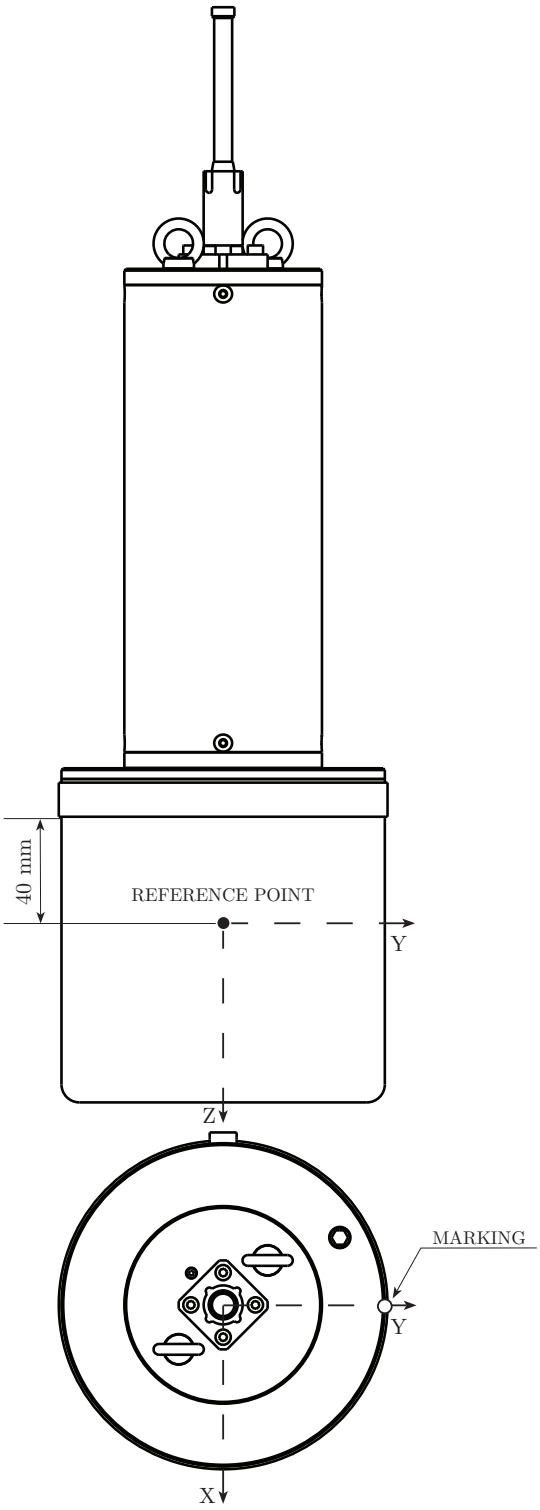

Figure 7: Local coordinate system of an S2C USBL communication and positioning device

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