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S2C Reference Manual

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1.9.F	January 2019	Minor typos fixed, PBM delivery status (AT?DP), System Time + System Clock (AT?UPX) added - Firmware v.1.9.13 and up.
2.0	February 2019	Notifications control, command description help, STATUS and RECVSRV ext. notifications, IM loopback added. Firmware 2.0 and up.

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.

For most S2C devices, instant messages are transferred with a constant bitrate of **976 bps**, acceptable for a wide range of acoustic channel parameters. For S2C HS underwater acoustic modems the bitrate is **1952 bps**.

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 (5.10.4) 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.

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 allows to configure and run a network of virtual underwater acoustic modems.

It is available as a standalone device and as a hardware-free framework, where a network of virtual underwater acoustic modems is run on EvoLogics server and accessed remotely.

The emulator is an efficient 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 a RS-232 input-output interface. Newer S2C devices (mid-2016) are equipped with the 2-channel Wake-Up Module that supports up to 2 RS-232 interfaces and reacts to incoming data on any of them.

The Wake-Up Module 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 5.12.

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.

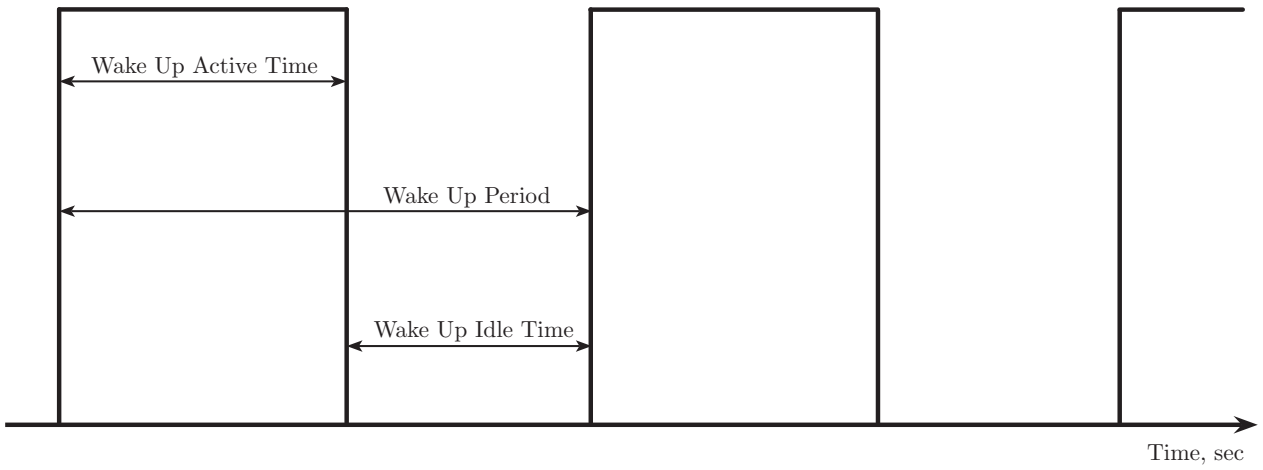

Figure 1: The Wake-Up toggle cycle

2.4 USBL positioning

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

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.

2.4.1 Positioning Strings

During the mission, the USBL device can automatically output target positions and other USBL-related data. If positioning data output is enabled (see 5.10.8), the device generates so called positioning strings with corresponding positioning information.

Positioning data values are refreshed during burst data exchange as well as during instant message exchange between the local device and the target.

Distance to the target is estimated during burst data exchange, as well as upon reception of instant message acknowledgements (i.e. after a bidirectional exchange of service data between the USBL-device and the target). Direction to the target is estimated after reception of any data from the target.

During instant message exchange, positioning strings are always generated after instant message reception notifications (the `RECV` strings, described in 5.5.7, 5.5.8 and 5.5.9).

See an overview of positioning strings below, refer to section 5.11 for detailed descriptions.

USBLLONG The device generates a `USBLLONG` string once a successful target fix was obtained. The string contains coordinates of the target. Read more about `USBLLONG` in section 5.11.1.

USBLANGLES If the USBL device did not calculate distance, but calculated the **direction** towards the target, it will generate a `USBLANGLES` string instead of the `USBLLONG` string. `USBLANGLES` string contains information about the bearing and elevation of the target. Read more about `USBLANGLES` in section 5.11.2.

Position fix failed If the device **failed** to estimate coordinates or direction to the target (i.e. target position fix failed), it generates a `USBLANGLES` string with `-1` in its `accuracy` field.

USBLPHYP and USBLPHYD If Positioning Data Output (see 5.10.8) and Extended Notifications (see 5.10.4) are enabled, the device generates additional `USBLPHYP` and `USBLPHYD` strings following a `USBLLONG` or `USBLANGLES` once the target position or target direction was obtained.

These strings contain extra information about the estimated position or direction. With enabled extended notifications, string output order is `USBLLONG` (or `USBLANGLES`), `USBLPHYP`, `USBLPHYD`.

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).

6 elementary arrays of three transducers per array are used to obtain 6 estimations of target coordinates in the local reference frame (see C for the local reference frame of the device). The `USBLPHYP` string contains 6 sets of coordinates, estimated by 6 elementary transducer arrays. See more about the string in section 5.11.3

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). See more about the string in section 5.11.4.

Please note: to avoid errors due to proximity to ferromagnetic materials, a magnetic mapping procedure is required after a device with a built-in AHRS is installed within its deployment infrastructure. See the **AHRS Calibration Guide** for details.

2.5 Advanced Timekeeping Module

A built-in Advanced Timekeeping Module (**ATM**) is an optional integrated electronic unit.

The ATM extends the device's timekeeping functionality: it accepts an external 1 PPS (pulse-per-second) input from a GPS receiver and optionally comes with an integrated Chip Scale Atomic Clock (CSAC). Read more about device timekeeping in section 4.4.

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.

3.1 Connecting to device interfaces

We recommend the **PuTTY**[3]software tool for connecting to S2C devices.

For connecting over Ethernet, you can also use **netcat**[4].

3.1.1 End-of-line settings

Terminal software automatically adds end-of-line markers to commands sent to the device - these are syntactical elements that do not appear in the terminal.

An Ethernet interface of your device is by default configured to accept the **line feed** (`LF`, `\n`, `0x0A`) end-of-line marker, a serial interface – the **carriage return** (`CR`, `\r`, `0x0D`).

If strings sent to an interface end with the wrong end-of-line marker, the device **does not** react with an error message!

To avoid unexpected behaviour,

make sure the software used to access the device is properly configured with correct end-of-line settings:

- For access over Ethernet, use the **line feed** (`\n`).
- For access over a serial interface, use **carriage return** (`\r`).

See more information on commands and end-of-line markers in section 5.1.2.

If you intend to use **PuTTY** to connect over Ethernet: please note, that **only the PuTTY installation you download from EvoLogics** allows to select the correct end-of-line marker.

[3]You can download **PuTTY** that allows to select the end-of-line marker from EvoLogics.
This installation of **PuTTY** allows to select the end-of-line marker - see `Raw` settings.
PuTTY for Windows 32-bit: https://lab.evologics.de/share/soft/windows/putty/x86/putty.exe.
PuTTY for Windows 64-bit: https://lab.evologics.de/share/soft/windows/putty/x86_64/putty.exe.

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

3.2 Data Channels

The D-MAC data-link layer protocol of S2C devices allows to create and configure up to 8 virtual channels within the acoustic communication link.

These virtual data channels allow to route burst data and instant messages between input-output interfaces of communicating devices: each input-output interface of a device is associated with a particular data channel, so data from a certain input-output interface of the transmitter is directed to a certain input-output interface of the receiver.

Each data channel has a unique identifier - the channel's Protocol ID.

Burst data packets from different data channels are multiplexed into packet trains according to channel priorities (see section 3.2.2 below). Upon reception, these packets are identified by the Protocol ID and directed to the correct input-output interface of the receiver.

Two commands (see 5.9.14, 5.9.14) allow to view the channel Protocol ID for the current interface - the interface used to access the device. Another command (5.9.15) lists all interfaces and the Protocol IDs of linked data channels.

With a specific command (see 5.9.14), the current interface can be reassigned to another data channel, so burst data and instant messages will be directed to another input-output interface of the remote device (see 5.9.14). See more on routing data between different data channels in section 3.2.1 that follows.

For devices with an Ethernet interface, interface strings and linked data channels can be edited with a web-based **S2C Configuration Utility** (see A.1 for details).

For devices with serial interfaces, interface strings and linked data channels can be edited with the **S2C Configuration Shell** (see B for details).

How burst data and instant messages are routed between different data channels is defined by a so called Extended Protocol Mode (see section 3.2.1 below), created as a transition between earlier versions of S2C firmware and its future editions.

3.2.1 Extended Protocol Mode

Extended Protocol Mode defines, how burst data and instant messages are routed between interfaces of the transmitter and the receiver. The mode can be enabled or disabled for the current interface with a corresponding command (see 5.10.2).

Extended Protocol Mode disabled Disabled Extended Protocol Mode is similar, but not identical to the standard routing, implemented in firmware version 1.7.18 and earlier.

In this case, burst data and instant messages from the sender's input-output interface are directed to the receiver's input-output interface linked to the same data channel. The channel Protocol IDs of the sender and the receiver match.

To have burst data and instant messages output at another interface of the receiving device, you must switch to that data channel - change the channel Protocol ID of the current interface to match the channel Protocol ID of the destination interface. Switching between data channels

can be performed with an AT command or by editing the interface configuration string (see 3.3 in further sections).

This method of routing between data channels will be deprecated in future versions of the firmware.

Extended Protocol Mode enabled If Extended Protocol Mode is enabled, instant messages from the sender can be specifically addressed to a receiver's interface, no matter what data channel it is linked to.

In this mode, commands to send instant messages must simply include the channel Protocol ID of the receiver's destination interface. There is no need to switch to another data channel, if the instant message has to be output at another interface of the receiver.

Instant messages will be received by all data channels and output at all interfaces linked to them, and notification about instant message reception will include the Protocol ID of the data channel it is intended for.

Burst data is not affected by Extended Protocol Mode: incoming data will be automatically transferred over the acoustic channel and output at the interface with the matching channel Protocol ID. To have burst data output at another interface of the receiving device, you must switch to that data channel - change the channel Protocol ID of the current interface to match the channel Protocol ID of the destination interface.

Extended Protocol Mode will be the only method of routing between channels implemented in future version of the firmware.

3.2.2 Channel Priority

As up to 8 virtual data channels share the acoustic link, one packet train can contain burst data 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.[5]

If an Ethernet interface is available to access the device, channel priorities can be modified with the web-based **S2C Configuration Utility** (see Appendix A.1 for details).

For devices with serial interfaces, channel priorities can be modified with the **S2C Configuration Shell** (see Appendix B for details).

[5]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 `Protocol ID`, an identifier assigned to the i-th channel, m_i - the number of packets in the transmission buffer of the i channel.

3.3 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 interface strings. The list of interfaces is displayed in the following format:

`<Channel Protocol ID> <Interface String>`

The `Channel Protocol ID` (see 3.2) and the `Interface String` 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 3.3.1 and 3.3.2 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 3.3.3.

If an Ethernet interface is available to access the device, interface strings can be edited with the web-based **S2C Configuration Utility** (see appendix A.1 for details).

For devices with serial interfaces, interface strings can be edited with the **S2C Configuration Shell** (see Appendix B for details).

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

3.3.1 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 3.3.3 for detailed description of the filters (pre-processing programs) and filter parameters, as well as their recommended configurations.

3.3.2 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 3.3.3 for detailed description of the filters (pre-processing programs) and filter parameters, as well as their recommended configurations.

3.3.3 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 3.3 above). Some filter parameters can be modified with AT commands, as described in sections that follow.

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.

3.3.4 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.

Regarding incoming data, 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 Reference Manual** version **Networking**. 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.

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

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.
-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 5.10.8.
	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 5.10.4.
	0	Extended notifications disabled. Default value.
-c <option>	1	Global settings control enabled. The command interpreter will execute control commands that modify global device settings (listed in section 5.9). Otherwise, it will only execute commands that modify settings, specific to the selected interface and/or data channel. Global settings control can be enabled/disabled with a command - read more in section 5.10.1.
	0	Global settings control disabled.
-f <option>	1	Extended Protocol Mode enabled. In this case, instant messages from the sender can be specifically addressed to a receiver's interface, no matter what data channel it is linked to. In this mode, control commands to send instant messages must simply include the channel Protocol ID of the receiver's destination interface. There is no need to switch to another data channel, if the instant message has to be output at another interface of the receiver. Instant messages will be received by all data channels and output at interfaces linked to them, and notification about instant message reception will include the Protocol ID of the data channel it is intended for. Extended Protocol Mode can be enabled/disabled with a command - read more in section 5.10.2.
	0	Extended Protocol Mode disabled. In this case, burst data and instant messages from the sender's input-output interface are directed to the receiver's input-output interface linked to the same data channel. The channel Protocol IDs of the sender and the receiver match. In this case, to have burst data and instant messages output at another interface of the receiving device, you must switch to that data channel - change the channel Protocol ID of the current interface to match the channel Protocol ID of the destination interface.

- 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 -c 0 -f 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, global settings control is disabled and Extended Protocol mode 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 -c 0 -f 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, global settings control is disabled and Extended Protocol mode 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"
  ```

3.3.5 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 3.3.3.

If the `at` command interpreter is enabled for the input-output interface (3.3.4), 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.

4.4 Device timekeeping

System Clock By default, the internal timekeeping of the S2C device is based on the **System Clock** - a 32-bit microseconds counter that defines the physical layer time. **System Clock** is reset when the physical layer hardware of the device is turned off. **System Clock** values can be requested with a corresponding command (5.9.17).

System Time The data-link layer time uses the **System time** parameter - by default, it's the number of seconds elapsed since the device has been powered on. **System time** can be modified by the user and will reset after device reboot (5.9.16).

For S2C devices with an Ethernet interface, **System time** can be synchronized with an external NTP server over the Network Time Protocol (NTP). With NTP synchronization **System Time** will correspond to Coordinated Universal Time (UTC).

Advanced Timekeeping Module A built-in Advanced Timekeeping Module (**ATM**) is an extra option available for S2C devices.

The ATM extends the device's timekeeping functionality: it accepts an external 1 PPS (pulse-per-second) input from a GPS receiver and optionally comes with an integrated Chip Scale Atomic Clock (CSAC)[6].

The atomic clock can be synchronized to the 1 PPS and UTC time from the GPS receiver. Thus, the ATM replaces the 32 bit counter as the physical layer clock to provide a highly precise local timing reference during subsea deployment. The web-based **Atomic Clock Utility** is available for Ethernet-enable S2C devices to discipline and synchronize the CSAC (see Appendix A.3).

An ATM-enabled device can automatically output 1 PPS (pulse-per-second) strings with current time values to the data interface (see 5.10.9). These External Clock Strings contain the **System Time**, **System Clock** and **UTC time** values, the latter if the device is interfaced with NMEA output from a GPS receiver (see 4.4.1 below).

4.4.1 UTC Time: NMEA input

An Ethernet-enabled S2C device with an **ATM** can be interfaced with NMEA output from a GPS receiver. This will include UTC time in the External Clock 1 PPS output of the S2C device.

Before you begin:

- Make sure the GPS receiver outputs both **GPZDA** and **GPGGA** NMEA sentences.

Description of NMEA, **GPZDA** and **GPGGA** formats is out of scope of this manual - please refer to online resources, if needed.

To enable UTC time over NMEA:

- Connect the GPS receiver to the S2C device over Ethernet.

[6] See the Factory Certificate of your device to check if it is equipped with an Advanced Timekeeping Module with or without an integrated atomic clock.

- Open a TCP socket in client mode:

  `<ip address>:12100`

  The `ip address` of your device is listed in its Factory Certificate. Port `12100` is reserved for NMEA input.

  The S2C device acts as a server and listens to this TCP socket for GPZDA and GPGGA data.

- Direct GPZDA and GPGGA data from the GPS receiver to the TCP socket.

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.

The 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.

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 commands to edit settings, specific to the current interface and/or data channel, the ”at” symbol `@` follows the `AT` prefix. Read more about data channels in section 3.2.
- In help commands, corresponding command characters and a dollar sign `$` follow the `AT` prefix.

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 an equal 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 entered after a command but before the response can 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 perform an action is accepted for execution.

When an acoustic connection to a remote device is established, some settings 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 5.7.4).

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 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	Check the interface string configurations: equal Protocol IDs for several interfaces is not allowed.
ERROR NO CONTROL	Attempted modification of global settings is not allowed, check the Global Settings Control for current interface.
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, local device is in Backoff state (see `AT?S`, section 5.7.4).

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 5.5.7, 5.5.8 and 5.5.9 for detailed descriptions.

- Successful or failed deliveries of instant messages.

  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 5.11.1 and 5.11.2.

  These notifications can be independently turned on and off for the current data channel (see section 5.10.8).

- Automatic setting adjustments, status of acoustic transmissions and other events. Section 5.10.4 provides the full list of extended notifications and their detailed descriptions.

  These extended notifications can be independently turned on and off for the current data channel (see section 5.10.4).

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

All notifications can be turned off for the selected data channel (see section 5.10.3). In this case, the device will only output burst data, command responses and error messages.

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 interface and data channel Help sections

Use AT@$ to see a list of commands, specific to the current interface and/or 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.

5.2.8 AT<cmd>$: See command format/description

Use AT<cmd>$ to output format and short description of the <cmd> command.

See an example in the table below:

	Example AT<cmd>$
+++	Switch to Command Mode.
OK	
AT*SENDIM$	Search for SENDIM format and short description.
AT*SENDIM[,<pid>],<len>,<dst>,<ack>,<data>	The SENDIM command format.
Send instant message to a remote device with destination address <dst>	The SENDIM short description.

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 5.13.3) to request the RMS value of the noise.
- Use AT?NOISE (see 5.13.8) 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 5.13.3 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 types 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 5.13.8 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 5.12.4), 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 5.7.4).
+++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 5.10.4),

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 5.10.4.

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, physical layer protocol version, data-link layer protocol version, manufacturer's information and the serial number of your S2C device.

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	View the Serial number of your device.
		3-6	Reserved for future use. Will generate an error report.
		7	View <device manufacturer> information.

Use ATI2 to check the serial number of your device before submitting a support inquiry (see section 6 for details)!

	Example ATI
+++	Switch to Command Mode
OK	
ATI0	Request the current firmware version
1.7	Firmware version number
ATI2	Request the serial number
1834/17#158/4	The serial number of your device
ATI1	Request the physical and data–layer protocol versions
phy: 0x40803016, mac: v1.7.1	
ATI5	
ERROR OUT OF RANGE	The n is 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. The channel Protocol ID (see 3.2) of the source input-output interface should match 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 `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 3.3.5).

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>	+++ OK AT?ZE 0 AT!E ERROR WRONG FORMAT	Switch to Command Mode. Get the current value.

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:

- If **Extended Protocol Mode** is disabled (see 3.2.1, 5.10.2), ensure you are sending data to the correct data channel - the channel mapped to the desired input-output interface of the receiver. The Protocol ID (see 3.2) of the source input-output interface should match 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>.

If the Extended Protocol Mode is enabled (see 3.2.1), include the channel Protocol ID of the receiver's destination interface in the command:

AT*SENDIM,p<destination PID>,<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>. The instant message is intended for the interface with channel Protocol ID <destination PID>.

See the parameter descriptions in the table below.

		Parameter Description
<destination PID>	0..7	Protocol ID of the data channel, linked to the destination interface of the receiver (3.2.1).
<length>		Message length - the data array length, max. 64 bytes. Zero-length allowed.
<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 5.9.20. 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.
<data>		The instant message – a binary data array. Zero-length allowed.

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).

Instant messages support loopback: you can send an instant message without acknowledgement to the local address of your device (i.e. destination address matches the local address). A message reception notification will be generated. An attempt to send an IM with acknowledgement to the local address will result in an error.

Example 1 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!ZF1	Enable Extended Protocol Mode (3.2.1).
OK	
AT?ZF	Check the Extended Protocol Mode status.
1	Extended Protocol Mode is enabled.
AT*SENDIM,4,10,ack,test	Send IM to address 10 with acknowledgement request.
ERROR WRONG FORMAT	In Extended Protocol Mode, channel Protocol ID of a receiver's interface must be included in the command.
AT*SENDIM,p3,4,10,ack,test	Command includes the Protocol ID of the destination.
OK	
DELIVEREDIM,10	Data was successfully delivered.
AT*SENDIM,p4,4,12,ack,test	Send IM to address 12.
BUSY BACKOFF STATE	The device is in Backoff State.

Example 2 SENDIM

+++	Switch to Command Mode.
OK	
AT?AL	Get the current Local Address.
2	The local address is 2.
AT*SENDIM,2,2,noack,tt	Send IM without acknowledgement to self - address 2.
OK	
RECVIM,2,2,2,noack,0,0,0,0.0000,tt	Data reception notification.
AT*SENDIM,2,2,ack,tt	Send IM with acknowledgement to self .
ERROR WRONG DESTINATION ADDRESS	Error: sending to self with acknowledgement is not allowed.

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 5.9.17. 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:

- If **Extended Protocol Mode** is disabled (see 3.2.1, 5.10.2), ensure you are sending data to the correct data channel - the channel mapped to the desired input-output interface of the receiver. The Protocol ID (see 3.2) of the source input-output interface should match 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>.

If the Extended Protocol Mode is enabled (see 3.2.1), include the channel Protocol ID of the receiver's destination interface in the command:

AT*SENDIMS,p<destination PID>,<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>. The IMS is intended for the interface with channel Protocol ID <destination PID>.

See the IMS parameter descriptions in the table below.

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

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

Parameter Description		
<destination PID>	0..7	Protocol ID of the data channel, linked to the destination interface of the receiver.
<length>		Message length - the data array length, max. 64 bytes. Zero-length allowed.
<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.
<data>		The IMS – a binary data array. Zero-length allowed.

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).

IMS messages support loopback: you can send an IMS to the local address of your device (i.e. destination address matches the local address). A message reception notification will be generated.

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 another 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:

- If **Extended Protocol Mode** is disabled (see 3.2.1, 5.10.2), ensure you are sending data to the correct data channel - the channel mapped to the desired input-output interface of the receiver. The Protocol ID (see 3.2) of the source input-output interface should match 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.

If the Extended Protocol Mode is enabled (see 3.2.1), include the channel Protocol ID of the receiver's destination interface in the command:

`AT*SENDPBM,p<destination PID>,<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. The PBM is intended for the interface with channel Protocol ID `<destination PID>`.

See the PBM parameter descriptions in the table below.

Parameter Description		
<destination PID>	0..7	Protocol ID of the data channel, linked to the destination interface of the receiver.
<length>		Message length - the data array length, max. 64 bytes. Zero-length allowed.
<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.
<destination PID>	0..7	Protocol ID of the data channel, linked to the destination interface of the receiver.
<data>		The PBM – a binary data array. Zero-length allowed.

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): demodulation of the incoming acoustic signal completed.
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 channel, 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:Instant message delivery status

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

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

Request		Instant 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.
	FAILED,im,<PID>	Delivery of an instant message failed.
	EXPIRED,ims,<PID>	A synchronous instant message has expired.

Here <PID> is the channel Protocol ID, described in detail in section 3.2.

For piggyback messages, use AT?DP (5.5.6) to request the delivery status.

	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 AT?DP: Piggyback message delivery status

Use AT?DP to request the status of a piggyback message delivery.

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

Request		Message delivery status
AT?DP	EMPTY	No messages are being delivered.
	DELIVERING,pbm,<PID>	Delivery of a PBM message is pending.

Here <PID> is the channel Protocol ID, described in detail in section 3.2.

	Example AT?DI
+++AT?DP	Get the current PBM delivery status.
+++AT?DP:5:EMPTY	No messages are being delivered.
+++AT*SENDPBM,4,12,test	Send PBM to address 12.
+++AT*SENDPBM:2:OK	
+++AT?DP	
+++AT?DP:16:DELIVERING,pbm,0	The PBM is being delivered.
+++AT?DP	Request the PBM delivery status.
+++AT?DP:5:EMPTY	No messages are being delivered.

5.5.7 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>.

If the Extended Protocol Mode is enabled (see 3.2.1), the notification will be output at all interfaces and will include the channel Protocol ID of the destination interface:

RECVIM,p<destination PID>,<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>. The instant message is intended for the interface with channel Protocol ID <destination PID>.

See the parameter descriptions in the table below.

		Parameter Description
<destination PID>	0..7	Protocol ID of the data channel, linked to the destination interface of the receiver.
<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 5.13.3. Signed number.
<integrity>		Incoming signal integrity level. See section 5.13.4.
<velocity>		Relative velocity of the devices, in m/s. See section 5.13.6. Signed number.
<data>		The instant message – a binary data array.

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 5.9.21.

For USBL-enabled devices (see 5.11): USBL positioning strings (USBLLONG, USBLANGLES, USBLPHYP, USBLPHYD) are always generated after RECV strings (RECVIM, RECVIMS, RECVPBM).

5.5.8 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>.

If the Extended Protocol Mode is enabled (see 3.2.1), the notification will be output at all interfaces and will include the channel Protocol ID of the destination interface:

RECVIMS,p<destination PID>,<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>. The IMS is intended for the interface with channel Protocol ID <destination PID>.

See the parameter descriptions in the table below.

		Parameter Description
<destination PID>	0..7	Protocol ID of the data channel, linked to the destination interface of the receiver.
<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 5.13.3. Signed number.
<integrity>		Incoming signal integrity level. See section 5.13.4.
<velocity>		Relative velocity of the devices, in m/s. See section 5.13.6. Signed number.
<data>		The IMS – a binary data array.

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 5.9.21.

For USBL-enabled devices (see 5.11): USBL positioning strings (USBLLONG, USBLANGLES, USBLPHYP, USBLPHYD) are always generated after RECV strings (RECVIM, RECVIMS, RECVPBM).

	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): demodulation of the incoming acoustic signal completed.
+++AT:51:RECVIMS,4,1,2,3349740860,182272,-40,120,0.1000,test	IMS received.

5.5.9 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>.

If the Extended Protocol Mode is enabled (see 3.2.1), the notification will be output at all interfaces and will include the channel Protocol ID of the destination interface:

RECVPBM,p<destination PID>,<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>. The PBM is intended for the interface with channel Protocol ID <destination PID>.

See the parameter descriptions in the table below.

		Parameter Description
<destination PID>	0..7	Protocol ID of the data channel, linked to the destination interface of the receiver.
<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 5.13.3. Signed number.
<integrity>		Incoming signal integrity level. See section 5.13.4.
<velocity>		Relative velocity of the devices, in m/s. See section 5.13.6. Signed number.
<data>		The PBM – a binary data array.

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 5.9.21.

For USBL-enabled devices (see 5.11): USBL positioning strings (`USBLLONG`, `USBLANGLES`, `USBLPHYP`, `USBLPHYD`) are always generated after `RECV` strings (`RECVIM`, `RECVIMS`, `RECVPBM`).

	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: demodulation of the incoming acoustic signal completed.
`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 5.10.4), the device will generate additional notifications about receiving and sending acoustic signals. Read more about these notifications below.

Notification	Description
BITRATE,<direction>,<bitrate>	Generated once the bitrate changed in remote-to-local or local-to-remote direction. See 5.13.1 and 5.13.2 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.
STATUS,<status>,<status_parameter>	Generated once the acoustic connection status changes. See section 5.7.4 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.
RECVFAILED,<velocity>, <rssi>,<integrity>	Device failed to demodulate the incoming signal.
RECVEND,<timestamp>, <duration>,<rssi>,<integrity>	Demodulation of acoustic signal completed.
RECVSRV,<dest>,<source>,service,<decoded>, <transmitted>,<rssi>,<integrity>	Burst data exchange service message received.
SENDSTART,<destination address>, <type>,<duration>,<delay>	Transmission of a <type> started.
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.
USBLPHYP,...	Only USBL-enabled devices: additional positioning string. See 5.11.3 for full format and details.
USBLPHYD,...	Only USBL-enabled devices: additional positioning string. See 5.11.4 for full format and details.

Please note: RECVEND means the device completed the demodulation procedure but does not indicate that demodulation was successful. A RECVFAILED notification follows **RECVEND** in case demodulation failed.

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 5.9.17.
<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 5.13.3 for more information.
<integrity>	Incoming signal's integrity level. See section 5.13.4 for more information.
<destination address>	Network address of the remote device.
<source>	
<decoded>	
<transmitted>	
<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 5.10.4) 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**.

See an example below for burst data exchange with extended notifications.

	Example Extended notifications
`test`	Send burst data to Remote address.
`+++AT:27:STATUS,INITIATION,ESTABLISH`	Acoustic connection status.
`+++AT:28:SENDSTART,3,service,122880,0`	Connection establishement: start of service message transmission.
`+++AT:35:SENDEND,3,service,4073393947,122880`	End of service message transmission.
`+++AT:9:RECVSTART`	Incoming acoustic signal detected.
`+++AT:33:RECVEND,4073760159,141312,-67,120`	Demodulation of incoming signal completed.
`+++AT:20:STATUS,ONLINE,STABLE`	Acoustic link is now ONLINE.
`+++AT:31:RECVSRV,3,1,service,0,0,-67,120`	Service message received.
`+++AT:19:BITRATE,local,38461`	Bitrate information.
`+++AT:30:SENDSTART,3,burst,42402,110000`	Start of burst data transmission.
`+++AT:32:SENDEND,3,burst,4074011471,42402`	End of burst data transmission.
`+++AT:33:SENDSTART,3,service,155648,180963`	Start of service message transmission.
`+++AT:35:SENDEND,3,service,4074234227,155648`	End of service message transmission.
`+++AT:9:RECVSTART`	Incoming acoustic signal detected.
`+++AT:33:RECVEND,4074633207,141312,-67,120`	Demodulation of incoming signal completed.
`+++AT:31:RECVSRV,3,1,service,1,1,-67,120`	Service message received.
`+++AT:19:BITRATE,local,38461`	Bitrate information.
`+++AT:33:SENDSTART,3,service,155648,110000`	Start of service message transmission.
`+++AT:35:SENDEND,3,service,4074884519,155648`	End of service message transmission.
`+++AT:9:RECVSTART`	Incoming acoustic signal detected.
`+++AT:33:RECVEND,4075283499,141312,-67,120`	Demodulation of incoming signal completed.
`+++AT:31:RECVSRV,3,1,service,0,0,-67,120`	Service message received.
`+++AT:19:BITRATE,local,38461`	Bitrate information.
`+++AT:33:SENDSTART,3,service,155648,110000`	Start of service message transmission.
`+++AT:35:SENDEND,3,service,4075534811,155648`	End of service message transmission.
`+++AT:9:RECVSTART`	Incoming acoustic signal detected.
`+++AT:33:RECVEND,4075933791,141312,-67,120`	Demodulation of incoming signal completed.
`+++AT:31:RECVSRV,3,1,service,0,0,-67,120`	Service message received.
`+++AT:19:BITRATE,local,38461`	Bitrate information.
`+++AT:33:SENDSTART,3,service,155648,110000`	Start of service message transmission.
`+++AT:35:SENDEND,3,service,4076185103,155648`	End of service message transmission.
`+++AT:28:STATUS,INITIATION,DISCONNECT`	Acoustic connection status.
`+++AT:9:RECVSTART`	Incoming acoustic signal detected.
`+++AT:33:RECVEND,4076584083,141312,-67,120`	Demodulation of incoming signal completed.
`+++AT:31:RECVSRV,3,1,service,0,0,-67,120`	Service message received.
`+++AT:19:BITRATE,local,38461`	Bitrate information.
`+++AT:33:SENDSTART,3,service,110592,110000`	Start of service message transmission.
`+++AT:35:SENDEND,3,service,4076835395,110592`	End of service message transmission.
`+++AT:24:STATUS,INITIATION,LISTEN`	Acoustic connection status.

5.7 Status requests

5.7.1 AT?MODE: Command interpreter

AT?MODE requests the command interpreter type (see 3.3.4), 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?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

5.7.3 AT?BV: Battery Voltage

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

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.
		28.87	The voltage is 28.87 V.
		AT!BV	
		ERROR WRONG FORMAT	

5.7.4 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 5.10.5.

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 3.3). 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.
Remote Address	Network address of the remote 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.
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	
Gain: 0	
Carrier Waveform ID: 2	
Local Address: 11	
Remote Address: 0	
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	
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	
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 5.9.16 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
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: global

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 5.10.4), 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 5.10.4.

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
- 3-3

We recommend using the 0 - 1 combination for communications between 2 devices. The 2 - 2 and 3 – 3 combinations are optimal for networking. Modem groups with different carrier waveform IDs can operate relatively close to each other without "overhearing" transmissions of the neighbouring network.

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 5.10.4) 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 5.10.4.

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..31

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	500..1200 (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.

Selecting the value Retry Timeout should be long enough for the signal to travel to the remote device and back, and should take into account the signal's duration as well.

As a rule of thumb, Retry Timeout value should exceed the **round-trip** time that corresponds to the device's maximum operation range **plus 1 second** to account for the maximum duration of the acoustic signal.

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 Retry Timeout should exceed 5000 ms (4 s round-trip-time plus 1 s signal duration).

Certain high-speed applications might require setting the Retry Timeout as short as possible.

SENDEND extended notifications (see 5.6) contain information about the sent acoustic signals. You can analyse the SENDEND messages to estimate the average signal duration for your communication scenario and use this value to set the Retry Timeout.

See 5.6 and 5.10.4 for details on SENDEND and extended notifications.

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 1..255	The acoustic connection will remain online. 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!KO0	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?PID, AT?ZS and AT!ZSn: Channel Protocol ID

Each input-output interface of your device is assigned to a particular data channel - a virtual channel for burst data and instant message exchange. Each data channel has a unique identifier - the Protocol ID. According to the channel's Protocol ID, data from the input-output interface of the transmitter is directed to the input-output interface of the receiver.

Protocol ID corresponds to the -p parameter of the command interpreter, enabled for the input-output interface (3.3.3).

The AT?ZS request returns the Protocol ID of the channel, associated with the current interface - the interface used to access the device. AT?PID performs the identical action - this command will be deprecated in future versions of the firmware.

Use AT!ZSn to change the Protocol ID of the current interface: the interface will be mapped to another data channel, and burst data and instant messages will be directed to another input-output interface of the receiver.

If the new Protocol ID value was already assigned to another interface of the local device, the interfaces will swap data channels. For example, if the current interface was mapped to a data channel with Protocol ID 1, and the other interface - to Protocol ID 3, when you assign the current interface to Protocol ID 3, the other interface of the local device will be assigned to Protocol ID 1.

To redirect instant messages to another interface of the receiver without changing the data channel, you can use the **Extended Protocol Mode** (see 5.10.2). In this mode, commands to transfer instant messages must include the data channel Protocol ID of the receiver's destination interface.

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

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

+++	Switch to Command Mode.
OK	
AT?ZS	Get the channel Protocol ID of the interface in use.
0	The interface is associated with Protocol ID 0.
AT?PID	Get the channel Protocol ID of the interface in use.
0	The interface is associated with Protocol ID 0.
AT!ZS1	Set the Protocol ID to 1.
ERROR NO CONTROL	Global Settings Control is disabled for the current channel.
AT@CTRL	Enable Global Settings Control for the current channel.
OK	
AT!ZS1	Set the Protocol ID to 1.
OK	
AT?ZS	The current interface is now associated with
1	Protocol ID 1.
AT?PID	Get the channel Protocol ID of the interface in use.
1	The interface is associated with Protocol ID 1.
AT!ZS8	
ERROR OUT OF RANGE	
AT?ZS5	
ERROR WRONG FORMAT	

5.9.15 AT?ZSL: Interface List

Each input-output interface of your device is assigned to a particular data channel - a virtual channel for burst data and instant message exchange. Each data channel has a unique identifier - the channel's Protocol ID. According to the channel's Protocol ID, data from the input-output interface of the transmitter is directed to the input-output interface of the receiver.

AT?ZSL requests the Interface List: a list of channel Protocol ID's and Interface Strings of input-output interfaces, mapped to those channels (see 3.3 for more information).

View Setting	Change Setting	Options	Range
AT?ZSL		n	0..7

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

5.9.16 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)[7]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 Configuration Utility**. Read more about using the **S2C Configuration Utility** in section A.1. Alternatively, you can use shell commands of the **S2C Configuration Shell**, see B.

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	

5.9.17 `AT?CLOCK`: System Clock

`System Clock` is a 32 bit microseconds counter, used for internal timekeeping. This counter defines the physical layer time of your device.

`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.

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

5.9.18 AT?UTX: System Time and System Clock

Use AT?UTX to view the current data link layer time (System Time, see 5.9.16 and physical layer time (System Clock, see 5.9.17).

The device will return the space-separated System Time and System Clock timestamps:

<System Time> <System clock>

View Value	Range
AT?UTX	floating point (seconds, System time) 0..2^{32} (microseconds, System Clock)

Example AT?UTX

+++ATC	Switch to Command Mode.
OK	
AT?UTX	Request the System Time and System Clock timestamps.
1548252670.262295 4054138242	The System Time and System Clock timestamps.

5.9.19 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 5.11).

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	

5.9.20 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	

5.9.21 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 5.5.7) 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: demodulation of the incoming acoustic signal completed.
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: demodulation of the incoming acoustic signal completed. 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 Settings and requests: interface and data channel

The following commands display or modify settings, specific to the selected interface and/or data channel (see section 3 and 2.1.3 for more information on input-output interfaces and data channels).

5.10.1 AT?CTRL and AT@CTRL: Global Settings Control

This parameter defines, if the command interpreter of the current interface - the interface you are using to access the device - executes control commands that modify global device settings. These commands are described in section 5.9.

Global Settings Control corresponds to the -c parameter of the command interpreter of an interface (see section 3.3.4 for details).

If Global Settings Control is enabled, the command interpreter of the current interface will execute control commands that modify global device settings. Otherwise, the device will generate an error message whenever a global setting modification is attempted.

Only one interface of your device can be used to execute global settings' modifications. If you enable Global Settings Control for an interface, it will be automatically disabled for other interfaces of your device.

Use the AT?CTRL command to check, if modifying global settings is enabled for the current interface.

Use AT@CTRL to enable Global Settings Control for the current interface, if needed.

It is impossible to turn off Global Settings Control for an interface in use to access the device. Global Settings Control will only be disabled, once it's turned on for another interface.

View Setting	Options	Description
AT?CTRL	0	Global Settings Control Off: global settings modification disabled.
	1	Global Settings Control On: global settings modification enabled.

Change Setting	Description
AT@CTRL	Global Settings Control On: global settings modification enabled.

Example AT?CTRL and AT@CTRL

+++	Switch to Command Mode.
OK	
AT?L	Check the Source Level value.
1	Source Level is currently set to 1.
AT!L2	Set Source Level to 2.
ERROR NO CONTROL	Global Settings Control is disabled for the current channel, setting modification is not allowed.
AT@CTRL	Enable Global Settings Control for the current channel.
OK	
AT!L2	Set Source Level to 2.
OK	
AT?L	Check the current Source Level value.
2	Source Level is now set to 2.
AT!CTRL3	
ERROR WRONG FORMAT	
AT!CTRL0	Its impossible to turn off Global Settings Control.
ERROR WRONG FORMAT	

5.10.2 AT?ZF and AT@ZFn: Extended Protocol Mode

Each input-output interface of a device is associated with a particular data channel. Data channels allow to route burst data and instant messages between input-output interfaces of communicating devices: data from a certain input-output interface of the transmitter is directed to a certain input-output interface of the receiver. **Extended Protocol Mode** defines, how burst data and instant messages are routed between different data channels.

If **Extended Protocol Mode** is disabled, burst data and instant messages from the sender's input-output interface are directed to the receiver's input-output interface linked to the same data channel. The channel Protocol IDs of the sender and the receiver match.

In this case, to have burst data and instant messages output at another interface of the receiving device, you must switch to that data channel - change the channel Protocol ID of the current interface to match the channel Protocol ID of the destination interface.

If **Extended Protocol Mode** is enabled, instant messages from the sender can be specifically addressed to a receiver's interface, no matter what data channel it is linked to. In this mode, control commands to send instant messages must simply include the channel Protocol ID of the receiver's destination interface. There is no need to switch to another data channel, if the instant message has to be output at another interface of the receiver.

Instant messages will be received by all data channels and output at interfaces linked to them, and notification about instant message reception will include Protocol ID of the data channel it is intended for.

Burst data is not affected by **Extended Protocol Mode**: incoming data will be automatically transferred over the acoustic channel and output at the interface with the matching channel Protocol ID. To have burst data output at another interface of the receiving device, you must switch to that data channel - change the channel Protocol ID of the current interface to match the channel Protocol ID of the destination interface.

Extended Protocol Mode corresponds to the `-f` parameter of the command interpreter of an interface (see section 3.3.4 for details).

View Setting	Change Setting	Options		Description
AT?ZF	AT@ZFn	n	0	Extended Protocol Mode disabled.
			1	Extended Protocol Mode enabled.

	Example AT?ZF and AT!ZFn
+++	Switch to Command Mode.
OK	
AT?ZF	Check the Extended Protocol Mode status.
0	Extended Protocol Mode is disabled.
AT*SENDIM,4,10,ack,test	Send IM to address 10 with acknowledgement request.
OK	
DELIVEREDIM,10	Data was successfully delivered.
AT!ZF1	Enable Extended Protocol Mode.
OK	
AT?ZF	Check the Extended Protocol Mode status.
1	Extended Protocol Mode is enabled.
AT*SENDIM,4,10,ack,test	Send IM to address 10 with acknowledgement request.
ERROR WRONG FORMAT	In Extended Protocol Mode, channel Protocol ID of a receiver's interface must be included in the command.
AT*SENDIM,p3,4,10,ack,test	Command includes the Protocol ID of the destination.
OK	
DELIVEREDIM,10	Data was successfully delivered.

5.10.3 AT?ZB and AT@ZBn: Notifications Control

The Notifications Control allows to enable or disable notifications output for the selected data channel.

Notifications (5.1.4) are strings the local device generates to inform about receiving instant messages, instant message delivery reports, positioning strings etc.

When Notifications Control is off for a data channel, the device does not output any notifications. The device does not output anything besides burst data, command responses and error messages.

View Setting	Change Setting	Options		Description
AT?ZB	AT@ZBn	n	0	Off: The device will not output notifications.
			1	On: The device will output notifications.

Example AT?ZB and AT@ZBn

+++	Switch to Command Mode.
OK	
AT?ZB	Get the current Notifications Control.
0	Notifications output is disabled.
AT*SENDIM,1,2,ack,t	Send IM to address 2 with delivery notification.
OK	Command response.
	No delivery report notification.
AT@ZB1	Enable notifications.
OK	
AT*SENDIM,1,2,ack,t	Send IM to address 2 with delivery notification.
OK	Command response.
DELIVEREDIM,2	Notification: IM delivered.

5.10.4 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 section 5.6 for the list of notification that can be enabled or disabled for the selected data channel.

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.

5.10.5 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

5.10.6 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.

5.10.7 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 5.7.4 for details).

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

This command has effect only for USBL-series devices. Other commands, that only affect USBL-capable devices are described in section 5.11 that follows.

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 5.11.1) or USBLANGLES (see 5.11.2) 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.

5.10.9 AT?ECLK, AT?ZA and AT@ZA: External Clock Output

These commands have effect only for devices with an optional Advanced Timekeeping Module (ATM) installed.

A Chip Scale Atomic Clock (CSAC) is optionally integrated into the ATM. The ATM accepts an external 1 PPS (pulse-per-second) input from a GPS receiver. The atomic clock can be synchronized to the 1 PPS and UTC time from the GPS receiver, so the ATM replaces the 32 bit counter as the physical layer clock to provide a highly precise local timing reference during subsea deployment.

Read more about device timekeeping in section 4.4.

See the Factory Certificate of your device to check if it is equipped with an Advanced Timekeeping Module with or without an integrated atomic clock.

The External Clock Output parameter defines if the device with an Advanced Timekeeping Module should automatically output 1 PPS strings with current clock values.

If External Clock Output is on, the device automatically generates External Clock ECLK strings that correspond to 1 PPS signals either from the CSAC or the external GPS receiver (see details below). The External Clock strings contain the current system time, physical layer clock and the UTC time (the latter if NMEA input from GPS is available, see 4.4.1).

View Setting	Change Setting	Options		Description
AT?ZA	AT@ZAn	n	0	Off: The device will not generate External Clock strings.
			1	On: The device will generate External Clock strings.

The External Clock Output ECLK string format is:

```
ECLK,<system time>,<physical clock time>,<current steer>,
<status flag>,<UTC time>
```

AT?ECLK allows to request the string with current clock values independently from the automatic External Clock Output.

A response to AT?ECLK has the following format:

```
<system time>,<physical clock time>,<current steer>,
<status flag>,<UTC time>
```

For devices without the ATM, AT?ECLK will produce an External Output String will zero values.

Detailed parameter descriptions are listed in the table below.

Parameter	Description
ECLK	String header, indicates automatic External Clock String output.
<system time>	Timestamp of the string output, in the local device's System Time, in s (s.ssssss).
<physical clock time>	Physical layer clock timestamp of the string output, the 0..2^{32} 32-bit counter value, in microseconds.
<current steer>	If the CSAC is absent, current steer (in pp10^{-12}) indicates the estimated frequency steer (adjustment) between the physical layer clock and the GPS 1 PPS. current steer is always 0 when the CSAC is installed.
<status flag>	Indicates the status of the ECLK output: 0 = ECLK corresponds to 1 PPS CSAC output, CSAC in normal operation. 1 = ECLK corresponds to 1 PPS CSAC output, CSAC in unlocked condition (for example, during warm-up). 2 = ECLK corresponds to 1 PPS output from external GPS receiver.
<UTC time>	UTC timestamp of the 1 PPS output, in seconds (s.ssssss): corresponds to 1 PPS CSAC output if CSAC is available, corresponds to 1 PPS GPS output if CSAC is not available.

If NMEA input from the GPS receiver is not available (see more on NMEA input in section 4.4.1), the UTC time field will contain zeros.

Example AT?ZA and AT@ZAn	
+++	Switch to Command Mode.
OK	
AT?ECLK	Request the current clock values.
48.498445,44867731,0,0,0.000000	External Clock output string with system time and system clock, UTC unavailable - no NMEA input from GPS (see 4.4).
AT@ZA1	Enable automatic External Clock Output.
OK	External Clock Output is enabled.
ECLK,55.498623,51867731,0,0,0.000000	ECLK string, UTC unavailable - no NMEA input from GPS.
ECLK,56.498642,52867731,0,0,0.000000	ECLK string, UTC unavailable - no NMEA input from GPS.
ECLK,57.498659,53867731,0,0,0.000000	ECLK string, UTC unavailable - no NMEA input from GPS.
ECLK,1064.946264,99506814,0,0,1479395424.000000	ECLK string, corresponds to CSAC 1 PPS.
ECLK,1065.946285,100506814,0,0,1479395425.000000	ECLK string, corresponds to CSAC 1 PPS.
ECLK,997.992923,32506814,0,2,1479395357.000000	ECLK string, corresponds to GPS 1 PPS.
ECLK,998.944786,33506814,0,0,1479395358.000000	ECLK string, corresponds to 1 PPS from CSAC.
ECLK,998.995500,33506814,0,2,1479395358.000000	ECLK string, corresponds to GPS 1 PPS.
ECLK,999.944805,34506814,0,0,1479395359.000000	ECLK string, corresponds to CSAC 1 PPS.

5.11 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.

Please note: to avoid errors due to proximity to ferromagnetic materials, a magnetic mapping procedure is required after a device with a built-in AHRS is installed within its deployment infrastructure. See the **AHRS Calibration Guide** for details.

5.11.1 USBLLONG: Positioning Data Output

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

If Positioning Data Output (see 5.10.8) 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 C 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 5.13.3 for more information.
<integrity>	Signal integrity level. See section 5.13.4 for more information.
<accuracy>	Accuracy of the position fix, in m.

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

Each position fix is obtained based on position estimates from several elementary USBL antennas (transducer triads). Deviations from the average value are computed to obtain the **position fix accuracy** as the standard deviation in meters.

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 during instant message exchange between the local device and the target - direction to the target upon instant message reception, distance - upon reception of instant message acknowledgements.

USBL positioning strings (USBLLONG, USBLANGLES, USBLPHYP, USBLPHYD) are always generated after RECV strings (RECVIM, RECVIMS, RECVPBM).

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.

If the device **failed to estimate direction to the target** (i.e. target position fix failed), USBLANGLES accuracy field will contain -1 (see section 5.11.2 below).

5.11.2 USBLANGLES: Target Direction Output

If Positioning Data Output (see 5.10.8) 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 C 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 5.13.3 for more information.
<integrity>	Signal integrity level. See section 5.13.4 for more information.
<accuracy>	Accuracy of the position fix, in radians. -1 if the device failed to estimate bearing and elevation of the target.

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 during instant message exchange between the local device and the target - direction to the target upon instant message reception.

Each position fix is obtained based on position estimates from several elementary USBL antennas (transducer triads). Deviations from the average value are computed to obtain the **position fix accuracy** as the standard deviation in radians.

If the device **failed to estimate direction to the target** (i.e. target position fix failed), USBLANGLES accuracy field will contain -1.

USBL positioning strings (USBLLONG, USBLANGLES, USBLPHYP, USBLPHYD) are always generated after RECV strings (RECVIM, RECVIMS, RECVPBM).

5.11.3 USBLPHYP: Coordinates Array Output

If Positioning Data Output (see 5.10.8) and Extended Notifications (see 5.10.4) are enabled for the current data channel, the device also generates a USBLPHYP string following a USBLLONG or USBLANGLES string once the target position or target direction was obtained.

The array of 5 elementary transducers composing the USBL antenna is shown in figure 2 below.

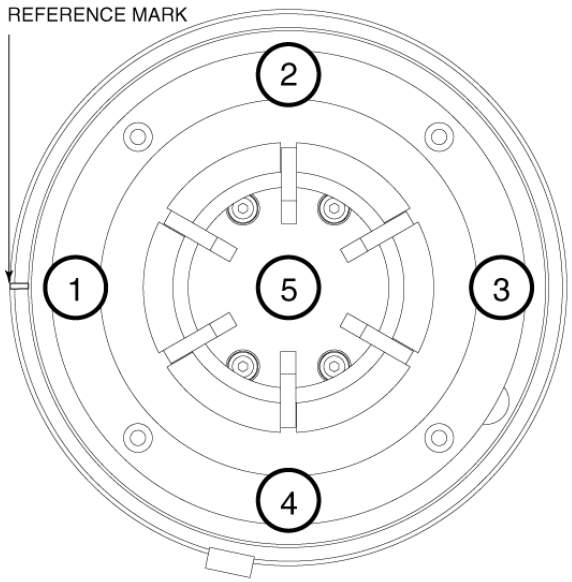

Figure 2: USBL antenna: transducer array

6 elementary arrays of three transducers per array are used to obtain 6 estimations of target coordinates in the local reference frame (see C 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:

USBLPHYP,<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.

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 during instant message exchange between the local device and the target - direction to the target upon instant message reception, distance - upon reception of instant message acknowledgements.

USBL positioning strings (USBLLONG, USBLANGLES, USBLPHYP, USBLPHYD) are always generated after RECV strings (RECVIM, RECVIMS, RECVPBM).

	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 C for the local reference frame and figure 2 for transducer numbering within the array.

5.11.4 USBLPHYD: Transducer Delays Output

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

If Positioning Data Output (see 5.10.8) and Extended Notifications (see 5.10.4) are enabled for the current data channel, the device generates a USBLPHYD string following a USBLPHYP string (after USBLLONG or USBLANGLES).

Acoustic signal from a transponder, attached to the tracking target, is received by the transducer array of the USBL antenna. TThe 5 transducers of the USBL antenna are shown in figure 2 in the previous section (see 5.11.3).

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 during instant message exchange between the local device and the target - direction to the target upon instant message reception, distance - upon reception of instant message acknowledgements.

USBL positioning strings (USBLLONG, USBLANGLES, USBLPHYP, USBLPHYD) are always generated after RECV strings (RECVIM, RECVIMS, RECVPBM).

5.11.5 AT?UP: Positioning (Deprecated)

Please note: this command is deprecated and will be removed in future versions of the firmware. We recommend to use Positioning Data Output (5.11.1) instead.

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 5.9.16).
<remote address>	The target's network address.
<X>,<Y>,<Z>	Coordinates, in m, floating point. See section C 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 C

5.11.6 AT?UPX: Motion-Compensated Positioning (Deprecated)

Please note: this command is deprecated and will be removed in future versions of the firmware. We recommend to use Positioning Data Output (5.11.1) instead.

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 C for the local reference frame).

Please note: to avoid errors due to proximity to ferromagnetic materials, a magnetic mapping procedure is required after a device with a built-in AHRS is installed within its deployment infrastructure. See the **AHRS Calibration Guide** for details.

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 5.9.16).
<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.

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

	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	

5.12 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.

5.12.1 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 5.12.2).

View Setting	Change Setting	Options	Range
AT?DA	AT!DAn	n	1..255 (s)

A new Wake-Up Active Time setting is **deferred until reboot**. Use AT&W (see 5.8.2) to store settings into the non-volatile memory of the device, so new value be applied after reset or shutdown.

	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	

5.12.2 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 5.12.1). NOTE: Duration of the active interval must be less than the total duration of the Wake-Up cycle.

View Setting	Change Setting	Options	Range
AT?DT	AT!DTn	n	1..255 (s)

A new Wake-Up Period setting is **deferred until reboot**. Use AT&W (see 5.8.2) to store settings into the non-volatile memory of the device, so new value be applied after reset or shutdown.

	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	

5.12.3 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	

5.12.4 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 5.12.5.

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.

5.12.5 AT?DR and AT!DRn: Remote Active Time

If using **Awake Remote Mode** (see section 5.12.4) 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	1..255 (s)

5.13 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.

5.13.1 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[10]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 5.10.4), 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.

You can turn extended notifications off with the AT@ZXn command, see more in section 5.10.4.

5.13.2 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:

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

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

If extended notifications are turned on for the current data channel (see 5.10.4), 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.

5.13.3 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	

5.13.4 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	

5.13.5 AT?T: Propagation Time

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

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	

5.13.6 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	

5.13.7 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 5.13.4).

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	

5.13.8 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>[11].

	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 5.13.3 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!

[11] 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.

5.14 Remote Device Control extension: commands and requests

Firmware versions 1.8 and higher support the **Remote Device Control** extension of the AT command set: Remote Device Control commands and requests can be sent to a remote device over the acoustic channel.

Once you enter a command or request in corresponding format, devices will automatically exchange synchronous instant messages (IMS, see 5.5.2) to perform the required action.

If extended notifications are turned on for the current data channel (see 5.10.4), the local device will generate notifications about receiving and sending acoustic signals during IMS exchange.

Remote Device Control commands and requests can be executed with a web-based **Transponder Communication Utility**, optionally available for devices with an Ethernet interface (see more in appendix A.2).

5.14.1 `AT%STATUS`: Status

`AT%STATUS` returns the current state of Remote Device Control.

The command format is following:

```
AT%STATUS
```

Your device will generate a corresponding notification:

```
%STATUS,<Status message>
```

The `Status message` informs about the current state of Remote Device Control:

		Parameter Description
`<Status message>`	idle	Remote Device Control is idle.
	busy:local	Remote Device Control state is busy, the local device is performing control actions over a remote device.
	busy:remote	Remote Device Control state is busy, a remote device is performing control actions over the local device.
	busy:error	The system encountered an error.

5.14.2 `Unsupported`: Wrong command syntax notification

Your device will generate a corresponding message, if a command or request of the Remote Device Control extension contains syntax errors:

```
%STATUS,unsupported
```

	Example AT%STATUS
+++	Switch to Command Mode.
OK	
AT%PRESSURE	Command is in wrong format.
OK	
%STATUS,unsupported	Wrong format message.

5.14.3 AT%RESET: Reset

Use AT%RESET to cancel a Remote Device Control command or request currently in progress.

The command format is following:

AT%RESET

This command will cancel any command or request, initiated by the local device, as well as any command or request, remotely initiated to be performed on the local device.

It will automatically clear the transmission buffer – and drop burst data and instant messages (see ATZ4 in section 5.3.8).

Your device will generate a corresponding notification:

%RESET,done

	Example AT%RESET
+++	Switch to Command Mode.
OK	
AT%RELEASE,1,4,release	Send command to remote device with address 1 to release, retry 4 times (5.14.4).
OK	
SENDSTART,10,ims,172032,0	Extended notifications: devices exchange IMS
SENDEND,10,ims,3974101543,172032	to perform the requested action.
SENDSTART,10,ims,172032,174480	
SENDEND,10,ims,3975301543,172032	
SENDSTART,10,ims,172032,173529	
SENDEND,10,ims,3976501543,172032	
AT%RESET	Reset Remote Device Control.
OK	
%RESET,done	Remote Device Control was reset.

5.14.4 AT%RELEASE: Acoustic Release Control

AT%RELEASE allows to control the acoustic release mechanism of a remote device.

The command format is following:

AT%RELEASE,<Destination Address>,<Retry>,<Command>,<Releaser ID>

See the parameter descriptions in the table below.

		Parameter Description
<Destination Address>	1..Highest Address	Network address of the remote device.
<Retry>		Number of command retries. (if the remote device has a Wake-Up Module installed, <Retry> must exceed the Wake-Up Period (5.12.2).
<Command>	check	Check status of the Acoustic Release.
	release	Send command to Release the mechanism.
	salvage	Send command to Salvage remote device.
<Releaser ID>	0..1	ID of the acoustic release mechanism of the remote device.

If the remote device is only equipped with one acoustic release mechanism, <Releaser ID> and the preceding comma can be omitted, as shown below:

AT%RELEASE,<Destination Address>,<Retry>,<Command>

Please note: the option to use the command without the <Releaser ID> parameter will be deprecated in future versions of the firmware. **We recommend using the full format of the command**.

Once the local device receives an answer from the remote device, it will generate a corresponding notification:

%RELEASE,<Remote Address>,<Releaser ID>,<Message>,
<Range>,<rssi>,<integrity>

or

%RELEASE,<Remote Address>,failed

If the initial command did not include the <Releaser ID>, it will not be present in the notification either:

%RELEASE,<Remote Address>,<Message>,<Range>,<rssi>,<integrity>

See the parameter descriptions in the table below.

		Parameter Description
<Remote Address>	1..Highest Address	Network address of the remote device.
<Releaser ID>	0..1	ID of the acoustic release mechanism of the remote device, will be omitted (including preceding comma) if is was absent in the command.
<Message>	heating	Releaser is heating.
	salvaging	Releaser being salvaged.
	opened	Releaser opened.
	closed	Releaser closed.
	opened:S	Releaser opened after S seconds of heating.
	closed:S	Releaser closed after S seconds of heating.
<Range >		Distance to remote device in meters, assuming speed of sound is 1500 m/s.
<rssi>		Received Signal Strength Indicator. See section 5.13.3. Signed number.
<integrity>		Incoming signal integrity level. See section 5.13.4.

	Example AT%RELEASE
+++	Switch to Command Mode.
OK	
AT%RELEASE,1,4,release	Send command to remote device with address 1 to release, retry 4 times.
OK	
%RELEASE,1,heating,500.002,-74,120	Remote releaser is heating.
%RELEASE,1,opened:10.0,,-74,120	Remote releaser opened after 10 seconds of heating.
AT%RELEASE,1,1,check,1	Check remote releaser with releaser ID 1.
OK	
%RELEASE,1,0,closed,-0.461,-74,135	Remote releaser with releaser ID 1 is closed.

5.14.5 AT%VOLTAGE: Check battery voltage

Use AT%VOLTAGE to check the battery voltage of the remote device.

The command format is following:

AT%VOLTAGE,<Destination Address>,<Retry>

See the parameter descriptions in the table below.

		Parameter Description
<Destination Address>	1..Highest Address	Network address of the remote device.
<Retry>		Number of command retries. (if the remote device has a Wake-Up Module installed, <Retry> must exceed the Wake-Up Period (5.12.2).

Once the local device receives an answer from the remote device, it will generate a corresponding notification:

%VOLTAGE,<Remote Address>,<Value>,<Range>,<rssi>,<integrity>

or

%VOLTAGE,<Remote Address>,failed

See the parameter descriptions in the table below.

		Parameter Description
<Remote Address>	1..Highest Address	Network address of the remote device.
<Value>		Battery voltage value, in V.
<Range >		Distance to remote device in meters, assuming speed of sound is 1500 m/s.
<rssi>		Received Signal Strength Indicator. See section 5.13.3. Signed number.
<integrity>		Incoming signal integrity level. See section 5.13.4.

Example AT%VOLTAGE	
+++	Switch to Command Mode.
OK	
AT%VOLTAGE,1,4	Send command to check battery voltage to a remote device with address 1, retry 4 times.
OK	
%VOLTAGE,1,24.10,500.002,-74,120	Battery voltage of the remote device is 24.10 V.

5.14.6 AT%PRESSURE: Check pressure sensor data

Use AT%PRESSURE to check the pressure sensor data of the remote device.

The command format is following:

AT%PRESSURE,<Destination Address>,<Retry>

See the parameter descriptions in the table below.

		Parameter Description
<Destination Address>	1..Highest Address	Network address of the remote device.
<Retry>		Number of command retries. (if the remote device has a Wake-Up Module installed, <Retry> must exceed the Wake-Up Period (5.12.2).

Once the local device receives an answer from the remote device, it will generate a corresponding notification:

%PRESSURE,<Remote Address>,<Value>,<Range>,<rssi>,<integrity>

or

%PRESSURE,<Remote Address>,failed

See the parameter descriptions in the table below.

		Parameter Description
<Remote Address>	1..Highest Address	Network address of the remote device.
<Value>		Pressure sensor data, in dBar.
	nothing	If no pressure sensor is installed.
<Range >		Distance to remote device in meters, assuming speed of sound is 1500 m/s.
<rssi>		Received Signal Strength Indicator. See section 5.13.3. Signed number.
<integrity>		Incoming signal integrity level. See section 5.13.4.

	Example AT%PRESSURE
+++	Switch to Command Mode.
OK	
AT%PRESSURE,1,4	Send command to request pressure sensor data to a remote device with address 1, retry 4 times.
OK	
%PRESSURE,1,39.41,500.002,-74,120	Pressure sensor data of the remote device is 39.41 dBar.

5.14.7 AT%AHRS: Check AHRS data

Use AT%AHRS to check the AHRS sensor data of the remote device.

The command format is following:

AT%AHRS,<Destination Address>,<Retry>

See the parameter descriptions in the table below.

		Parameter Description
<Destination Address>	1..Highest Address	Network address of the remote device.
<Retry>		Number of command retries. (if the remote device has a Wake-Up Module installed, <Retry> must exceed the Wake-Up Period (5.12.2).

Once the local device receives an answer from the remote device, it will generate a corresponding notification:

%AHRS,<Remote Address>,<Value>,<Range>,<rssi>,<integrity>

or

%AHRS,<Remote Address>,failed

See the parameter descriptions in the table below.

		Parameter Description
<Remote Address>	1..Highest Address	Network address of the remote device.
<Value>		Pitch:Roll:Yaw angles in NED (North East Down) reference frame, in degrees.
	nothing	If no AHRS sensor is installed.
<Range >		Distance to remote device in meters, assuming speed of sound is 1500 m/s.
<rssi>		Received Signal Strength Indicator. See section 5.13.3. Signed number.
<integrity>		Incoming signal integrity level. See section 5.13.4.

	Example AT%AHRS
+++	Switch to Command Mode.
OK	
AT%AHRS,1,4	Send command to request pressure sensor data to a remote device with address 1, retry 4 times.
OK	
%AHRS,1,0.00:0.00:0.00,500.002,-74,120	Roll, Pitch and Yaw angles are 0.00.
AT@ZX1	Turning on extended notifications.
OK	
AT%AHRS,10,4	Request AHRS data from remote device with address 10, try 4 times.
OK	
SENDSTART,10,ims,163840,0	Try 1.
SENDEND,10,ims,3863571865,163840	
SENDSTART,10,ims,163840,171730	Try 2.
SENDEND,10,ims,3864771865,163840	
SENDSTART,10,ims,163840,169416	Try 3.
SENDEND,10,ims,3865971865,163840	
SENDSTART,10,ims,163840,169388	Try 4.
SENDEND,10,ims,3867171865,163840	
%AHRS,10,failed	Request failed after 4 attempts.

5.14.8 AT%OPTO: Optocoupler Control

If the remote device is equipped with an optional optocoupler, use AT%OPTO to control the optocoupler and check its state.

Use the following command to check the remote optocoupler(s) state:

AT%OPTO,<Destination Address>,<Retry>,check

See parameter descriptions in the table below.

		Parameter Description
<Destination Address>	1..Highest Address	Network address of the remote device.
<Retry>		Number of command retries. (if the remote device has a Wake-Up Module installed, <Retry> must exceed the Wake-Up Period (5.12.2).

Once the local device receives an answer from the remote device, it will generate a corresponding notification:

%OPTO,<Remote Address>,<Previous State>:<State>,<Range>,<rssi>,<integrity>

or

%OPTO,<Remote Address>,failed

See parameter descriptions in the table below.

		Parameter Description
<Remote Address>	1..Highest Address	Network address of the remote device.
<Previous State>	update or timeout	Indicates if the optocoupler(s) previous state was set manually (update) or was a roll-back after a timeout (timeout). See more on timeouts below.
<State>	0..3	Decimal representation of the current binary state of up to two optocouplers: 0 - optocoupler 1 off, optocoupler 2 off; 1 - optocoupler 1 on, optocoupler 2 off; 2 - optocoupler 1 off, optocoupler 2 on; 3 - optocoupler 1 on, optocoupler 2 on.
<Range >		Distance to remote device in meters, assuming speed of sound is 1500 m/s.
<rssi>		Received Signal Strength Indicator. See section 5.13.3. Signed number.
<integrity>		Incoming signal integrity level. See section 5.13.4.

Use the following command to switch the remote optocoupler(s) on/off:

AT%OPTO,<Destination Address>,<Retry>,set,<State>,<Timeout>

See parameter descriptions in the table below.

Parameter Description		
<Destination Address>	1..Highest Address	Network address of the remote device.
<Retry>		Number of command retries. (if the remote device has a Wake-Up Module installed, <Retry> must exceed the Wake-Up Period (5.12.2).
<State>	0..3	Decimal representation of binary state of up to two optocouplers: 0 - optocoupler 1 off, optocoupler 2 off; 1 - optocoupler 1 on, optocoupler 2 off; 2 - optocoupler 1 off, optocoupler 2 on; 3 - optocoupler 1 on, optocoupler 2 on.
<Timeout>	0..22500	Optocoupler(s) state roll-back timeout, in ms. Once the timeout runs out, the optocoupler(s) will roll back to 0 (switched off). If Timeout is set to 0 or is out of range, roll-back is disabled - the optocoupler(s) will remain in the state set by the set command. If a new set command is received before a roll-back timeout runs out, optocoupler(s) will immediately switch to the new state and a new timeout will begin.

Once the local device receives an answer from the remote device, it will generate a corresponding notification:

%OPTO,<Remote Address>,<Previous State>:<State>,<Range>,<rssi>,<integrity>

or

%OPTO,<Remote Address>,failed

See parameter descriptions in the table below.

Parameter Description		
<Remote Address>	1..Highest Address	Network address of the remote device.
<Previous State>	update or timeout	Indicates if the optocoupler(s) previous state was set manually (update) or was a roll-back after a timeout (timeout). See more on timeouts above.
<State>	0..3	Decimal representation of the current binary state of up to two optocouplers: 0 - optocoupler 1 off, optocoupler 2 off; 1 - optocoupler 1 on, optocoupler 2 off; 2 - optocoupler 1 off, optocoupler 2 on; 3 - optocoupler 1 on, optocoupler 2 on.
<Range >		Distance to remote device in meters, assuming speed of sound is 1500 m/s.
<rssi>		Received Signal Strength Indicator. See section 5.13.3. Signed number.
<integrity>		Incoming signal integrity level. See section 5.13.4.

	Example AT%OPTO
+++	Switch to Command Mode.
OK	
AT%OPTO,2,4,check	Check optocoupler state for remote device with address 2, retry 4 times.
OK	
%OPTO,2,update:0,-0.491,-62,98	Optocoupler state is 0 - optocoupler 1 is off, optocoupler 2 is off, previous state was set manually.
AT%OPTO,2,4,set,1,2000	Set optocouplers for remote device with address 2 to state 1, retry 4 times, roll-back to previous state after 2 seconds.
OK	
%OPTO,2,update:1,-0.491,-62,98	Optocoupler state is now 1 - optocoupler 1 is on, optocoupler 2 is off, previous state was set manually.
AT%OPTO,2,4,check	Check optocoupler state for remote device with address 2, retry 4 times.
OK	
%OPTO,2,timeout:0,-0.488,-62,98	Optocoupler state is 1 - optocoupler 1 is on, optocoupler 2 is off, previous state was a roll-back.
AT%OPTO,2,4,set,3,3000	Set optocouplers for remote device with address 2 to state 3, retry 4 times, roll back to previous state after 3 seconds.
OK	
%OPTO,2,timeout:3,-0.490,-62,99	Optocoupler state is now 3 - optocoupler 1 is on, optocoupler 2 is on, previous state was a roll-back.

5.14.9 AT%CONFIG: Change Remote Device Settings

Use AT%CONFIG to change settings of a remote device. Remote Device Control currently supports only the Source Level (5.9.1) setting.

The command format is following:

AT%CONFIG,<Destination Address>,<Retry>,<Setting>,<Value>

See the parameter descriptions in the table below.

		Parameter Description
<Destination Address>	1..Highest Address	Network address of the remote device.
<Retry>		Number of command retries. (if the remote device has a Wake-Up Module installed, <Retry> must exceed the Wake-Up Period (5.12.2).
<Setting>	source_level	Only Source Level (5.9.1) is currently supported by Remote Device Control.
<Value>	0 ..3	See the section on Source Level (5.9.1) for values range and other details.

Once the local device receives an answer from the remote device, it will generate a corresponding notification:

%CONFIG,<Remote Address>,<Value>,<Range>,<rssi>,<integrity>

or

%CONFIG,<Remote Address>,failed

See the parameter descriptions in the table below.

		Parameter Description
<Remote Address>	1..Highest Address	Network address of the remote device.
<Value>		.
<Range >		Distance to remote device in meters, assuming speed of sound is 1500 m/s.
<rssi>		Received Signal Strength Indicator. See section 5.13.3. Signed number.
<integrity>		Incoming signal integrity level. See section 5.13.4.

	Example AT%CONFIG
+++	Switch to Command Mode.
OK	
AT%CONFIG,1,4,source_level,3	Send command to set Source Level of the remote device with address 1 to 3, retry 4 times.
OK	
%CONFIG,1,?:3,500.002,-84,120	.

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: S2C Configuration Utility

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.

The Utility opens in a web-browser and does not require additional installation steps.

A.1.1 Opening the S2C 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:

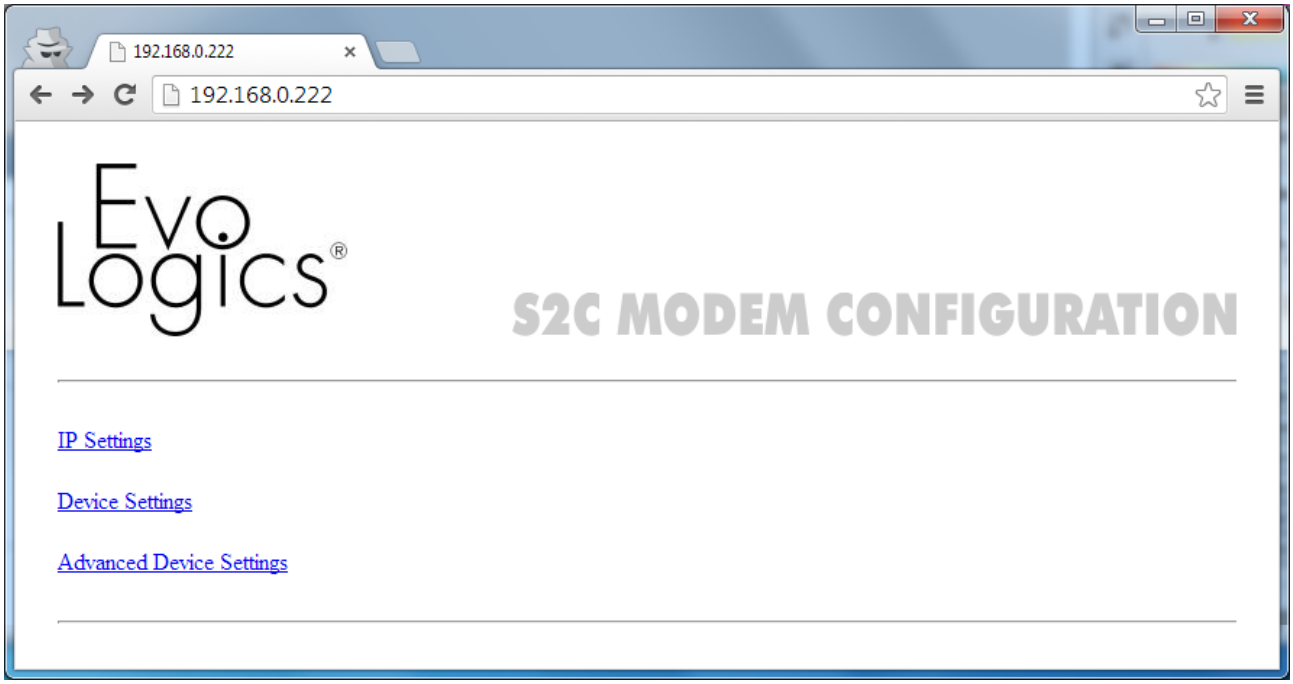

Figure 3: S2C Configuration Utility: main page

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

Please note: **to apply any changes you made with the Configuration Utility, the device must be reset**.

A.1.2 S2C Configuration utility: IP Settings

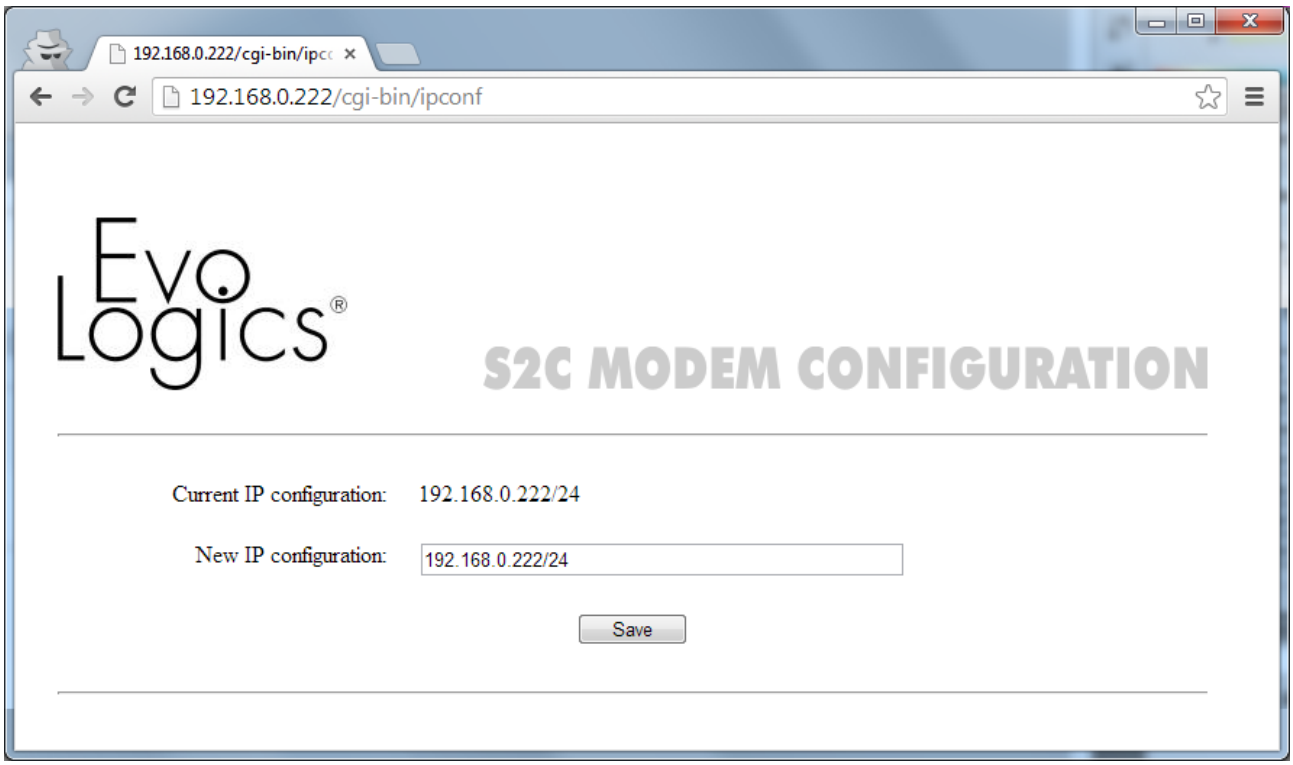

Figure 4: S2C Configuration Utility: **IP configuration** page

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.

New settings will be applied after the device is reset. **Reset the device to apply new settings.**

A.1.3 S2C Configuration utility: Device Settings

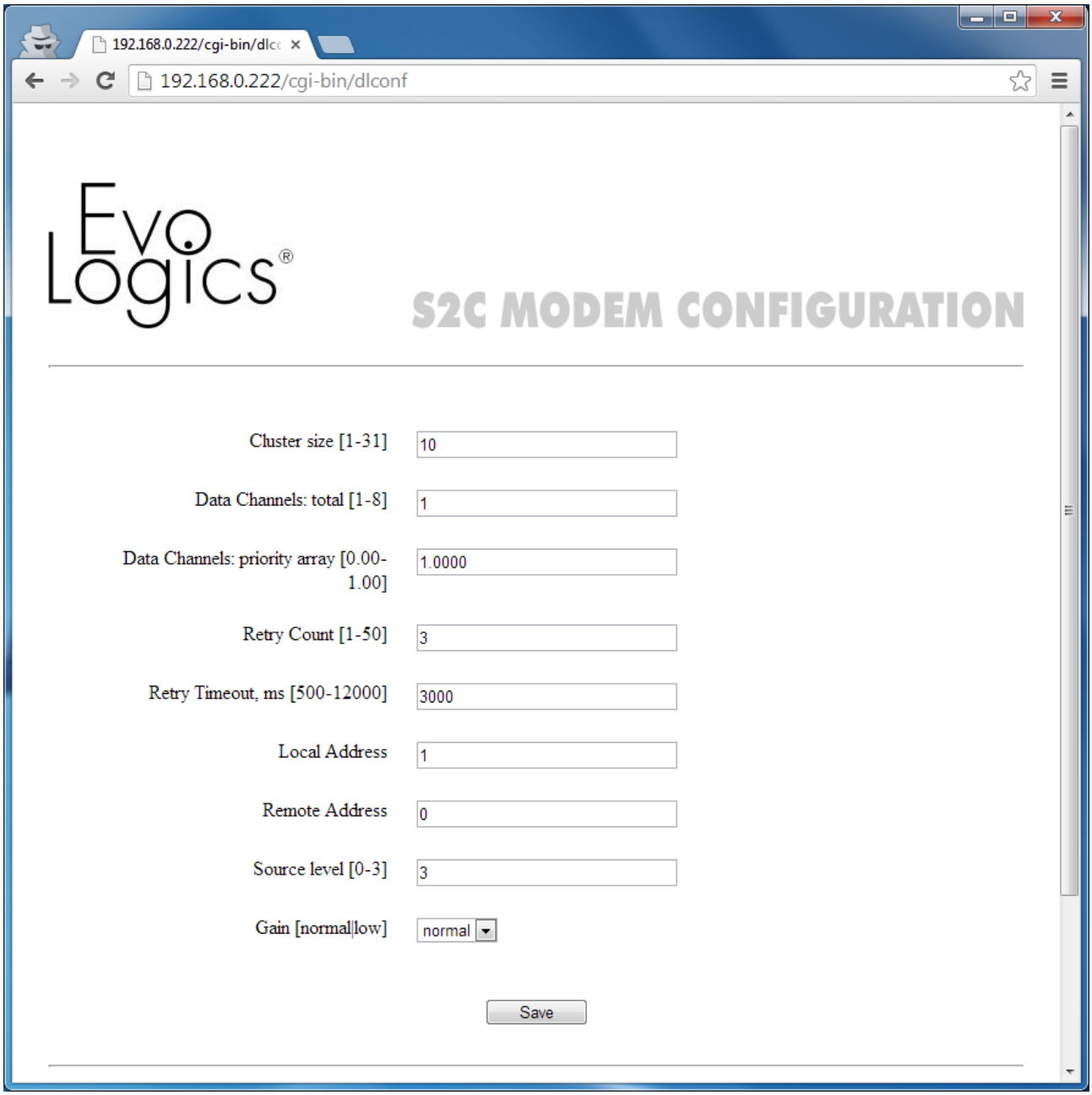

Figure 5: S2C Configuration Utility: **Device Settings** page

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 3.2).
Data Channels: priority array	0.00 .. 1.00	Space-separated priorities of the data channels (see 3.2.2), 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.1.4 S2C Configuration utility: Advanced Device Settings

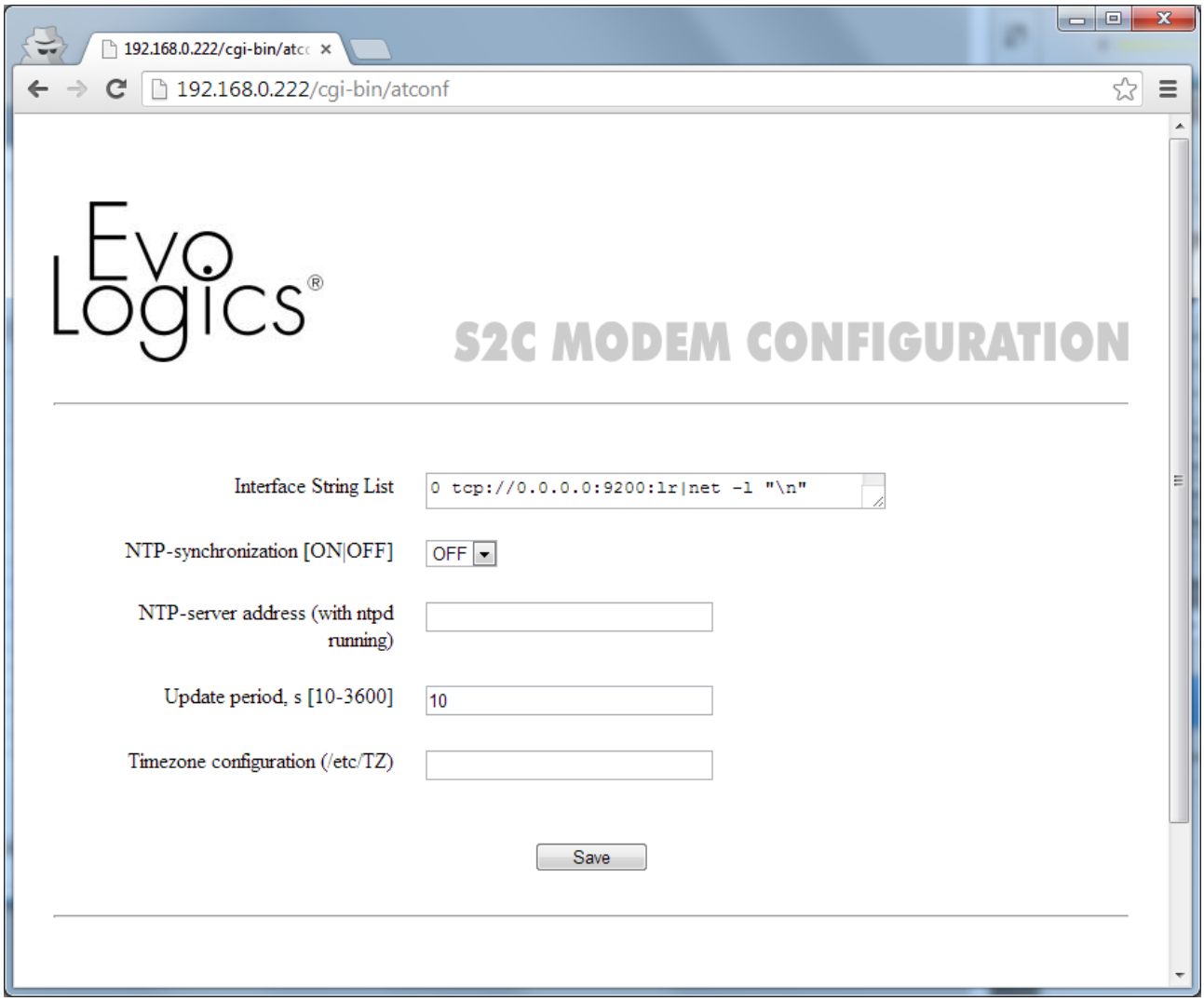

Figure 6: S2C Configuration Utility: **Advanced Device Settings** page

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 3.3). 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` (5.9.16) 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.

A.2 Transponder Communication Utility

The optional **Transponder communication utility** with a web-based user interface provides basic controls to connect to deployed S2C devices (for example, to LBL baseline transponders) over the acoustic channel, check their status, request sensor data and remotely modify some settings.

A.2.1 Opening the utility

To access the **Transponder communication utility**:

- Open the **S2C Configuration Utility**, as described in section A.1.1.
- Go to the **Transponder communication** page.

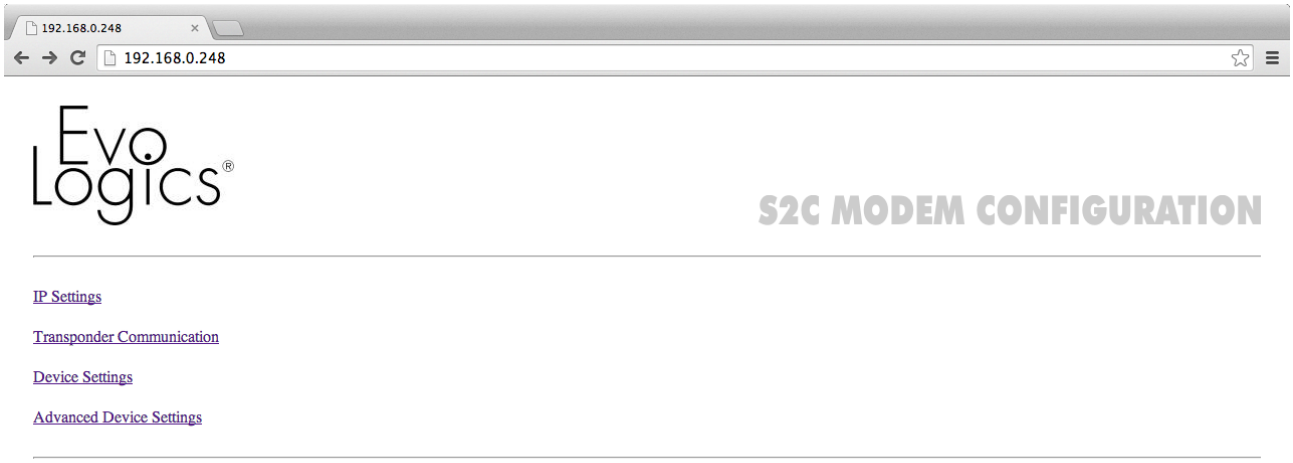

Figure 7: S2C Transponder Communication utility

- If you do not see the **Transponder communication page** in the **S2C Configuration Utility**, the **Transponder Communication Utility** is not enabled for your device.

A.2.2 Transponder Communication Utility: Control elements

The main controls of the utility are:

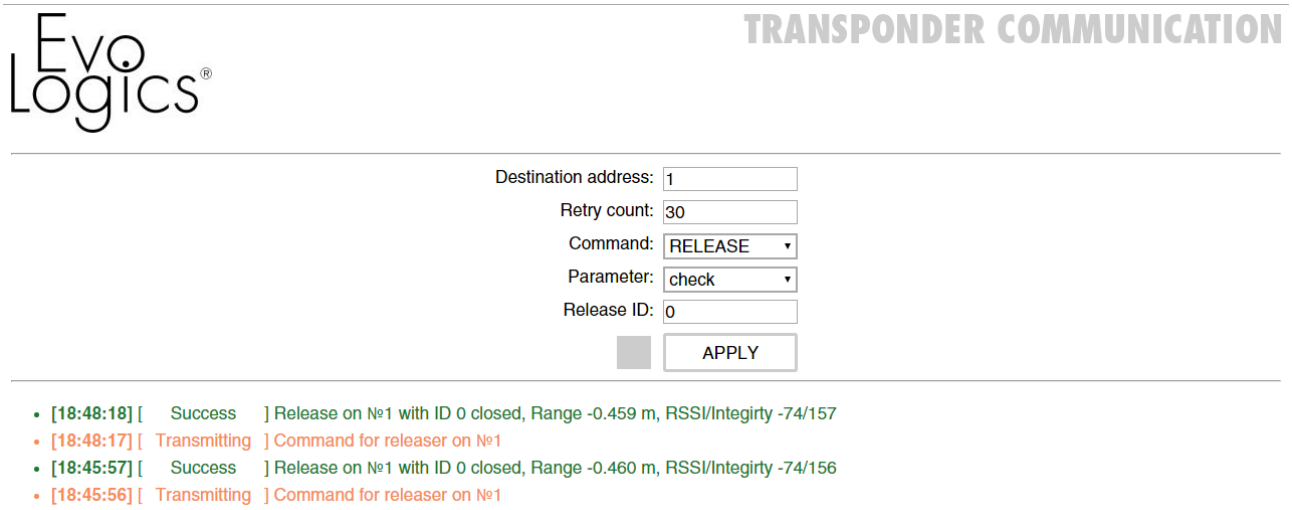

Figure 8: Transponder Communication Utility main page

- **Destination address** defines the address of the device to communicate with. For LBL baseline transponders, it corresponds to the baseline node number.

  A `failed` status will appear if source and destination addresses match.

- **Retry count** defines, how many times will your device retry to execute a command or request over the acoustic channel.

  Your device retries transmitting the command or request every 1 second.

  If the deployed S2C device you are sending commands to is equipped with a Wake-Up Module (see section 2.3 for details on the power-saving Wake-Up Module and its settings), the **Retry count** should amount at least twice the **Wake-Up Period** of the deployed S2C device (LBL baseline transponder). 30 seconds is recommended if the **Wake-Up Period** of the remote S2C device was left at its default setting before deployment.

- **Command** offers a drop-down list of command and requests you can send to the remote device over the acoustic channel. They correspond to the **Remote Device Control** extension of the AT command set, described in section 5.14:

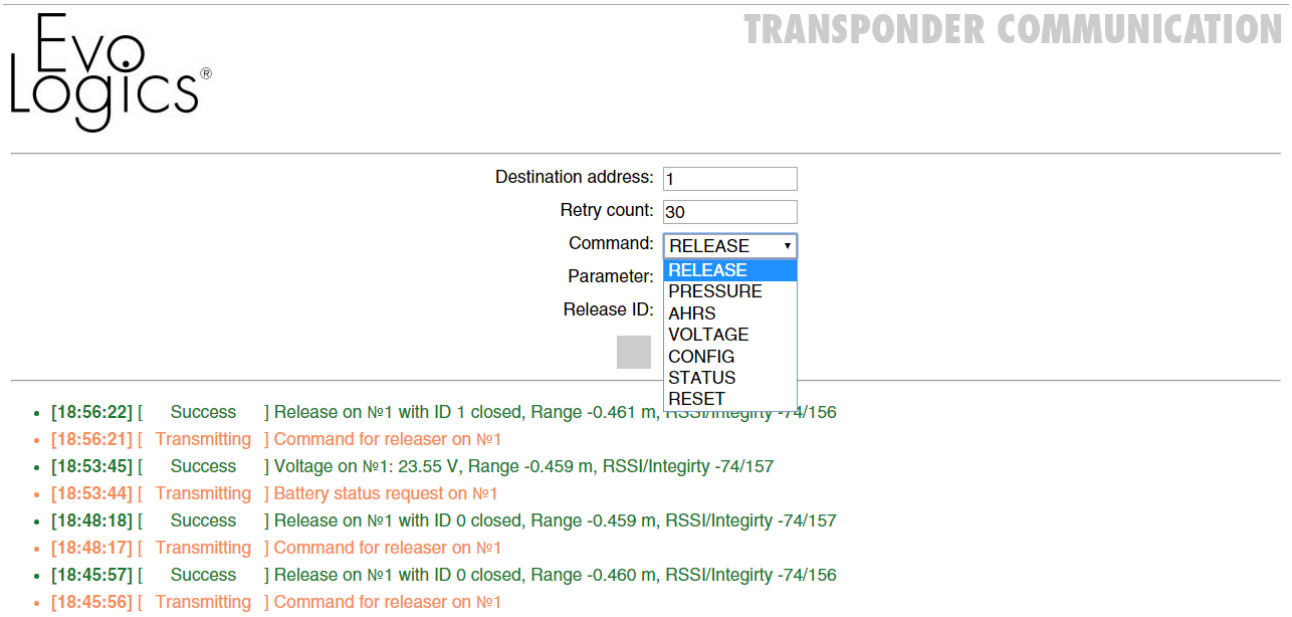

Figure 9: Transponder Communication Utility: commands list

- **Release** allows to check and activate the acoustic release mechanism(s) of the remote device (see section 5.14.4 about the corresponding AT command).
  - Enter the **Release ID** (0 or 1) in the corresponding field if the remote device has two acoustic release mechanisms installed.
  - Choose **Check** from the **Parameter** drop-down list to request the current status of the selected acoustic release mechanism.
  - Choose **Release** from the **Parameter** list to trigger the remote acoustic release mechanism to open. The release procedure is completed as soon as the release mechanism ”open” status is detected or if retry count is exceeded.
  - Select **Salvage** from the list to trigger a force-opening procedure of the acoustic release mechanism.

    This emergency procedure does not check if the release mechanism is ”open”, repeat sending this command to force-open the release mechanism. The **Salvage** procedure includes repeated heating of the release mechanism and should be used only in case of emergency, as it can damage the device.
- **Pressure** command requests the pressure (in dBar), measured by the built-in pressure sensor of the remote device (see section 5.14.6 about the corresponding AT command).
- **AHRS** command requests the roll, pitch and yaw angles (in degrees) measured by the built-in AHRS of the remote device (see section 5.14.7 about the corresponding AT command).
- **Voltage** requests the battery voltage (in V) of the selected remote device (see section 5.14.5 about the corresponding AT command).

- **CONFIG** allows to change settings of a remote device (see section 5.14.9 about the corresponding AT command).

  Currently only `Source Level` (5.9.1) of a deployed device can be changed remotely. Remember: if testing in-air, use `Source Level` 3 - the **lowest** transmission power setting.

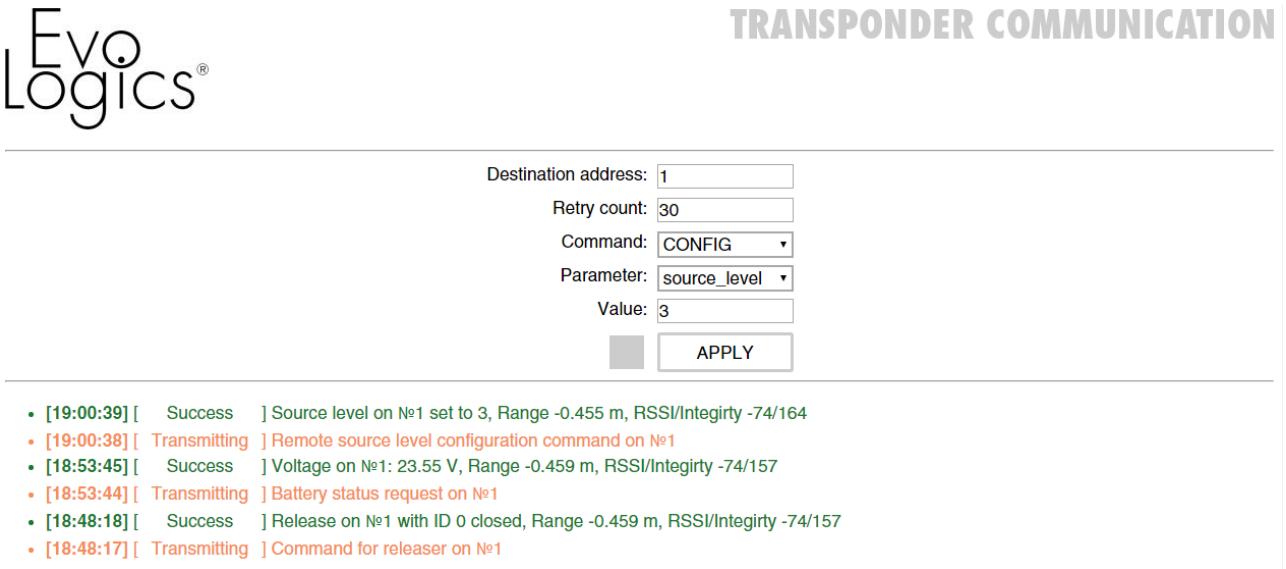

Figure 10: Transponder Communication Utility: **Config**

- **STATUS** returns the current state of the Remote Device Control, described in section 5.14.1.
- **RESET** cancels a command or request currently in progress (see section 5.14.3 about the corresponding AT command).

Once the **APPLY** button is pressed, the local device establishes an acoustic connection to the deployed device (baseline transponder) to perform the requested action.

The **Transmission indicator** will blink RED during an outgoing acoustic transmission and GREEN when receiving a response from the remote device.

Please note: transmission indicator requires WebSocket support (Firefox 6, Safari 6, Google Chrome 14, Opera 12.10, Internet Explorer 10 and higher). If your web browser does not support WebSocket, transmission indicator will not be displayed.

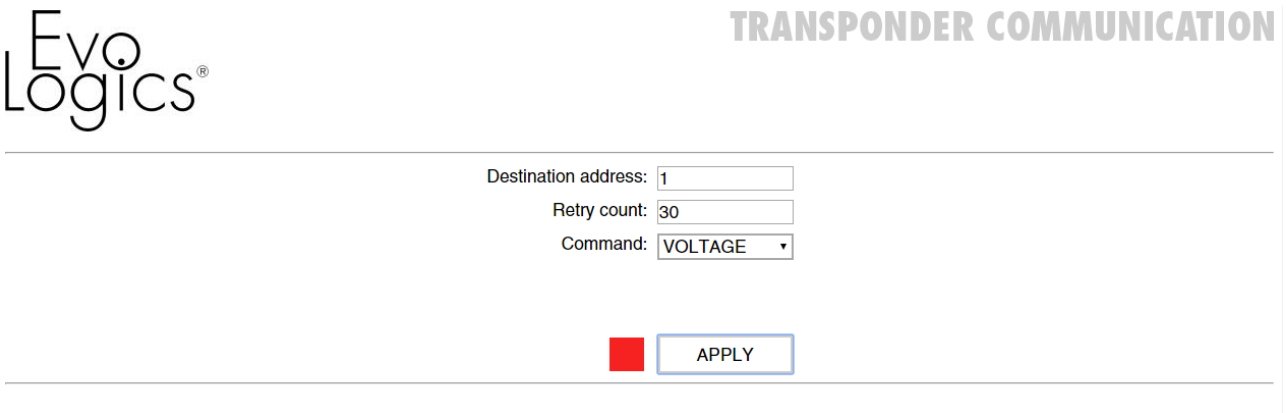

Figure 11: Transponder Communication Utility: outgoing transmission indicator

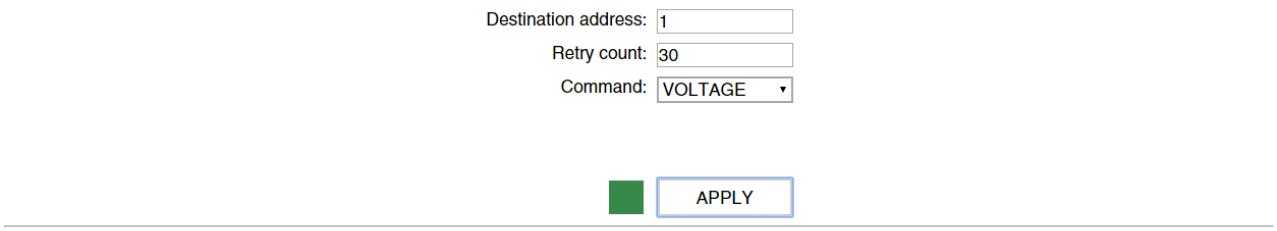

Figure 12: Transponder Communication Utility: incoming transmission indicator

If the **Transmission indicator** blinks red or green, though you have not performed any action in the Transponder Communication Utility, it means the local device is involved in another communication and/or positioning session (for example, initiated by SiNAPS software).

Make sure you end all communication and/or positioning activity with a deployed device before using the Utility to remotely control it.

A.2.3 Transponder Communication Utility: Status log

The **Status log** is updated every time the local device transmits a command/request or receives a response to its command/request:

- The status log displays:
  - **Timestamp** of the current action.
  - **Status** of the action being executed: `Transmitting`, `Success` or `Failed`.

    The `Failed` status appears when transmission is impossible because the source and destination addresses match.
  - The **Status message**.

    During transmission, it displays the command/request being transmitted and the **Destination Address** (the baseline node number for LBL transponders).

    After successful communication with a remote device, the **Status message** contains the requested values, the estimated distance to the remote device (in m) and diagnostic information about the acoustic link quality:

    `<Value>, <Destination Address>, Distance:<distance> m, RSSI/Integrity: <RSSI>/<Integrity>`

    The `RSSI` (Received Signal Strength Indicator) indicates the received acoustic signal level in dB re 1 V and represents the relative received signal strength. RSSI is a signed number. Higher RSSI values correspond to stronger acoustic signals (5.13.3).

    The `Integrity` value illustrates distortion of the received acoustic signal. Higher Integrity values correspond to less distorted signals. An acoustic link is considered weak if the Integrity value is less than 100 (5.13.4).

A.3 Atomic Clock Utility

For S2C devices with a built-in atomic clock, the **Atomic Clock Utility** with a web-based user interface provides the controls to monitor, discipline (adjust) and synchronize the atomic clock with an external GPS receiver. The Utility is only available for devices with Ethernet.

See the Factory Certificate of your device to check if it is equipped with an integrated atomic clock and an Ethernet interface.

A.3.1 Atomic clock: an overview

The integrated Chip-Scale Atomic Clock (CSAC)[12]is a passive atomic clock. Its principal outputs are the 10 MHz square and one pulse per second (1 PPS) signals from a temperature-compensated crystal oscillator, used for highly accurate timekeeping of the S2C device. For S2C devices with a built-in CSAC, it replaces the 32 bit counter as the physical layer clock and provides a precise local timing reference during subsea deployment.

The long-term accuracy and stability of the CSAC can be improved by periodic disciplining to an external GPS. During the disciplining procedure, the timing output of the CSAC is compared to that of the GPS system and the frequency of the clock is gently steered into compliance with GPS time. Read more about disciplining in section A.3.4.

A synchronization procedure allows to adjust the CSAC output to GPS time: the rising edge of the CSAC pulse is matched to the rising edge of the GPS 1 PPS. Synchronization to GPS must be performed before each deployment of your S2C device - read more about synchronization in section A.3.5.

After the CSAC is interfaced with an external GPS, use the **Atomic Clock Utility** to discipline or synchronize the CSAC.

[12]Microsemi Quantum^{TM} SA.45s CSAC

A.3.2 Connecting the external GPS receiver

A 1 PPS from an external GPS receiver must be applied to the CSAC for synchronization and disciplining.

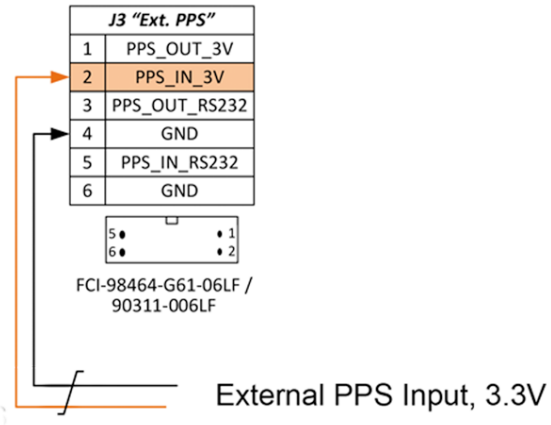

Figure 13: S2C OEM devices: CSAC connection diagram

For OEM S2C devices (no housing), connection diagram of the CSAC is shown above.

- Connect the 3.3 V 1 PPS output from an external GPS receiver to Pin 9 of the CSAC.

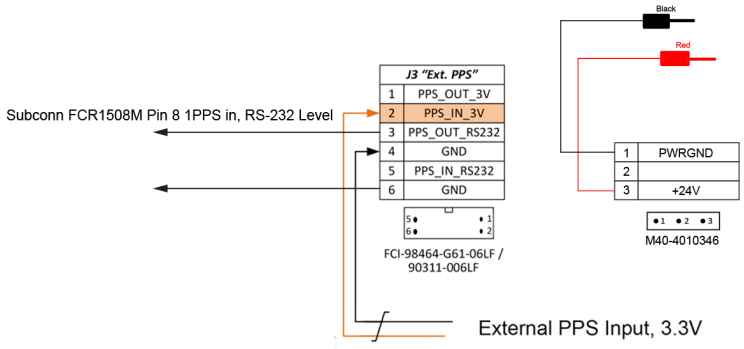

Figure 14: S2C devices with housing: voltage level converter connection diagram

For S2C devices with housing, use the voltage level converter. The connection diagram is shown above.

A.3.3 Opening the utility

To access the **Atomic Clock utility**:

- Open the **S2C Configuration Utility**, as described in section A.1.1.
- Go to the **Atomic Clock Utility** page.
- The **Atomic Clock Utility** page will appear. The control elements are described in corresponding sections that follow.

  If you do not see the **Atomic Clock Utility** page in the **S2C Configuration Utility**, the **Atomic Clock Utility** is not enabled for your device.

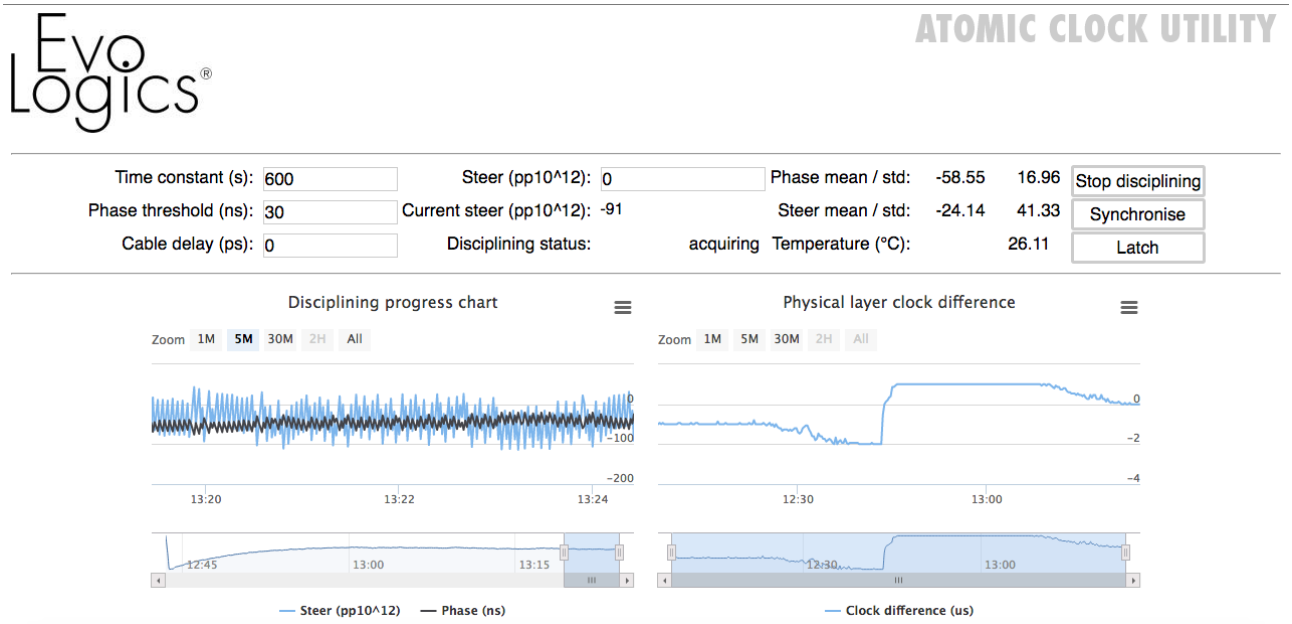

Figure 15: S2C Atomic Clock utility

A.3.4 Disciplining the atomic clock

The disciplining should be performed from time to time to remove cumulative frequency aging offsets. Please refer to the CSAC manufacturer's instructions for more details and recommendations on disciplining the CSAC.

Disciplining is a two-step procedure: first, the frequency of the CSAC is steered (adjusted) to match the external reference - the 1 PPS signal from a GPS receiver. Next, the obtained steering value must be saved into the non-volatile memory of the clock.

During disciplining, a high-resolution phase meter, implemented within the CSAC, measures the time difference between the CSAC 1 PPS output and the externally applied reference 1 PPS from the GPS. The phase meter measures the relative phase between the CSAC and the reference once per second with a resolution of 450 ps.

Based on the measurements of the phase meter, internal steering algorithms adjust the frequency of the CSAC's microwave synthesizer so as to simultaneously steer both the phase and frequency to that of the external reference, ultimately achieving accuracies of $<$ 5 ns and 5 x 10^{-13}, respectively

The disciplining algorithm is successfully finished, when the magnitude of the phase measurement (phase difference between the CSAC 1 PPS and the GPS 1 PPS) **is less than phase threshold for two time constants of duration**.

Prior to the onset of steering, the disciplining algorithms first perform an initialization sequence in which the variables of the steering algorithm are reset to defaults and a 1 PPS synchronization operation (see more in section A.3.5) is executed to bring the 1 PPS CSAC output within 100 ns of the reference, thereby avoiding large frequency excursions. There is no need to manually launch synchronization before disciplining.

Before you begin:

- Make sure the 1 PPS output of the GPS is connected to the CSAC, as described in section A.3.2 above.
- Make sure the PC is connected to the S2C device, make sure the GPS receiver, the PC and the S2C device are turned on.

Follow the steps below to perform CSAC disciplining:

- Open the Atomic Clock Utility, as described in section A.3.3.
- Enter the **Time Constant** (in seconds) into the corresponding field. We recommend to set this value to 300 s. Please refer to the CSAC manufacturer's instructions for more details on selecting the time constant for disciplining.
- Enter the **Phase Threshold** (in nanoseconds).

  This parameter defines the upper limit of phase magnitude for disciplining - when the magnitude of phase difference between the CSAC and the GPS 1 PPS is less than this threshold for two time constants, the disciplining goal is reached.

  The threshold value should be selected based on the noise properties of the GPS receiver used for disciplining.

  In our example (see Figure 16) we set this value to 30 ns.

- Enter the **Cable delay** (in 100 picoseconds).

  Cable length compensation can be applied to allow for known delay (or advance) in the arrival time of the reference 1 PPS at the CSAC. The compensation is represented as a signed integer in units of 100 ps, the maximum value is +/- 1000 units (i.e. 100 ns).

- Press **Start disciplining** to start the procedure.

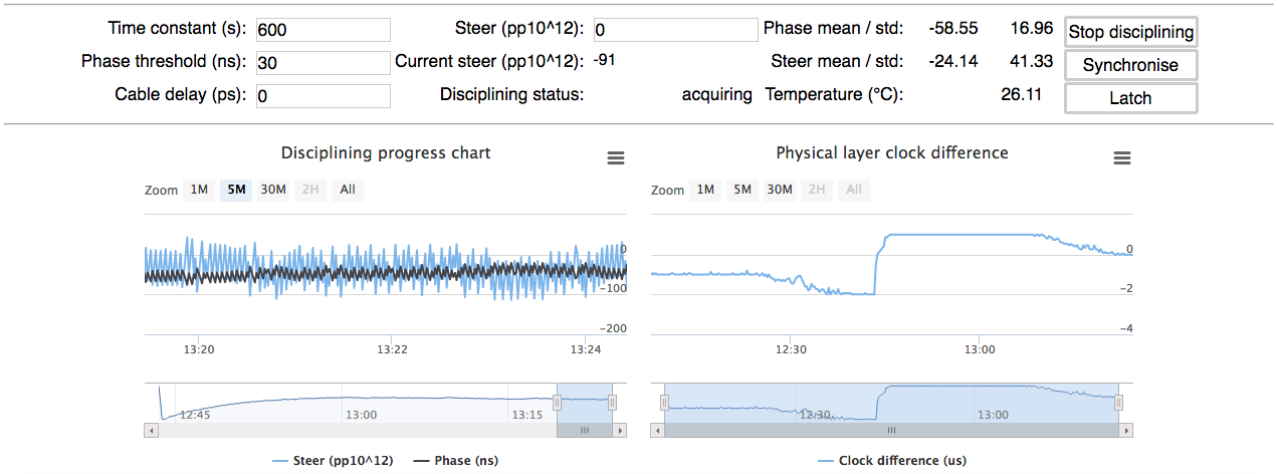

Figure 16: S2C Atomic Clock utility

Disciplining progress can be monitored on the corresponding chart (see Figure 16 above).

Disciplining parameters are displayed in the corresponding fields:

- **Current Steer** (in pp 10^{-12}) is the present value of frequency adjustment.
- **Phase mean** / **std** is the mean value and standard deviation of the phase difference between the CSAC 1 PPS and the GPS 1 PPS, averaged over XX seconds.
- **Steer mean** / **std** is the mean value and standard deviation of frequency steering during the procedure, averaged over XX seconds.
- **Temperature, C°** is the CSAC temperature (in Celsius).

The **Disciplining Status** field displays **acquiring** during the procedure.

Once the magnitude of phase difference between the CSAC and the GPS 1 PPS is less than this threshold for two time constants, **Disciplining Status** displays **locked**.

Disciplining goal was reached - the CSAC was steered to 1 PPS from the external GPS reference.

Frequency steering is volatile. After reboot, the CSAC will return to its previous frequency setting, unless the obtained steering value is not stored into its non-volatile memory.

To store the obtained steering value:

- When **Disciplining Status** is **locked**, copy the steering value from the **Current Steer** field and paste it into the **Steer** field or enter it manually (in pp 10^{-12}).
- To store the **Steer** value to the non-volatile CSAC memory, press the **Latch** button.

Following a **Latch** command, the value of **Steer** is reset to zero.

You have successfully performed disciplining of the CSAC.

A.3.5 Synchronizing the atomic clock

Before deployment of the S2C device, its CSAC should be synchronized with a 1 PPS signal from the external GPS receiver. During the procedure, the CSAC's output is synchronized to within one clock cycle (+/- 100 ns) of the external reference - the rising edge of the CSAC output occurs nearest to the rising edge of the GPS 1 PPS. Therefore, during deployment, internal timekeeping of your S2C device will be synchronized with GPS time.

There is no need to manually launch synchronization before disciplining - synchronization is automatically executed during disciplining initiation.

Before you begin:

- Make sure the 1 PPS output of the GPS is connected to the CSAC, as described in section A.3.2 above.
- Make sure the PC is connected to the S2C device, make sure the GPS receiver, the PC and the S2C device are turned on.

To execute synchronization before deployment:

- Open the Atomic Clock Utility, as described in section A.3.3.
- Press **Synchronize** to initiate the procedure.

Synchronization progress can be monitored on the corresponding chart (see Figure 16 above).

B Appendix II: S2C Configuration Shell

The S2C Configuration Shell allows to configure input-output interfaces and modify some settings of your S2C device with shell commands. In addition, it offers several tools for system diagnostics.

B.1 Opening the S2C Configuration Shell

To connect to the S2C device and open the S2C Configuration Shell, use **PuTTY** or a similar software tool.

For devices with serial interfaces, please note: to access the Configuration Shell, you must connect to the **Service** serial interface of your device. If your connecting cable is not wired to access the service serial interface (there is no connector marked **Service** on the cable), please see the details in section B.1.1 below.

B.1.1 S2C Configuration Shell over Serial interface

To access the Configuration Shell, you must connect to the **Service serial interface**. Please use the connector marked **Service** on the standard cable you received with your device.

If your cable is not wired to provide access to the service interface (there is no **Service** connector):

- Contact EvoLogics to order a **Service cable**. Use this cable and connect to the serial port of your S2C device.

  or

- Request the **Service cable** wiring specifications from EvoLogics and manufacture your own Service cable.

To access the S2C Configuration Shell, connect to the Service serial interface, turn on the PC and the S2C device and use the **PuTTY** client:

- Open **PuTTY**.
- Go to the **Serial** connection parameters and configure the connection:

  The service serial connection parameters are **115200 8-N-1** (baudrate: 115200, data bits: 8, parity: none, stop bits: 1).
- Go to **Session** and press **Open** to start the serial communication session.
- The terminal window will open. Press **Enter**.
- When prompted, enter the username `config` and press **Enter** (leave the password blank).

B.1.2 S2C Configuration Shell over Ethernet interface

Use **PuTTY** and establish a SSH connection to the S2C device:

- Before you connect, 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 or the Configuration Shell, make sure your PC is configured in the same subnet.

- Select **SSH** and enter your device's IP address.

  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 or the Configuration Shell, make sure you enter the correct IP address.

- When prompted, enter the username `config` and press **Enter** (leave the password blank).

B.1.3 Open the S2C Configuration Shell

Once you have successfully established a connection over service serial interface or an SSH connection over Ethernet, the Configuration Shell welcome screen will appear. See the example below:

```
Welcome to EvoLogics Configuration Shell.

Commands:
<parameter> = value -  change parameter value
ls     -  list parameters
list   -  list parameters with descriptions
save   -  save parameters to Settings profile
          (i.e. to non-volatile memory - values will be applied
          after reboot or shutdown)
reload -  load parameters from Settings profile (i.e. from non-volatile memory)
reset  -  reset parameters to factory defaults
quit   -  quit shell

Diagnostic and control commands:
reboot     - reboot system
dmesg      - show system log
date       - show/set date
ping       - ping IP
traceroute - traceroute IP
ip         - show/manipulate routing, devices, policy routing

Please note:

Parameters list:
1. modified parameters that were not stored to the non-volatile
   memory are marked with "!".
```

```
   Marked values will be lost after reboot or shutdown.
   Use "save" to store parameters to the non-volatile memory (Settings profile).
2. "interface" parameter:
   use interface=<n> to remove data channel <n> from the Interface list.
   Only the last data channel of the Interface list can be removed!
   Data channel 0 cannot be removed.
   use interface=<n Interface string> to add or modify Interface strings.
```

B.2 Configuration Commands

Commands, available in the Configuration Shell, are listed below. These commands allow to modify and save some settings of the S2C device.

Please see section B.4 for advanced diagnostics and control commands, executable from the Configuration Shell.

Type a command and press **Enter** to execute it:

- `ls` – a list of parameters and their current values are displayed.

  Parameters that were not stored to the Settings Profile (the non-volatile memory of the device) are marked with an exclamation point `!`.

  Marked values will be lost after reboot or shutdown. Use `save` to store parameters to the Settings profile. Read more about the Settings Profile in section 5.8.2.

- `list` – a list of parameters with their short descriptions is displayed.

  Parameters that were not stored to the Settings Profile (the non-volatile memory of the device) are marked with an exclamation point `!`.

- `<parameter> = value` – parameter name, change parameter value

- `save` – save current parameter values to the Settings profile (i.e. to non-volatile memory of the device, the values will be applied after reboot or shutdown). Read more about the Settings Profile in section 5.8.2.

- `reload` – load parameter values from the Settings profile (i.e. from the non-volatile memory of the device). Read more about the Settings Profile in section 5.8.2.

- `reset` – reset parameter values to factory defaults.

- `quit` – quit the Configuration Shell.

B.3 Device Settings

The table below lists device settings, that you can modify with the S2C Configuration Shell.

Parameter	Description
`cluster_size`	**Cluster size** (1-31) defines the number of data packets in a packet train. See more in section 5.9.8.
`burst_data_channels`	This parameter defines the number of data channels (1-8), configured on the device. Read more about data channels in section 3.2.
`channel_priority_array`	The array (0.00-1.00) defines the priorities of data channels. See more in section 3.2.2.
`retry_count`	**Retry Count** (1-50) defines the number of connection establishment retries. See more in section 5.9.10.
`retry_timeout`	**Retry Timeout** (500-16000 ms) defines the time interval that the device waits for a response before retrying to establish a connection. See more in section 5.9.11.
`local_address`	**Local Address** is the address of the device. See more in section 5.9.5.
`remote_address`	**Remote Address** is the address of a remote device for communication. See more in section 5.9.6.
`source_level`	**Source Level** (1-3) defines the sound pressure level in transmission mode. See more in section 5.9.1.
`gain`	**Gain** (`normal` or `low`) defines the amplifier gain. See more in section 5.9.3.
`wakeup_uart_baudrates`	Baudrates on serial interfaces of the Wake-Up Module. **Baudrates must match baudrates of serial interfaces, configured in the interface List!** The setting has no effect for devices without RS-232 interfaces and Wake-Up Module.
`usbl_adjust_angles`	Internal parameter - the USBL frame adjustment vector (roll, pitch, yaw angles in degrees). Always `0.0000 0.0000 0.0000` for USBL devices with standard antenna, `0.0000 0.0000 45.0000` for USBL devices with streamlined antenna. **Do not change this setting!**
`interface`	The **Interface List** is the data channels configuration – a list of data channel Protocol ID's and Interface Strings of input-output interfaces, mapped to those channels. See 5.9.15 for more information on the Interface List. Use command `interface=<n>` to remove a data channel `n`. Only the last data channel of the Interface list can be removed! Data channel with Protocol ID 0 cannot be removed. Use `interface=<n Interface string>` command to add or modify Interface strings (i.e. configure new or existing data channels). See 3.3 for more information on Interface Strings.
`ntp_sync`	**NTP-synchronization** (`ON` or `OFF`) defines if the System Time of your device is synchronized with an external NTP server. See section 4.4 for more details on device timekeeping.
`ntpd_address`	This parameter defines the NTP-server address (with ntpd running) for System Time synchronization over NTP.
`ntp_update_period`	The NTP update period (10-3600 seconds) defines the update period for System Time synchronization over NTP.
`time_zone`	This parameter defines the timezone configuration (/etc/TZ format) for System Time synchronization over NTP.

The example below illustrates response to the `list` command:

```
> list
# Cluster size [1-31]
cluster_size = 10
# Total number of data channels [1-8]
burst_data_channels = 1
# Data Channels: priority array [0.00-1.00]
channel_priority_array = 1.0000
# Retry Count [1-50]
retry_count = 3
# Retry Timeout, ms [500-16000]
retry_timeout = 4000
# Local Address
local_address = 2
# Remote Address
remote_address = 1
# Source level [0-3]
source_level = 1
# Gain [normal|low]
gain = normal
# Baudrates on serial interfaces of the Wake-Up Module
wakeup_uart_baudrates = 19200 0
# USBL frame adjustment vector (roll, pitch, yaw) in degrees (Streamline: 0 0 45)
usbl_adjust_angles = 0.0000 0.0000 0.0000
# Interface List
interface = 0 tcp://0.0.0.0:9200:lr|net -l "\n"
# NTP-synchronization [ON|OFF]
ntp_sync = OFF
# NTP-server address (with ntpd running)
ntpd_address =
# NTP update period, s [10-3600]
ntp_update_period = 10
# Timezone configuration (/etc/TZ)
time_zone =
```

The following example illustrates setting a new value to the `retry_timeout` parameter:

```
> retry_timeout = 3000
> ls
  cluster_size = 10
  burst_data_channels = 1
  channel_priority_array = 1.0000
  retry_count = 3
! retry_timeout = 3000
  local_address = 2
  remote_address = 1
  source_level = 1
  gain = normal
  wakeup_uart_baudrates = 19200 0
```

```
usbl_adjust_angles = 0.0000 0.0000 0.0000
interface = 0 tcp://0.0.0.0:9200:lr|net -l "\n"
ntp_sync = OFF
ntpd_address =
ntp_update_period = 10
time_zone =
```

Note that the new value is not saved into the Settings Profile and is marked with an exclamation point `!`.

B.4 System diagnostic and control commands

S2C Configuration Shell offers several Linux-based utilities[1] for advanced diagnostic purposes:

- `reboot` – reboot the system.
- `dmesg` – show system log.
- `date` – show/set time and date.

  The command format is:

  `date [OPTIONS] [+FMT] [TIME]`

  See the table below for options:

Option	Description
`[-s] TIME`	Set time to TIME
`-u`	Work in UTC (don't convert to local time)
`-R`	Output RFC-822 compliant date string
`-I[SPEC]`	Output ISO-8601 compliant date string SPEC='date' (default) for date only, 'hours', 'minutes', or 'seconds' for date and time to the indicated precision
`-r FILE`	Display last modification time of FILE
`-d TIME`	Display TIME, not 'now'
`-D FMT`	Use FMT for -d TIME conversion

Recognized `TIME` formats are:

```
hh:mm[:ss]
[YYYY.]MM.DD-hh:mm[:ss]
YYYY-MM-DD hh:mm[:ss]
[[[[[YY]YY]MM]DD]hh]mm[.ss]
```

Example:

```
> date
Fri Jan  5 16:20:51 UTC 2018
> date -s 201801051200.42
Fri Jan  5 12:00:42 UTC 2018
> date
Fri Jan  5 12:00:43 UTC 2018
```

[1] Read more information about the implemented utilities online: https://busybox.net/downloads/BusyBox.html

- `ping` – test reachability of an IP address.

  The command format is:

  ```
  ping [OPTIONS] HOST
  ```

  See the table below for options:

Option	Description
`-4, -6`	Force IPv4 or IPv6 hostname resolution
`-c CNT`	Send only CNT pings (default:4)
`-s SIZE`	Send SIZE data bytes in packets (default:56)
`-I IFACE/IP`	Use interface or IP address as source
`-W SEC`	Seconds to wait for the first response (default:10) (after all -c CNT packets are sent)
`-w SEC`	Seconds until ping exits (default:infinite) (can exit earlier with -c CNT)
`-q`	Quiet, only displays output at start and when finished

  Example:

  ```
  > ping 192.168.0.1
  PING 192.168.0.1 (192.168.0.1): 56 data bytes
  64 bytes from 192.168.0.1: seq=0 ttl=64 time=1.476 ms
  64 bytes from 192.168.0.1: seq=1 ttl=64 time=0.835 ms
  64 bytes from 192.168.0.1: seq=2 ttl=64 time=0.708 ms
  64 bytes from 192.168.0.1: seq=3 ttl=64 time=0.682 ms

  --- 192.168.0.1 ping statistics ---
  4 packets transmitted, 4 packets received, 0% packet loss
  round-trip min/avg/max = 0.682/0.925/1.476 ms
  ```

- `traceroute` – trace and display the network route to an IP address.

  The command format is:

  ```
  traceroute [-FIldnrv] [-f 1st_ttl] [-m max_ttl] [-p port#] [-q nqueries]
  [-s src_addr] [-t tos] [-w wait] [-g gateway] [-i iface]
  [-z pausemsecs] HOST [data size]
  ```

See the table below for options:

Option	Description
-F	Set the don't fragment bit
-I	Use ICMP ECHO instead of UDP datagrams
-l	Display the ttl value of the returned packet
-d	Set SO_DEBUG options to socket
-n	Print hop addresses numerically rather than symbolically
-r	Bypass the normal routing tables and send directly to a host
-v	Verbose
-m max_ttl	Max time-to-live (max number of hops)
-p port#	Base UDP port number used in probes (default 33434)
-q nqueries	Number of probes per 'ttl' (default 3)
-s src_addr	IP address to use as the source address
-t tos	Type-of-service in probe packets (default 0)
-w wait	Time in seconds to wait for a response (default 3 sec)
-g	Loose source route gateway (8 max)

Example:

```
> traceroute 192.168.0.1
traceroute to 192.168.0.1 (192.168.0.1), 30 hops max, 38 byte packets
 1  repos.evologics.de (192.168.0.1)  0.615 ms  0.555 ms  0.469 ms
```

- `ip` – display routing, devices, routing policy

  The command format is:

  ```
  ip [OPTIONS] {address | route | link | tunnel | rule} {COMMAND}

  ip [OPTIONS] OBJECT {COMMAND}
  ```

  where OBJECT := address — route — link — tunnel — rule OPTIONS := -f[amily] inet — inet6 — link — -o[neline]

  Example 1:

  ```
  > ip addr
  1: lo: <LOOPBACK,UP,LOWER_UP> mtu 16436 qdisc noqueue
      link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
      inet 127.0.0.1/8 scope host lo
  2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast qlen 1000
      link/ether 8c:8e:76:00:8e:e8 brd ff:ff:ff:ff:ff:ff
      inet 192.168.0.205/24 brd 192.168.0.255 scope global eth0
  ```

  Example 2:

  ```
  > ip route
  192.168.0.0/24 dev eth0  src 192.168.0.205
  ```

C Appendix III

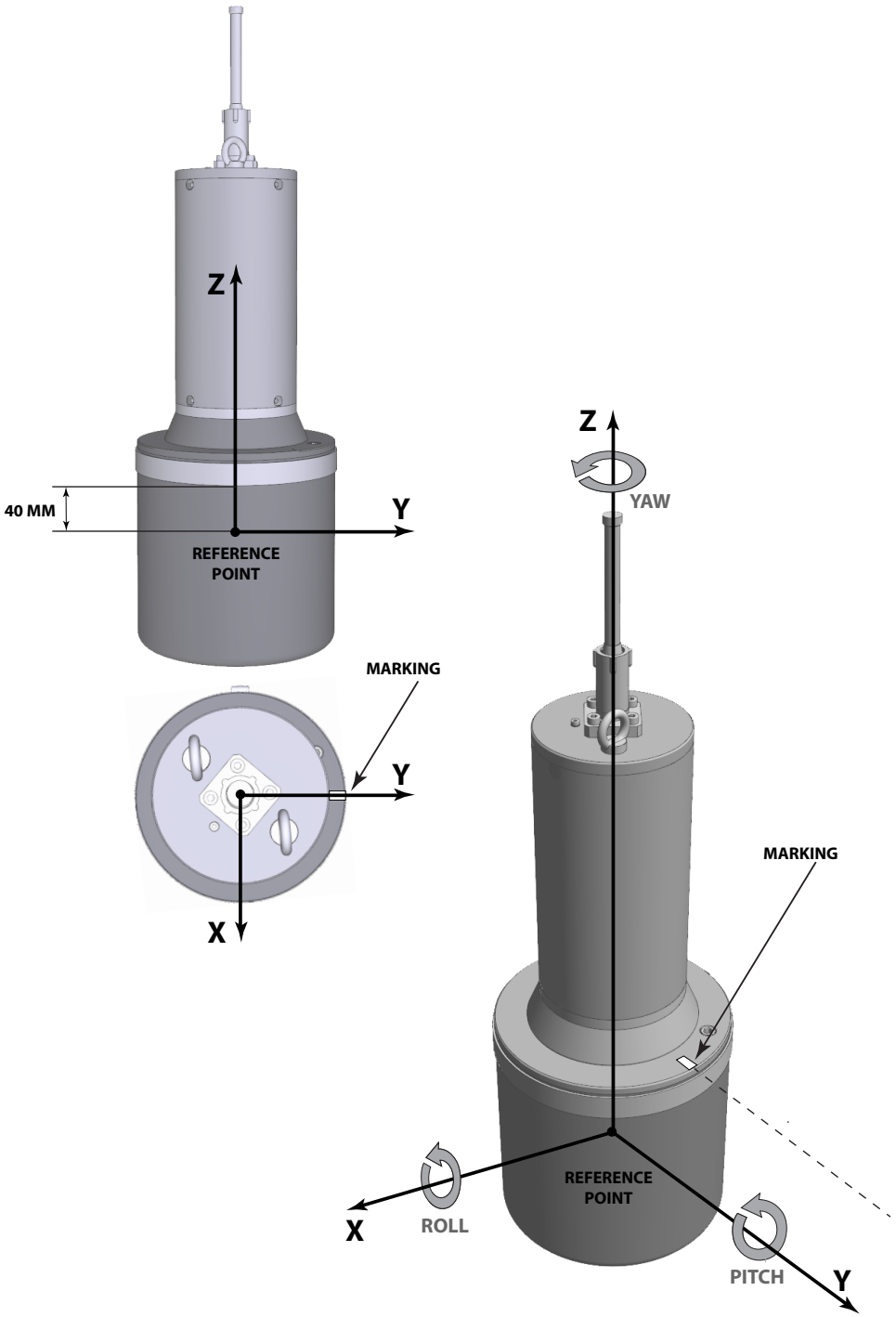

Figure 17: Local coordinate system of an S2C USBL communication and positioning device

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