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Getting Started Guide

S2C M 18/34 Underwater Acoustic Modem

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Contents

1 Introduction

1.1 Overview

The S2C M 18/34 underwater acoustic modem provides a full-duplex digital communication link using EvoLogics' patented S2C (Sweep-Spread Carrier) modulation technique.

S2C is a sophisticated spread spectrum communication method. It exploits the advantages of carefully optimized chirp pulses to transmit data in harsh subsea conditions, delivering an excellent performance, highly resistant to the negative effects of multipath propagation, ambient noise, Doppler shifts etc.

Furthermore, the challenges of high-speed data transmissions in dynamic underwater environment are met with the self-adaptive algorithms that adjust S2C parameters to maintain the highest bitrate possible in given conditions. Reliability of the underwater communication link is increased with software-embedded FEC (Forward Error Correction) processing. ARQ (Automatic Repeat Query) technique ensures that data with unrecoverable errors is automatically retransmitted. EvoLogics' own MAC (Media Access Control) communication protocol implements a novel interwoven order of data packets and protects the transfers from long propagation delays.

Each S2C device responds to remote connection requests, as it has a configurable individual address. Data exchange between S2C devices is bidirectional. Commands and high-priority messages can be transmitted as Instant Messages from the receiver to the transmitter without interrupting the main data flow from the transmitter to the receiver or affecting the network throughput. In addition, S2C devices provide useful features of measuring the physical parameters of the underwater acoustic channel.

The device's firmware includes an extensive set of commands that offers full control over its functionality (see S2C Reference Guide for more information).

A wide selection of configuration options enables seamless integration into any underwater system, proving the device to be a reliable and highly adjustable tool for multiple subsea applications.

1.2 About this document

This document is a guide to set up your device, turn it on and perform a quick functionality test. It contains recommendations on handling, operating and storing S2C devices.

However, this guide does provide detailed information on device features and does not describe the command set to operate your device. A separate document - the S2C Reference Guide - is dedicated to device operation and is supplied along with the hardware.

2 Technical specifications

model:	S2C M 18-34
operational range:	up to 3500 m
	(can vary depending on environmental conditions)
operational depth:	200 m (Delrin housing)
	2000 m (Stainless steel housing)
transducer beam pattern:	horizontally omnidirectional
(see directivity diagrams in Fig. 1)	
interface:	Ethernet or RS-232
nominal acoustic bitrate:	up to 13.9 kbps
power supply:	external 24 VDC (19 VDC-28 VDC)
operational frequency band:	18 kHz - 34 kHz
power consumption:	
Standby mode	2.5 mW
Receive mode	0.8 W[1]
Transmit mode	up to 55 W (software configurable)
Listen mode[2]	5 mW - 285 mW (software configurable)

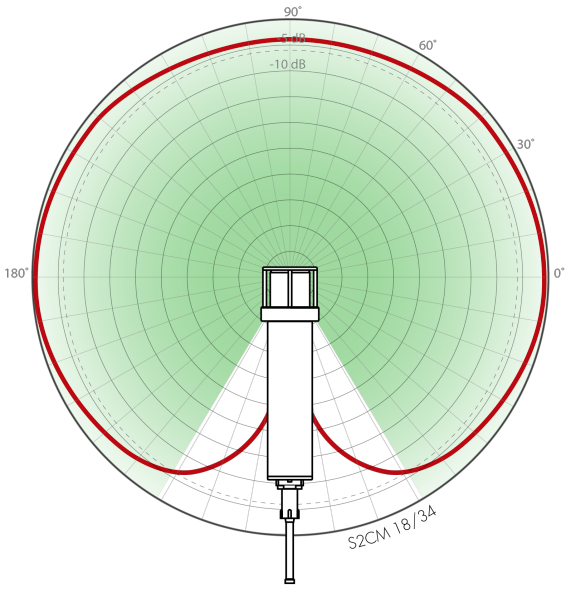

Figure 1: Transducer directivity pattern (vertical plane)

[1] Power consumption for the RS-232 interface option. Add 500 mW for the Ethernet interface option.

[2] User-configurable Listen Mode is only available with a Wake-Up module installed. Power consumption in Listen Mode depends on Listen Mode settings.

3 Setting up S2C devices

The following instructions describe a typical set-up for testing and configuring S2C devices.

To start operations, each device should be connected to an external DC power source and a data source (the host system - a PC).

This section includes instructions on turning on the device and connecting it to a PC.

Proceed to section 4 for detailed instructions on carrying out an acoustic communication test that comprises setting up two (or more) S2C devices, establishing an acoustic link between them and transmitting data.

Once the device is proved fully-functional, it is ready for installation into an underwater communication and/or positioning system. See section 7 for installation recommendations.

3.1 Before you begin

– Unpack the device and other hardware components.
Immediately report any shipping damages!

S2C devices are shipped in plastic scratch-protective nets.
Use the net for transportation purposes only!

– Ensure **Firmware compatibility**:

If you plan to use your new device with an older EvoLogics product, **make sure the firmware version of your previously purchased product matches the firmware version of your new device.**

The firmware version of your new EvoLogics device is listed in its **Factory Certificate**. See the corresponding Factory Certificates or use AT commands (see S2C Reference Guide) to check firmware versions of your older EvoLogics products. Contact EvoLogics to request a firmware update for your previously purchased devices, if needed.

3.2 Turning the device on/off

Please refer to the **Factory Certificate** of your device for its connector pin layouts. The Factory Certificate defines the interfaces, connectors and pin layouts of your device.

Pins labeled NC and Service must be left unconnected!
Do not connect anything to pins labeled NC and Service
unless instructed otherwise by EvoLogics.

For devices with an RS-232 interface:
Make sure you do not confuse pins `V-(Power_GND)` **and** `RS232 Gnd`**:**
connecting power ground to serial interface signal ground causes a malfunction that is not covered by EvoLogics warranty.

– According to the pin layout, connect the device to an external DC power source. See section 3.2.1 for detailed recommendations on selecting a DC power source for S2C devices.

Make all electric connections before turning on the device!
Provide proper grounding!

If you are using the connecting cable you ordered from EvoLogics, the pin color code of the standard EvoLogics connecting cable is:

– **V+** (24V): red

– **V-** (Power_GND): black

– **Power_ON** : blue

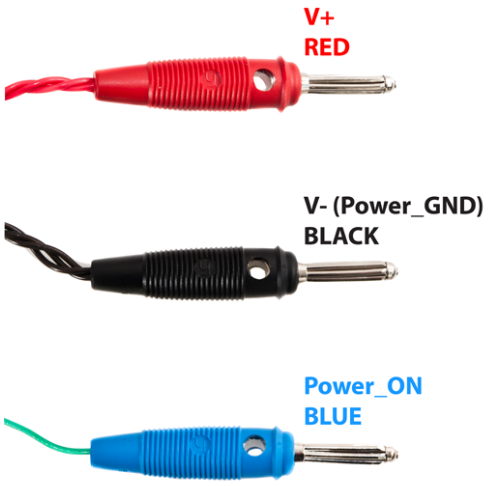

Figure 2: EvoLogics standard cable: color coding

Always check the Factory Certificate for the pin layout of your device!

Check polarity when connecting to the power supply!

– A device without a Wake-Up Module is turned **on** by connecting pins **Power_ON** and **V-** (Power_GND).

  Use an on/off switch (mechanical relay, optocoupler or transistor switch) of your choice or connect the wires directly.

  When choosing a switch, remember that it must handle a 24 VDC (19 VDC-28 VDC) voltage and minimum 10 mA current.

– The device is turned **off** by disconnecting pins **Power_ON** and **V-** (Power_GND).

If your S2C device is equipped with a Wake-Up Module:

Do NOT connect the Power_ON pin to V- pin to turn on the device!

The Wake-Up Module turns on the S2C device once it detects incoming acoustic signals or incoming data on the host interface.
An S2C device with an acoustic Wake-Up Module does not work properly if **Power_ON** is connected to **V-**!

3.2.1 DC Power Source selection

S2C devices are configured for nominal power of 24 VDC.

You may use an external power source ranging from 19 VDC to 28 VDC.

Make sure at least the minimum allowed input voltage is supplied at the device's connector. Mind the voltage drop across the power supply cables during the transmission!

Please note, that if the voltage differs from nominal (within the approved range), the sound pressure level (SPL) and power consumption values will differ from those stated in the Factory Certificate of your device.

- Reduced voltage will reduce the output SPL and power consumption values.
- Increased voltage will increase the output SPL and power consumption values.

If using an external power source exceeding the nominal value:

Do NOT use the maximum Source Level setting!

Never set the Source Level to 0 if the external power source exceeds the nominal value!

Other important considerations to mind when selecting an external power source:

- The transducer's impedance is resonant, leading to short (microseconds) peaks of current consumption.

  To assure best performance, we strongly recommend using low-output-impedance power sources, capable to handle high-peak currents (lead-acid batteries, NiMH etc.).

  

  If the power supply does not support high-peak currents, unpredictable hardware resets can occur!

- When choosing an external power source, please note, that the unit's current limiting is set at 10 A.
- Use the shortest connecting cables available.

Same considerations apply when choosing a power supply for deployment in an underwater communication system.

3.3 Connecting to a PC

- Connect the device to a corresponding PC interface.

  The device can be connected over Ethernet, RS-232, RS-485 or RS-422 interface.

  Check the Factory Certificate of your device to make sure you are connecting it to the correct interface!

  Use an interface converter if necessary. Make sure the converter is compatible with your PC and is properly configured.

- Turn the device on, as described in section 3.2.

- Proceed to the next section to establish and test the connection between your S2C device and the PC.

3.3.1 Establishing connection to a PC

Use a terminal application to establish a connection between the PC and the S2C device.

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

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

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`).

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** 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.

RS-232/422/485 interface

If you connected your device to a PC over RS-232/422/485, use **PuTTY** to check the connection:

- Open **PuTTY**.
- Go to **Serial** connection parameters and make sure they match those listed in the Factory Certificate of your device. See figure 8 below for details. All serial connection parameters for your device are listed in its Factory Certificate.

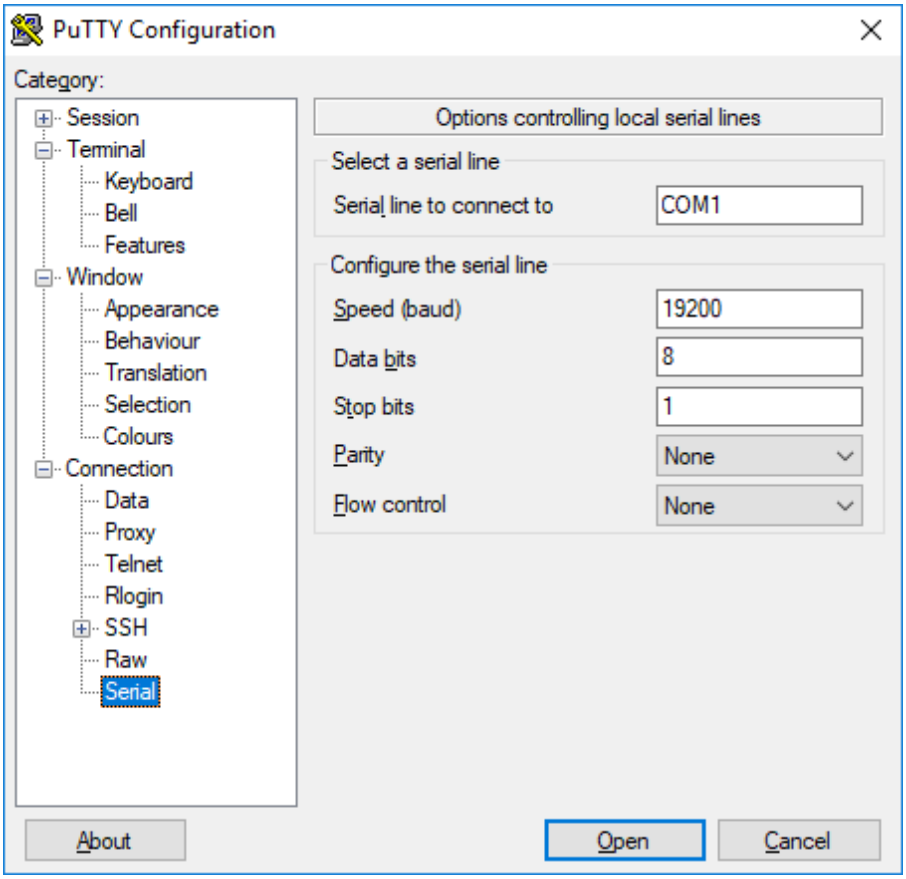

Figure 3: Serial connection parameters

– Go to **Session** and press **Open** to start the serial communication session.

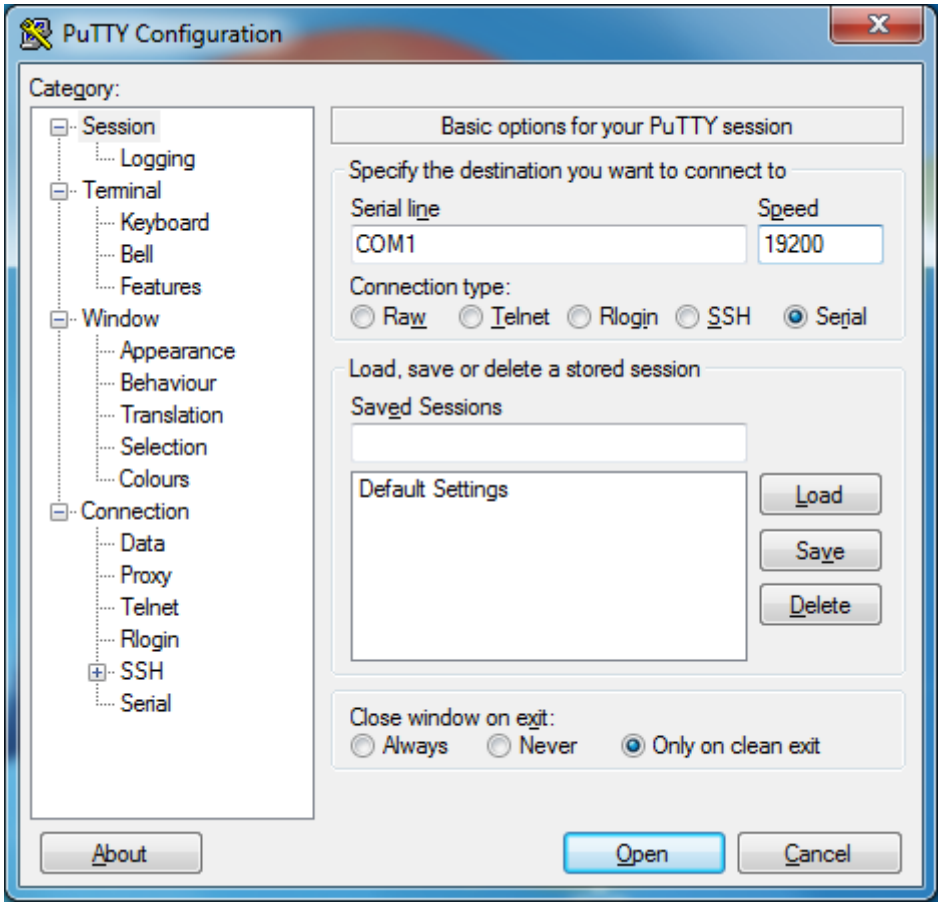

Figure 4: Serial connection parameters

Ethernet interface

If you connected your device to a PC over Ethernet, you can use either **netcat** or the EvoLogics edition of **PuTTY**.

netcat To check the connection using **netcat**:

– Open **netcat** and type in the **IP address** and **port number** of your device.

The IP address of your device is listed in its Factory Certificate.

The default port number is **9200**.

Make sure to use the correct port number if you previously modified it with the S2C Configuration Utility or the S2C Configuration Shell (see S2C Reference Guide).

– Press **Enter**.

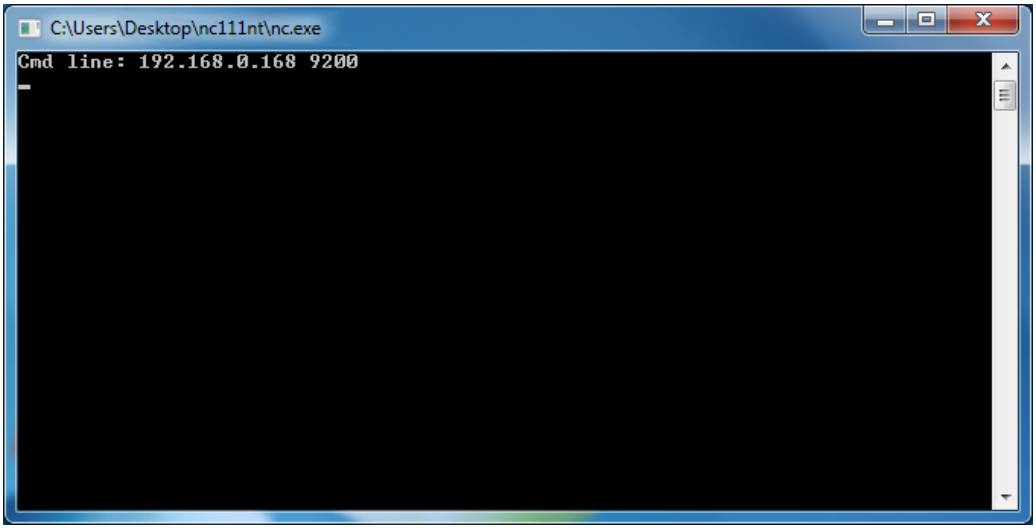

Figure 5: Ethernet connection

PuTTY Please note, that **only the PuTTY installation you download from EvoLogics** allows to connect to S2C devices over Ethernet.

This installation allows to select the correct end-of-line marker for connecting over Ethernet.

To establish a raw Ethernet connection:

– Go to **Raw** parameters and select the line feed **LF**:

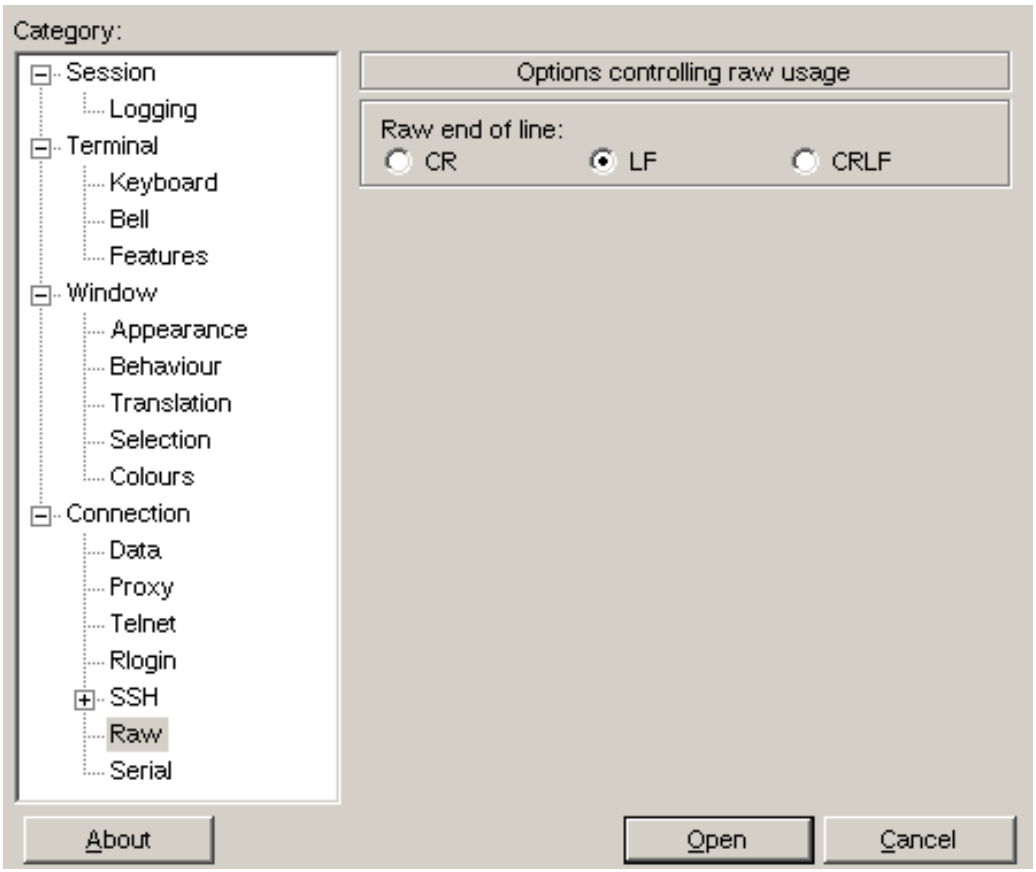

Figure 6: Ethernet connection: end of line setting

– Go to **Session** and enter the **IP address** and **port number** of your device.

  The IP address of your device is listed in its Factory Certificate.

  The default port number is **9200**.

  Make sure to use the correct port number if you previously modified it with the S2C Configuration Utility or the S2C Configuration Shell (see S2C Reference Guide).

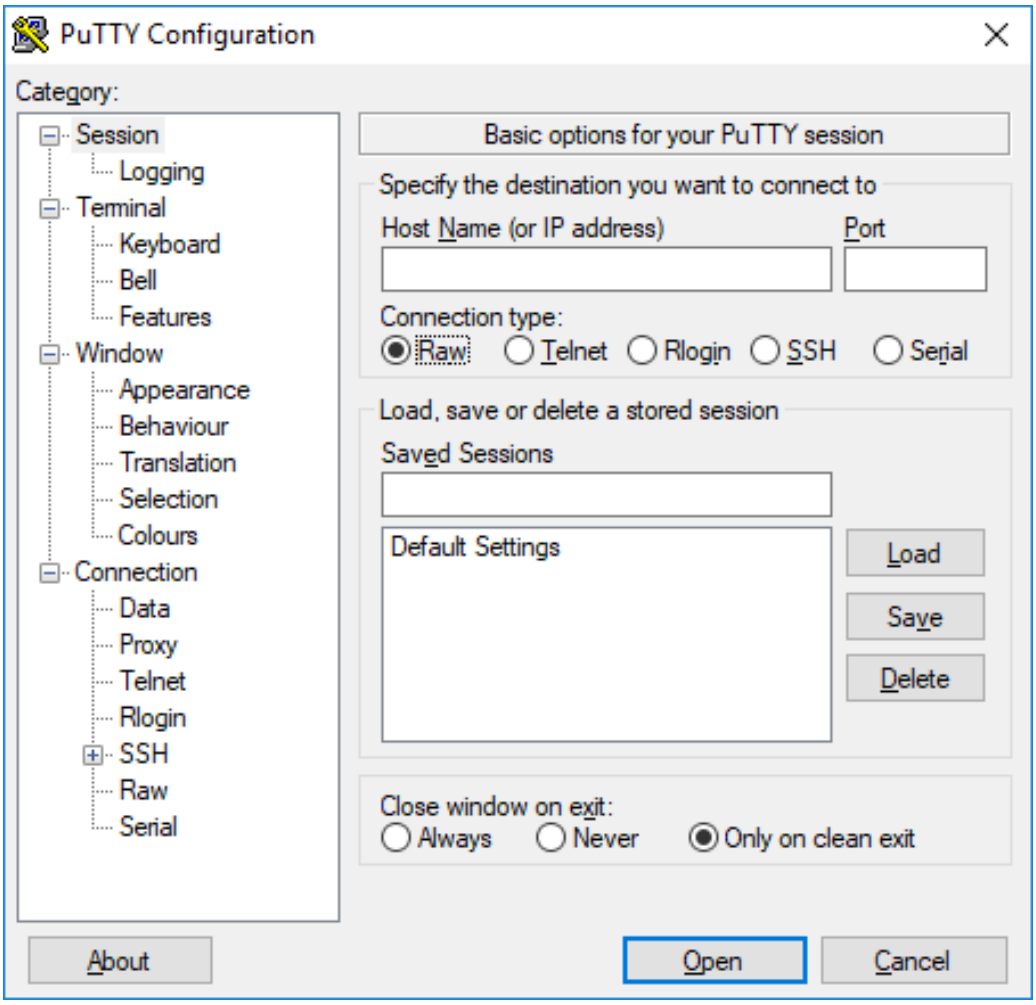

Figure 7: Ethernet connection parameters

– Select the **Raw** connection type and press **Open** to start the communication session.

3.3.2 Testing the connection to a PC

After establishing a connection, test it as described below:

- Type `+++AT?S` to request the S2C device status information. Press **Enter**.
- If the response is `+++INITIATION LISTEN <Pool Size>`

  (`<Pool Size>` stands for the free space in the transmission buffer), you have successfully connected the PC to the S2C device. The device is ready to establish an acoustic connection with another device.

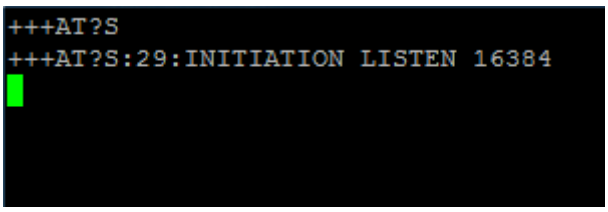

Figure 8: Testing the connection to a PC

4 Testing S2C devices

To perform an acoustic communication test, you must set up two (or more) S2C devices, establish an acoustic link between them and transmit data.

4.1 Setup for testing in water

Mind the following considerations when setting up devices for an underwater communication test:

- **Avoid clamping a device with Delrin housing in the middle**! Force applied in the middle will deform the plastic housing and cause leakage. Water would damage the electronics inside the device.

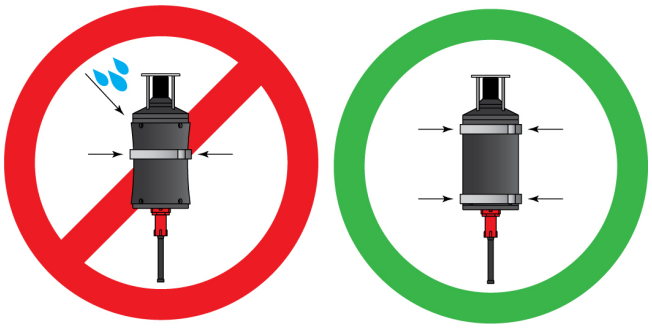

Figure 9: Mounting devices with Delrin housing

  For devices with Delrin housing, opt for placing the mounting on both edges of the housing.

- Install two modems under water at approximately the same depth within at least 1 m from each other.
- For the **S2C M HS** ”mini”-modem, please consider the following:

  the device must be installed at least 1 m away from reflecting surfaces and other obstacles that can interfere with sound propagation.

  The high operating frequency makes the device more susceptible to sound reflection.
- Mind the transducers’ directivity patterns. For best performance, orient the modems to keep the transducers’ acoustic axes in the same plane.
- We recommend testing the transducers at depths not less than 2 m.
- In open water, the optimal depth is determined by the properties of the underwater acoustic channel and the sound velocity profile.
- In a test pool, make sure the modems are at least 1 m away from the surface and the walls. The test pool must measure no less than 3 x 2 x 2 m.
- Make sure there are no obstacles between the devices. Avoid concrete walls or other objects that cause strong backscattering.
- If a test pool is not available, a quick communications test can be conducted in a small water tank that fits two devices with their transducers touching.

Before you begin the underwater communication test:

- Make sure each S2C device is connected to both a power supply and a PC running terminal software (PuTTY etc.).
- Turn the devices ON, as described in section 3.2.
- Follow the steps in section 4.3 to test an acoustic link.

4.2 Setup for testing in air

Though S2C devices are designed for underwater operation, for some models it is allowed to perform a quick functionality test in air.

Your S2C M 18/34 device is suitable for a short in-air check.

When considering an in-air test, please remember, that modem transducers are carefully matched to perform best in water. If operated in air, transducer parameters change dramatically, and resulting characteristics will differ from those measured in water. EvoLogics does not guarantee that all types of S2C devices will successfully operate in air.

When testing in air, make sure to use the lowest transmission power setting (Source Level 3). See S2C Reference Guide for more information on **Source Level**.

High-power air transmission can damage the device!
EvoLogics warranty does not cover these damages!

- Make sure each modem is set to low transmission power (Source Level 3).

  See S2C Reference Guide for more information on **Source Level**.
- Place 2 devices with their transducers as close as possible. See Fig. 10 for reference.

  Make sure there are no obstacles between the devices.
- Make sure each device is connected to both a power supply and a PC.
- Turn the devices on, as described in section 3.2.
- To test the acoustic link, follow the steps described in section 4.3.

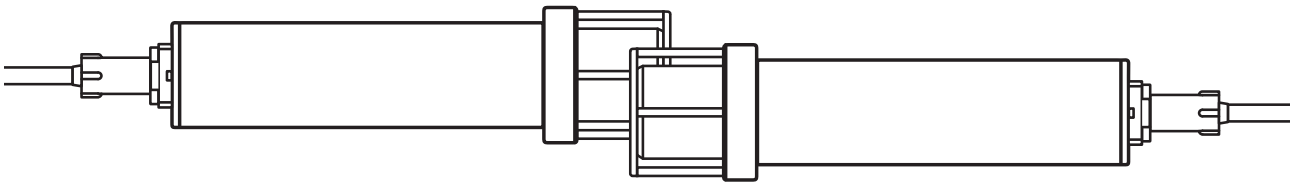

Figure 10: Device positioning for in-air testing

4.3 Testing an acoustic link with standard terminal applications

The following instructions describe the process of testing and configuring S2C devices with standard terminal applications.

We recommend the **PuTTY** software tool for connecting to S2C devices. For connections over Ethernet, you can also use **netcat**. See 3.3.1 for details.

A device, connected directly to the PC, is further referred to as host device. A device, connected via acoustic link, is further referred to as remote device.

S2C devices support 2 modes of communication: Data Mode and Command Mode. In Data Mode all input information is treated as data to be transmitted to a remote device.

In Command Mode all input information is treated as commands to the host device (the device supports a set of AT commands, similar to the standard set of commands used in device communications). Settings made via AT commands are automatically applied and used until the device is reset, rebooted or modified with another command.

4.3.1 Connecting to the host device

- Make sure the host device is connected to both a power supply and a PC running the terminal application.
- Turn the device ON, as described in section 3.2.
- Open the devices input interface using the terminal application, as described in section 3.3.1.
- Type +++ to enter Command mode, wait 1 second.
- If the response is `OK` the operation was successful.

4.3.2 Checking the host device connection

Press ”Enter” after each command in the following sections.

- Send `AT?S` to request modem status information.

  If the response is `INITIATION LISTEN <Pool Size>`, the modem is ready for a connection, initialized by the remote modem. Here `<Pool Size>` stands for the free space in the transmission buffer.

  If the response is `INITIATION ESTABLISH <Pool Size>`, the modem is currently trying to establish a connection with the remote modem.

For more information on statuses, please see the S2C Reference Guide.

4.3.3 Changing host device settings

To change the **Source Level** setting, that defines the sound pressure level (SPL) in transmission mode:

- Send `AT!Ln`

  where `n` is the **Source Level** value, **Source Level** 3 is the lowest setting, **Source Level** 0 is the highest setting.

High-power air transmission can damage the device!
EvoLogics warranty does not cover these damages!

- Send `AT&W` to save the settings.
- Go to Data Mode:

  Send `ATO`
- Send some bytes of information to the remote modem by pressing any keys.
- Go back to Command mode:

  type +++, wait 1 second.
- Request status information:

  Send `AT?S` to request the host devices status information.

  If the response is `ONLINE NORMAL`,

  the host device has successfully established a connection to the remote device.
- If the remote device is online, you may check the quality of acoustic connection, determined by properties of the acoustic channel:

  Send `AT?E` to get input signal level.

  Send `AT?I` to get signal integrity level.

  Send `AT?BR` to get remote-to-local bitrate.

  Send `AT?BL` to get local-to-remote bitrate.

See S2C Reference Guide for more information on these parameters.

5 Configuring S2C devices

- For devices with an Ethernet interface, some settings can be modified with the web-based **S2C Configuration Utility**. See the S2C Reference Guide for details.
- For devices with a serial interface, device settings can be modified with the **S2C Configuration Shell**. See the S2C Reference Guide for details.
- Another option to change settings is to use AT commands (see S2C Reference Guide for detailed instructions).

6 Maintenance

Remember, that S2C devices are not intended for in-air communication!

An in-air transmission can damage your device!
EvoLogics warranty does not cover these damages!

Section 4.2 states if your device is suitable for a short test in air using the lowest transmission power setting. Never attempt in-air testing if is not allowed for your device!

6.1 Handling, operating and storing devices

Handle your device with care:

- **Prevent mechanical damage to fragile acoustic components - avoid shocks, strong vibration, heavy abrasion.**

  A protective cage for your device can be ordered from EvoLogics. Contact us for more information on protective cages and mounting frames.

- **Avoid exposing the device to direct sunlight!**

  Overheating can damage the transducer, the plastic and other parts of your device!

  Mind the temperature ranges below:

  Operating temperature range: $0°$C ... $+\,60°$C
  Storage temperature range: $0°$C ... $+\,60°$C

- **Do not use aggressive chemicals or solvents to clean the exterior of your device!**

  After use, thoroughly rinse the device with fresh water. You may use a soft, non-abrasive sponge or filtered pressurized air if needed.

- Take proper care of cables and connectors:
  - Keep the connectors clean. Remove any sand or mud, use contact-cleaning spray and pressurized air if needed.
  - Do not over-tighten connector nuts. Avoid sharp bends at cable entry!
  - Rotate only the connector nut when disconnecting a cable. Do not pull the cables to unplug them!
  - After each use, protect connectors with plastic end caps.
- Mind the following for devices with AlMg housing:
  - The AlMg housing is anodized, an additional Mg protector prevents electrochemical corrosion. **Avoid contact with abrasive materials to keep the anodizing intact!**
  - Mind the protective coating when electrically connecting the modem to other underwater equipment.
  - Avoid contact with titanium alloys as it might cause intense electrochemical corrosion!

7 System integration recommendations

Please remember: on practice, every situation is unique and has to be approached individually. When in doubt, ask EvoLogics for advice!

7.1 General considerations

This section presents some general considerations to mind when integrating your S2C R-series/M-series Underwater Acoustic Modem into a new or existing system:

- Deploy the device away from sources of noise and turbulence, such as propellers, thrusters, other rotating machinery etc. See 7.2 for more advice on measuring the noise levels.
- Deploy the device away from potential sources of **electromagnetic interference** (EMI) that can degrade the performance of your device.
- For the **S2C M HS** ”mini”-modem, please consider the following:

  the device must be installed at least 1 m away from reflecting surfaces and other obstacles that can interfere with sound propagation.

  The high operating frequency makes the device more susceptible to sound reflection.

  For fastest performance, use the S2C M HS device without the frame that protects its transducer.
- Keep maximum distance from the sources of vibration that can affect the device, such as the vessel’s machinery etc.
- For device in metal housing: mind **galvanic corrosion** (see 7.3) when choosing the mounting arrangement for your device as well as its surrounding infrastructure.
- For devices in Delrin housing:

  When choosing the mounting arrangement, **avoid clamping a device with Delrin housing in the middle**. Force applied in the middle will deform the plastic housing and cause leakage. Water will damage the electronics inside the device!

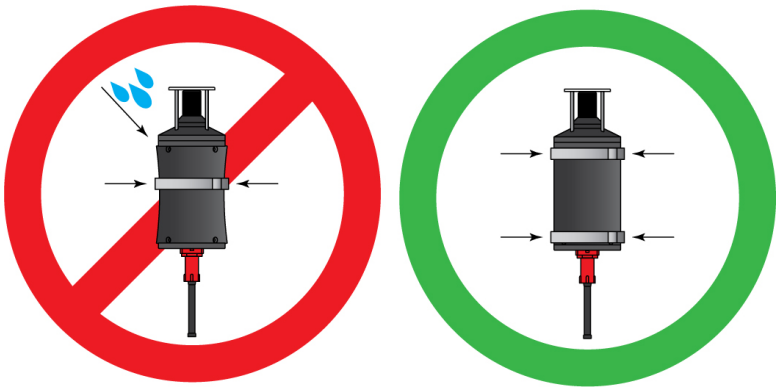

Figure 11: Mounting devices with Delrin housing

For devices with Delrin housing, opt for placing the mounting on both edges of the housing!

7.2 Noise analysis

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

We recommend to perform a noise test during system integration of your S2C device:

to analyse and identify the sources of noise, your device can switch into a noise measurement mode – the **Noise State**. In **Noise State** several specific commands are available to analyse the analog input noise. Read more about the **Noise state** and the relevant commands in the **S2C Reference Guide**, supplied with your device.

Recommended steps for analysing the noise:

- Perform a dry test: setup your S2C device and all components of the system it is integrated with in air.
- Measure the RMS value of the noise, as described in the **S2C Reference Guide**.

  If the **RMS value of the noise exceeds -80**, the noise interferes with your device's performance. A further investigation is recommended.
- To investigate the sources of noise, obtain the noise sample, as described in the **S2C Reference Guide**.

  Perform spectral analysis or use other known 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 while running all equipment/machinery of the surrounding infrastructure.

7.3 Galvanic corrosion

Measures to prevent galvanic corrosion are very important when installing an S2C device with metal housing on a vessel, underwater vehicle etc..

When two metals are submerged in an electrolyte (such as seawater), while electrically connected, the less noble metal will experience galvanic corrosion.

Coupled in a galvanic cell, the more noble material becomes the cathode, while the less noble material corrodes as the anode.

The nobility of metals is indicated in galvanic series, available for different environments[5].

- If the housing of your S2C device is made of AlMg–alloy:

  AlMg is a less noble metal than steel, commonly used for mounting elements, frames and other hardware. AlMg is therefore very prone to galvanic corrosion, when it is not properly isolated from the other metal.

  Please, mind the galvanic corrosion of AlMg when choosing the mounting arrangement!

- If the housing of your S2C device is made of titanium:

  Titanium is found at the noble, cathodic end of galvanic series.

  Please mind, that the titanium housing of the S2C device can cause galvanic corrosion of the surrounding metal parts! It is recommended to use titanium-only arrangements to mount a S2C device with titanium housing.

Contact EvoLogics for more advice on avoiding galvanic corrosion!

[5] A galvanic series is an arrangement of metals that indicates the relative nobility of different metals and alloys, ranged by their corrosion potentials. When two metals are coupled, the less noble metal in the series will corrode. The bigger the potential difference between the materials, the more galvanically incompatible they are. The series order may change in different environments.
See an example of a galvanic series for seawater online.

8 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.