RBR*quartz³* APT INSTRUMENT GUIDE

rbr-global.com

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1 RBR*quartz*³ APT

The RBR*quartz*³ APT (Accelerometer, Pressure, Temperature) combines a triaxial quartz accelerometer with the Paroscientific Digiquartz® pressure sensor, building on the capabilities of the RBR bottom pressure recorders.

The instrument is designed for rapid ROV deployment, and penetrates the seabed to ensure good seismic coupling and insulation from potential noise sources. The RBR*quartz*³ APT supports both autonomous installation and realtime data streaming to cabled observatories. The sub-second integration time consumes less power during sampling, significantly extending the time until the next battery replacement.

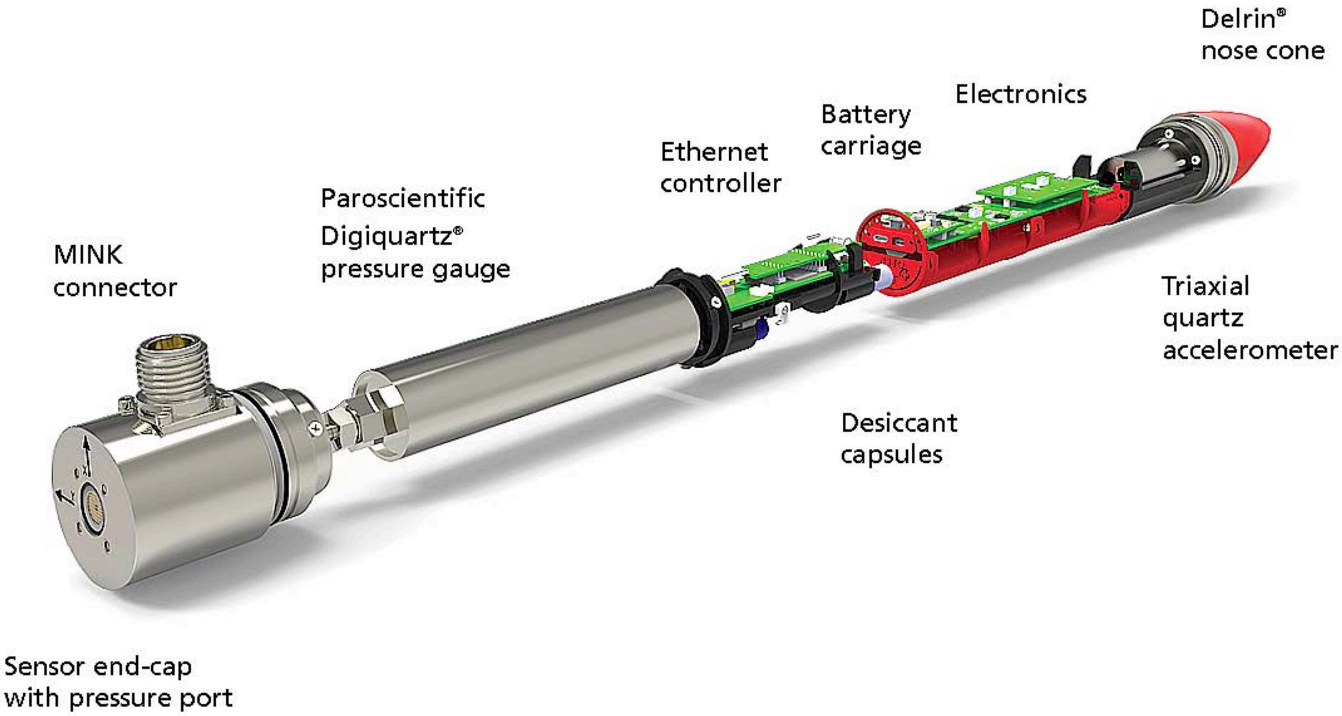
The RBR*quartz*³ APT is ideal for ocean bottom earthquake and tsunami early detection and monitoring.

Key features of the RBR*quartz*³ APT are:

- Long deployments
- High accuracy
- Quartz stability
- 10ppb pressure resolution
- 16Hz strong- and weak-motion accelerometer
- TCP/IP socket over Ethernet*

*Available upon request.

For a detailed description of bottom pressure recording using the RBR*quartz*³ APT, refer to the Ruskin User Guide: Standard loggers³.



RBR*quartz*³ APT

2 Specifications

Instrument

Specification	Description
Storage	240 million readings*
Power	8 AA-type cells
External power	4.5V to 30V
Communications	Internal: USB-C External: USB and RS-232/RS-485, or Ethernet
Clock drift	±60 second/year
Max depth rating	7000m
Housing	Titanium
Diameter	60mm
Length	880mm (with Ethernet)**
Weight	5.7kg in air, 3.2kg in water (with Ethernet)**

*Each sample can include multiple readings.

**Length and weight depend on configuration. Non-Ethernet versions have slightly different lengths and weights.

Temperature sensor

Specification	Description
Range	-2°C to 45°C
Initial accuracy	±0.002°C
Resolution	0.00005°C
Typical stability	±0.002°C/year
Time constant	~30s (embedded)

Pressure sensor

Specification	Description
Range	4000 / 7000dbar
Initial accuracy	±0.01% full scale
Resolution	10ppb (at 1Hz sampling rate)
Thermal sensitivity	<0.0008% full scale per °C

Accelerometer

Specification	Description
Range	±3g
Resolution	<100ng

Power supply selection

If connected, an external power supply will be used preferentially over the internal batteries as long as the voltage remains 9V or greater. If it drops below 9V or complete disconnection occurs, the system automatically switches to the internal batteries.

Power consumption

When the external power is present, the power consumption is ~1.5W continuous with an Ethernet connection and ~66mW with a serial connection.

Clock

The instrument's clock is maintained during brief disconnections. This time is usually sufficient to change batteries or replace desiccants.

USB-C power

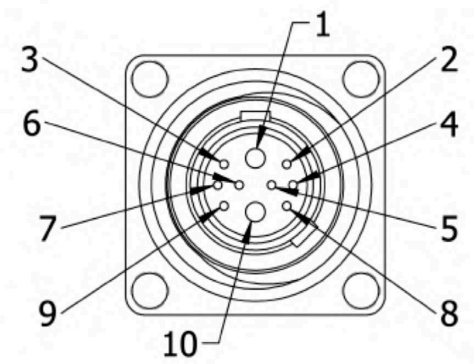
The USB-C cable provides power sufficient for configuration or data download. However, the instrument requires an internal or external power supply to perform sampling.

Deployment estimates

Deployment times are estimated for lithium thionyl chloride batteries based on both memory and internal battery capacity.

Speed	Time (days)	# of samples
16Hz	27	~38 million
8Hz	32	~22 million
4Hz	32	~11 million
2Hz	32	~6 million
2s	35	~2 million

External MINK-10-FCR connector pinout



Pin No.	RS-232	RS-485	Ethernet
1	Power 4.5V to 30V		
2	N/C	RD(A)	Data output from the instrument (Tx+)
3	N/C	N/C	Data input into the instrument (Rx+)
4	Data output from the instrument (Tx)	RD(B)+	Data output from the instrument (Tx-)
5	Ground		
6	Data input into the instrument (Rx)	TD(B)+	N/C
7	N/C	N/C	Data input into the instrument (Rx-)
8	N/C		
9	N/C	TD(A)-	N/C
10	Ground		

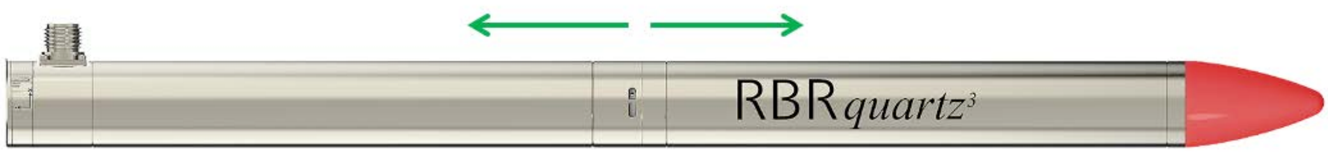
3 Hardware

3.1 Opening and closing the instrument

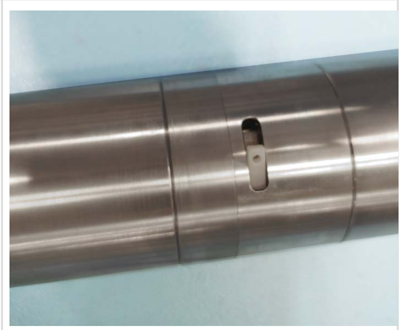
Opening the RBR*quartz*³ APT

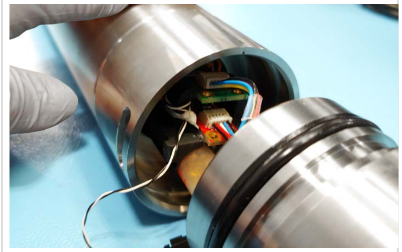
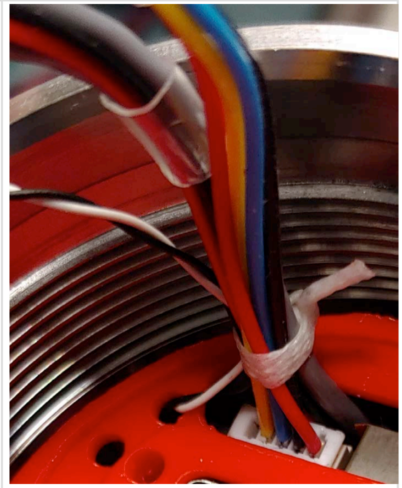
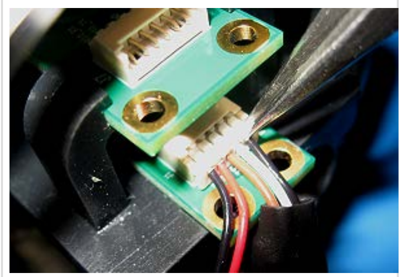
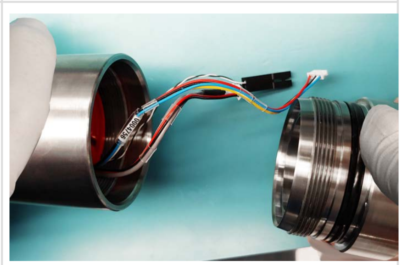
> Do not attempt twisting the housing sections at any joint while the two halves of the instruments are together. The RBR*quartz*³ APT has internal wires which may be damaged by such actions.

The only proper way of opening the RBR*quartz*³ APT is to disconnect it in the middle into two halves first. Follow the steps below.

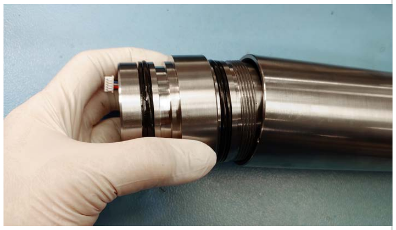
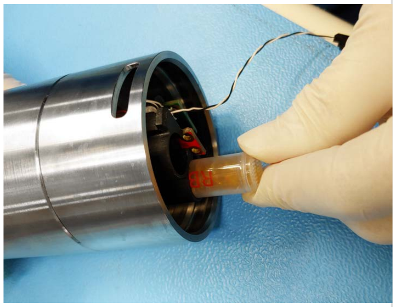
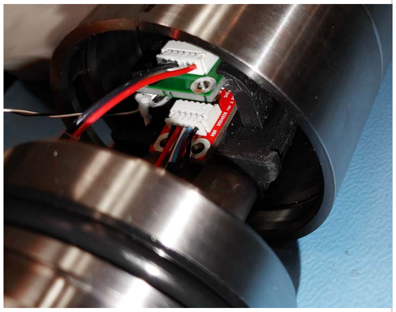


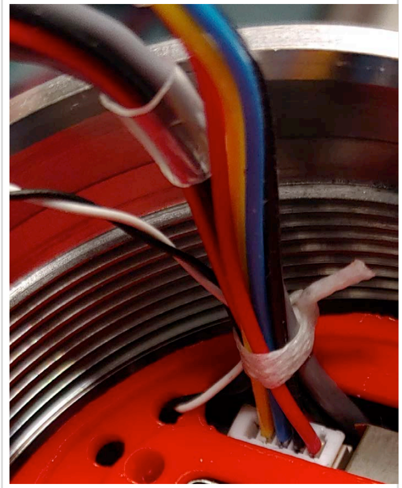
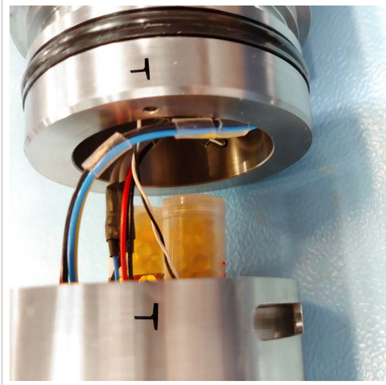
RBR*quartz*³ APT

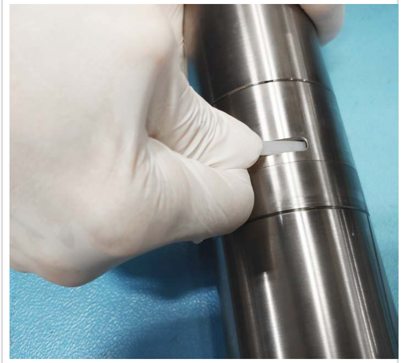
Step	Description	Images
1	Locate the nylon locking strap on the side of the instrument. The exposed edge has a hole in it.	
2	Using a pair of pliers, pull the nylon strap out of its locking groove. ⓘ It is normal to have a little silicone compound on this strap to help with its insertion/removal from the groove.	

Step	Description	Images
3	Gently pull apart the two halves of the instrument. The wire assemblies allow for a gap of about 60mm.	
4	Remove the strain relief lacing tape and nylon straps from the wire assemblies.	
5	Disconnect the wire assemblies: 1. Using tweezers or plastic spudgers, gently wiggle the six-pin and five-pin connectors and pull them out from the PCBs. 2. Hold the two parts of the two-pin connector with the tips of your fingers and pull them apart. Never pull by the wires when separating the connectors.	 
6	Once the wire assemblies are disconnected, the two halves of the RBR*quartz*^{3} APT can now be handled independently.	

Closing the RBR*quartz*³ APT

Step	Description	Images
1	Replace the two sets of O-rings which were exposed when the instrument was open.	
2	Screw the coupling back onto the instrument.	
3	Replace the desiccant capsules. Fresh desiccant is orange.	
4	Replace the batteries, ensuring correct polarity.	
5	Reconnect the wiring, in this order: 1. the five-pin connector to the small lower board 2. the six-pin connector to the larger board 3. the two-pin connector (two-wire connection)	

Step	Description	Images
6	Put the strain relief lacing tape and nylon straps on the wire assemblies.	
7	With a removable marker, mark the location of the dowel pin on outside of the housing. Also, mark the location of the mating dowel pinhole on the outside of the coupler.	
8	Reassemble the two halves of the instrument: 1. Align the markings. 2. Make sure the dowel pin goes right into the hole. 3. Gently push the two sections together. 4. Inspect the joint, as O-rings may get snagged on the cutout for the strap. If any O-ring debris is found, go to **Opening the RBR*quartz*^{3} APT**, Steps 3-5, and replace the damaged O-ring. Then, go to **Closing the RBR*quartz*^{3} APT**, Step 5, and continue with the re-assembly.	

Step	Description	Images
9	Using pliers or your thumb, push the nylon locking strap into the slot all the way in, cut-off end first. The instrument is now closed.	

3.2 RBR*quartz*^{3} APT interface

The RBR*quartz*^{3} APT instrument provides an internal USB-C port and several external communication options. Select from RS-232, RS-485, and Ethernet at the time of order, and RBR will wire the battery end-cap to support your preferred external connection.

ⓘ Refer to Opening and closing the instrument for details on accessing connection ports.
Refer to Specifications for the external MINK-10-FCR connector pinout diagram.

USB-C connection

Remove the battery end-cap to access the USB-C port located inside the instrument body.

A USB-C desktop cable is supplied in the instrument support kit. Use this cable to download data from the instrument to your computer.

USB-C port

ⓘ The mini-display port located next to the USB-C port is not used.

MINK connector

The RBR*quartz*³ APT instrument has an external MINK-10-FCR connector. The MINK interface provides both data and power connections and is located near the pressure sensor. The MINK data and power connections allow for extended deployments by providing external power and realtime data access without jeopardising the watertight seal.

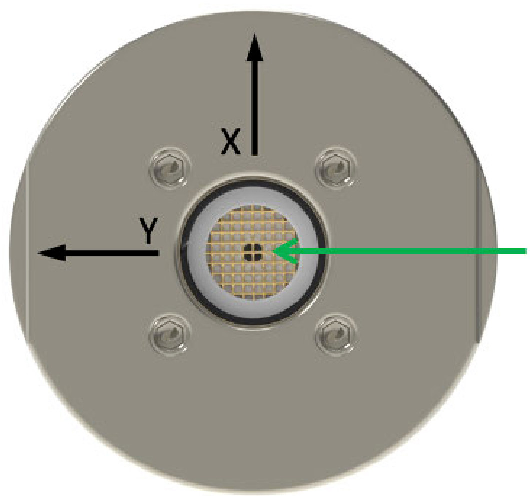
MINK-10-FCR connector

3.3 Orientation and datum location

The datum of the RBR*quartz*³ APT is located at the centre of the pressure sensor port. RBR performs an offset adjustment with the sensor facing upwards. It is recommended to deploy the RBR*quartz*³ APT vertically to match the way it was calibrated, with the nose cone of the instrument penetrating the seabed.

Recommended orientation:

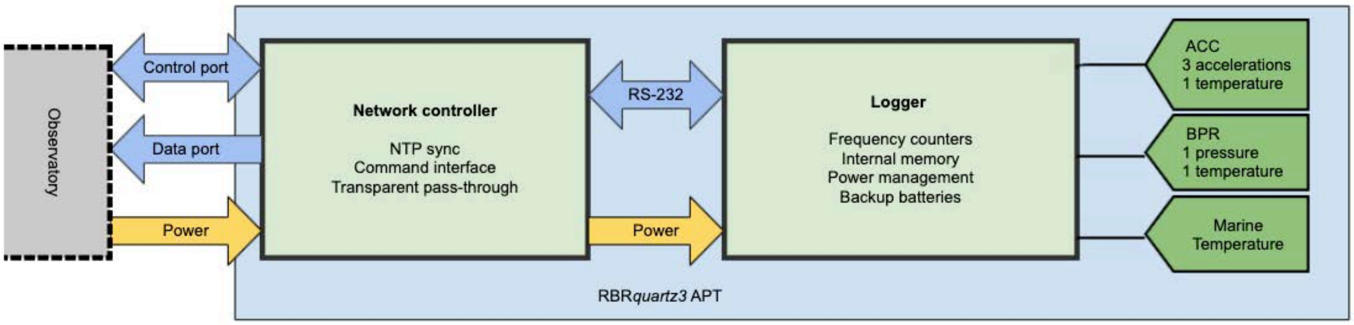
sensors facing up



Datum location

4 Ethernet commands

At the time of order, you can request your RBR*quartz*[3] APT wired for Ethernet and power. See the pinout diagram in the Specifications section and the hardware structure of the instrument, in the block diagram below.



You do not need to open your instrument to connect it to your network. Connect your terminal to the MINK port located outside the instrument body using a compatible MINK cable. The instrument will appear on your network.

1. IP connections

IP connections to the instrument are made via two different ports.

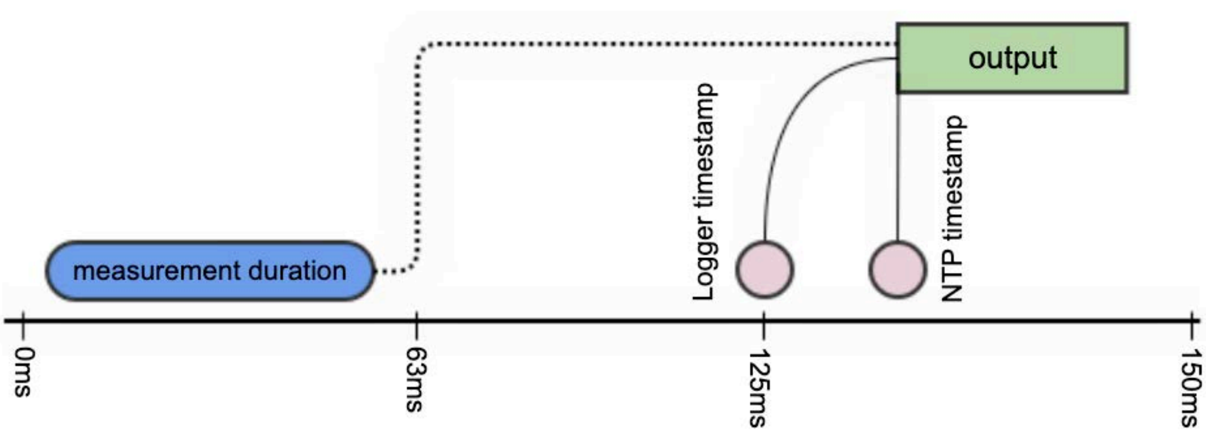
The first is the data port (23) which is a read-only socket where the client should simply listen for the measured data that is being streamed out. The second is the control port (2323) which permits some settings to be modified.

Upon connection to the control port (2323), there will be no immediate response or banner. You can enter commands by typing them in.

When entering a command, terminate with linefeed. Any carriage returns will be ignored.

2. Performance and timing considerations

- Logger



Logger readings will be timestamped no earlier than 63ms and no later than 125ms from when the reading was completed. The resolution of logger timestamps is 63ms. Logger output of the timestamped sample will occur within 63ms of the indicated timestamp.

- NTP-based tagging

The network controller associates each sample received from the logger with an NTP-based timestamp upon receiving the first character of the line of data from the logger. The resolution of NTP-based timestamps is 5ms. After receiving the entire sample, it is sent to the TCP connection within 5ms.

3. Starting up for the first time

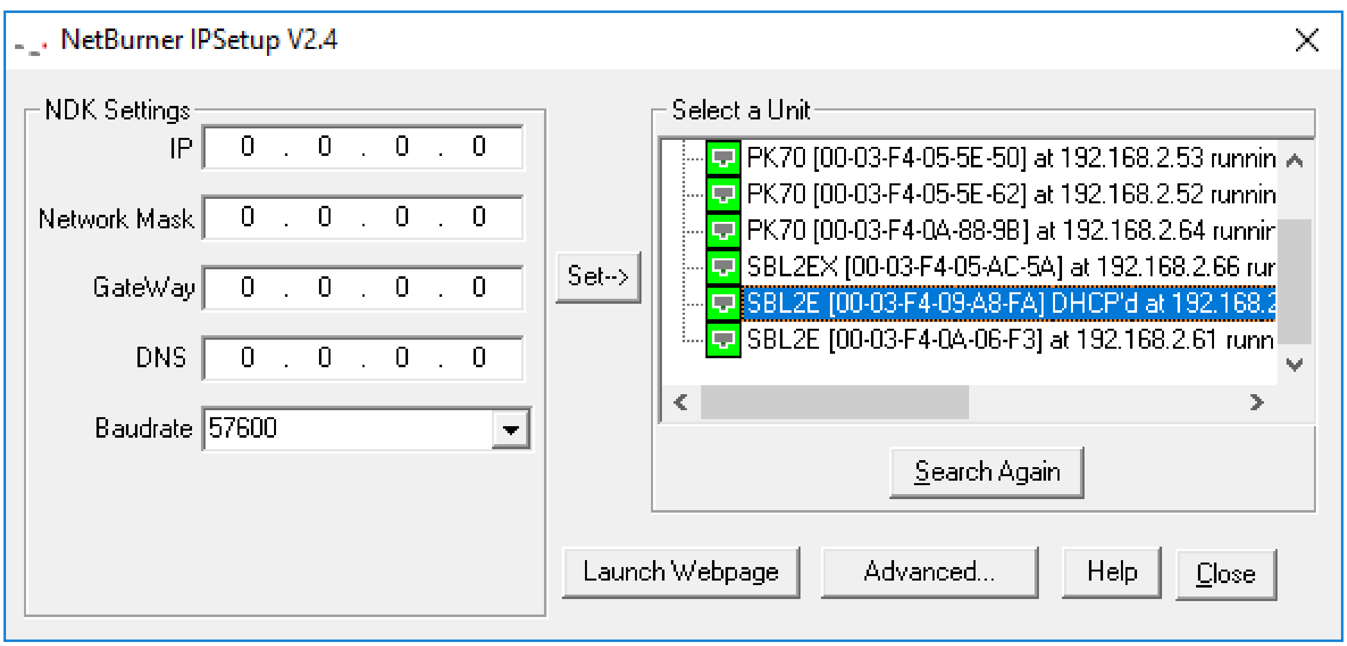
In order to start the logger, use the transparent mode in the control interface and the following commands. These assume that the logger clock has been reset already, if of interest (`clock` command).

```
deployment starttime = 20000101000000, endtime = 20991231235959
sampling mode = continuous, period = 63
enable erasememory = true
```

4. Configuring network settings

To configure the network controller, download the Windows-only executable IPSetup binary required to run on a host on the same subnet (same UDP broadcast domain) as the instrument.

In its default state, the instrument will attempt to acquire network configuration information via DHCP. Using IPSetup, configure the static IP address, network mask, gateway, and DNS server of the instrument. No other settings in IPSetup should be changed at risk of an invalid configuration requiring the instrument to be returned to RBR for service.



5. Periodic stop-erase-start procedure

```
disable
enable erasememory = true
```

As the instrument has a linear memory, in order to provide protection for a possible network outage it is important to periodically stop the logging, erase the memory, and restart. This process should take less than ten seconds, during which there will be no streaming data, nor logged data. As the logger memory will fill in ~25 days, this process should be followed every 20 days (or 3 weeks) to give some margin for human error.

6. Procedure after an observatory outage

```
<download while still running - may take hours or days>
// chunksize := 500
// offsetdataread := 0
>> meminfo
<< meminfo used = YYY
// totalsize := YYY
// while (offsetdataread < totalsize) {
// while (offsetdataread < totalsize) {
>> readdata dataset = 1, size = chunksize, offset = offsetdataread
<< readdata dataset = 1, size = nbytesread, offset = 2000 offsetread<cr><lf><bytes[0…
nbbytesread]-of-data><crc>
// if crc ok
// {
// append bytes read to output file
// offsetdataread := offsetdataread + nbbytesread
// }
// }
>> meminfo
<< meminfo used = YYY
// totalsize := YYY
// }
<end of download>
>> disable
>> enable erasememory=true
```

The download can be performed by reading all the bytes in dataset 1 and writing them in a *.bin file. Ruskin is able to read directly those files.

For more details on the **read** and **meminfo** commands and the CRC calculation, please refer to the L3 command reference.

7. Stopping the instruments and preparing for shipment

```
disable
```

The only command required to be sent to the logger (using the transparent mode in the control interface) is `disable`. The control interface will still be active but may be powered down by removing the patch cable. The internal batteries will continue to provide backup power to the logger RTC (~10uA) and will last for many years in this state.

8. Control port commands

Upon connection to the control port (2323), there will be no immediate response nor banner. If the command required is known, it can be entered immediately (all commands are terminated with line-feed, and any carriage returns are ignored). If the commands are not known, the question mark ("?") command can be used to display the network controller control menu.

The control port connection supports a single connection. It is important that the connection is closed after use, permitting others to establish connections if necessary.

```
------ RBRquartz3 APT NETWORK INTERFACE CONTROL MENU ------

 D: Display current settings
 S: Set NTP source
 R: Set NTP refresh rate
 J: Set the timestamp jump tolerance
 E: Set the transparent mode inactivity timeout
 T: Enter transparent mode
 !: Exit transparent mode (once in transparent mode)
 Q: Close this connection
 #: Reset the RBRquartz3 APT network interface
 ?: Print this menu
```

- D: Display current settings

```
RBRquartz3 APT Network Interface v1.5.1
Uptime: 0 days 00:13:03.340
Current time: 2021-05-10 15:11:48.248
System parameters
-----------------
NTP time sync rate (min):                 1
NTP source:                               NTP pool
Timestamp jump tolerance (s):             1800
Transparent mode inactivity timeout (s):  10
Last valid time sync:                     2021-05-10 15:11:02.934
```

The current settings shown include:

- Uptime: approximate time since the last reboot - either due to power up or the `#` reset command.
- Current time: this clock is maintained according to the NTP settings.
- NTP time sync rate: frequency at which the NTP source is polled to correct for clock drift. See `R` command.
- NTP source: Either the IP address of the NTP server or the phrase “NTP pool”. See the `S` command.
- Timestamp jump tolerance: time tolerance in seconds for the difference in the logger clock between two subsequent samples. (Only when the new sample is in the future)
- Transparent mode inactivity timeout: timeout for leaving transparent mode if no input is received in the set amount of time.
- Last valid time sync: the last time at which a successful poll of the NTP source occurred.

- S: Set NTP source

```
Enter NTP source (IP address, a.b.c.d).
To use pool.ntp.org, enter 0.
```

By default, the NTP Pool will be used as the source of NTP times. A custom NTP server can be used by providing its IP address.

Whenever this value is changed, an NTP poll is performed immediately and the schedule for polling is restarted.

- R: Set NTP refresh rate

```
Enter the NTP refresh rate (number of minutes, 1-60; default: 1):
```

The frequency with which time is polled from the NTP source can be adjusted.

Whenever this value is changed, an NTP poll is performed immediately and the schedule for polling is restarted.

- J: Set the timestamp jump tolerance

```
Enter the timestamp jump tolerance (number of seconds, 1-86400; default: 1800):
```

The time tolerance between two subsequent instrument samples to trigger a clock sync with the logger. This will accommodate cases where the logger is reconfigured externally.

- E: Set the transparent mode inactivity timeout

```
Enter the transparent mode inactivity timeout (number of seconds, 10-60; default: 10):
```

The time for exiting transparent mode automatically if no commands are issued in that time frame.

- T: Enter transparent mode

```
Data streaming off
Transparent mode on
```

To communicate with the instrument directly, use the `T` command to enter transparent mode. Upon entering transparent mode, the instrument's streaming output will be automatically disabled. While in transparent mode no output will be sent to the data client; however, any connections to the data port will remain open and will resume receiving data when transparent mode is closed. Upon leaving transparent mode, the streaming output of the instrument will be automatically re-enabled (providing that the instrument is enabled).

There are two ways of leaving transparent mode: manually escaping with the `!` character (described below), and an automatic configurable idle timeout. If 10 seconds, or the set time, elapse without characters being received by the network controller, transparent mode will automatically be closed and streaming output will be restarted.

Transparent mode is maintained across multiple control client connections. If the control client is disconnected without escaping from transparent mode (i.e., by abruptly terminating the socket connection), future connections will be placed directly into transparent mode (unless the idle timeout has been exceeded).

- !: Exit transparent mode (once in transparent mode)

```
Data streaming on
Transparent mode off
```

When in transparent mode, send a `!` character to immediately leave the mode and restart instrument streaming.

See the notes for the `T` command for details on the behaviour of the data port upon leaving transparent mode.

- Q: Close this connection

```
Connection closed by foreign host.
```

Explicitly close the connection to the control port.

- #: Reset the APT network controller

```
Resetting server. All connections will be lost!
Connection closed by foreign host.
```

The control interface is reset by this command, a process that takes <10s. All network connections are lost and will have to be re-established. The network controller clock is reset to the beginning of 1970, but the first NTP sync should be done by the time the first connection is made.

- ?: Print this menu

Displays the menu as shown above.

8. Data port format

The data port provides read-only data and does not respond to any commands.

9. Sample data

The format of the data is as follows:

#	Name	Format	Notes
1	Logger time NTP offset corrected	YYYY-MM-DD HH:MM:SS.sss format.	The time that the internal logger reports corrected with the latest NTP offset. The current NTP time may be examined using the `D` command via the control interface.
2	Logger time	YYYY-MM-DD HH:MM:SS.sss format.	The time that the internal logger reports. This clock may be read and set using the `now` command via transparent mode. Drift should be ±60s/year.
3	BPR temperature (C)	Double precision (64 bit) floating-point number.	The temperature derived from the BPR.
4	BPR pressure (dbar)	Double precision (64 bit) floating-point number.	The pressure derived from the BPR.
5	BPR pressure period (ps)	Double precision (64 bit) floating-point number.	The period of the pressure channel of the BPR.
6	BPR temperature period (ps)	Double precision (64 bit) floating-point number.	The period of the temperature channel of the BPR.

```
2021-05-06 19:03:37.924, 2021-05-06 15:03:37.000, 26.141700000, 9.235400000,
30284722.000000000, 5752694.000000000
```

One variation to the normal data format will occur when an internal error occurs. This error usually happens on a single channel at a time, and is most often caused by a failed electrical connection so that no valid readings are available. If this occurs, it will look like the following sensor error example:

```
2021-05-06 19:03:39.924, 2021-05-06 15:03:39.000, Error-9, 9.232900000,
30284722.000000000, 5752694.000000000
```

All errors should be reported to RBR for investigation.

10. Events

- All events obey the following format:

```
#EVENT_NAME, timestamp, eventPayload1, eventPayload2, ..., eventPayloadn- 1,
eventPayloadn
```

EVENT_NAME is a string name for the event
timestamp is the time at which the event occurred; depending on the event type, this may correspond to a corrected sample time
eventPayload1 ... eventPayloadn are the payload values for the event

- NTP synchronization events

When an NTP synchronization occurs, one #NTPSYNC event will be generated on the output:

```
2021-05-06 19:03:38.924, 2021-05-06 15:03:38.000, 26.141700000, 9.235400000,
30284722.000000000, 5752694.000000000
#NTPSYNC, 2021-05-06 19:03:39.924, 2021-05-06 15:03:39.000, 924
2021-05-06 19:03:39.924, 2021-05-06 15:03:39.000, 26.141700000, 9.235400000,
30284722.000000000, 5752694.000000000
```

#NTPSYNC corresponds to an NTP offset adjustment
Its timestamp is the logger time for the sample on which synchronization occurred corrected with the new NTP offset
eventPayload1 is the logger time for the sample on which synchronization occurred
eventPayload2 is the new NTP offset in milliseconds

5 Deployment

Deployment procedure of the RBR*quartz*^{3} APT depends on whether its MINK connector is wired for Ethernet or for RS-232/RS-485. See the pinout diagram in the Specifications section.

You will require a MINK cable and/or adaptor compatible with your instrument configuration. These are included with the instrument if requested at the time of order.

5.1 RBR*quartz*^{3} APT with Ethernet

At the time of order, you can request your RBR*quartz*^{3} APT wired for Ethernet and power. See the pinout diagram in the Specifications section.

> ⓘ You do not need to open the instrument to connect it to your network. Follow the steps below.

Deploying RBR*quartz*^{3} APT

1. Connect your terminal to the MINK or MCBH port located outside the instrument body using a compatible patch cable. The instrument will appear on your network.
2. Connect to the control port (2323).
3. Enter the question mark (" `?` ") command, terminated with linefeed, to display the network controller control menu.

```
------ RBRquartz3 APT NETWORK INTERFACE CONTROL MENU ------

 D: Display current settings
 S: Set NTP source
 R: Set NTP refresh rate
 J: Set the timestamp jump tolerance
 E: Set the transparent mode inactivity timeout
 T: Enter transparent mode
 !: Exit transparent mode (once in transparent mode)
 Q: Close this connection
 #: Reset the RBRquartz3 APT network interface
 ?: Print this menu
```

4. Enter " `T` " to enable the transparent mode.
5. Enter " `clock` " to reset the instrument clock if necessary.

6. Enter deployment parameters, for example:

```
deployment starttime = 20000101000000, endtime = 20991231235959
sampling mode = continuous, period = 63
```

7. Erase the memory and start the deployment.

```
enable erasememory = true
```

ⓘ For more information on deploying the RBR*quartz*[3] APT with Ethernet, see Ethernet commands.

5.2 RBR*quartz*[3] APT with RS-232 or RS-485

At the time of order, you can request your RBR*quartz*[3] APT wired for RS-232/RS-485 and power. See the pinout diagram in the Specifications section.

ⓘ You do not need to open your instrument to connect it to Ruskin. Follow the steps below.

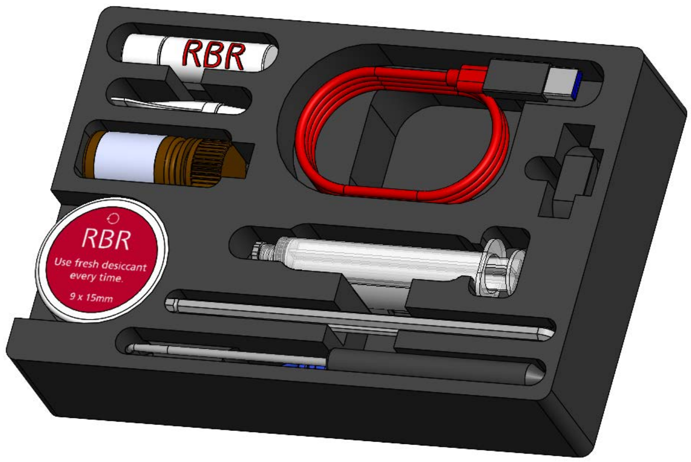
Deploying the RBR*quartz*[3] APT

1. Connect your computer to the MINK port located outside the instrument body using a compatible MINK cable. The instrument will appear on Ruskin.
2. Select the required sampling mode and speed.
3. Select "UTC" or "Local" to synchronise the instrument clock to the computer.
4. Choose whether to start "now" or at a future point in time.
5. Review the estimated end date to ensure it fulfils the deployment requirements. Longer deployments can be achieved with better battery chemistry or lower sampling speeds.
6. Click "Enable" to start the deployment.

For a detailed description of Ruskin software and its use for the the RBR*quartz*[3] APT, refer to the Ruskin User Guide: Standard loggers[3].

6 General maintenance

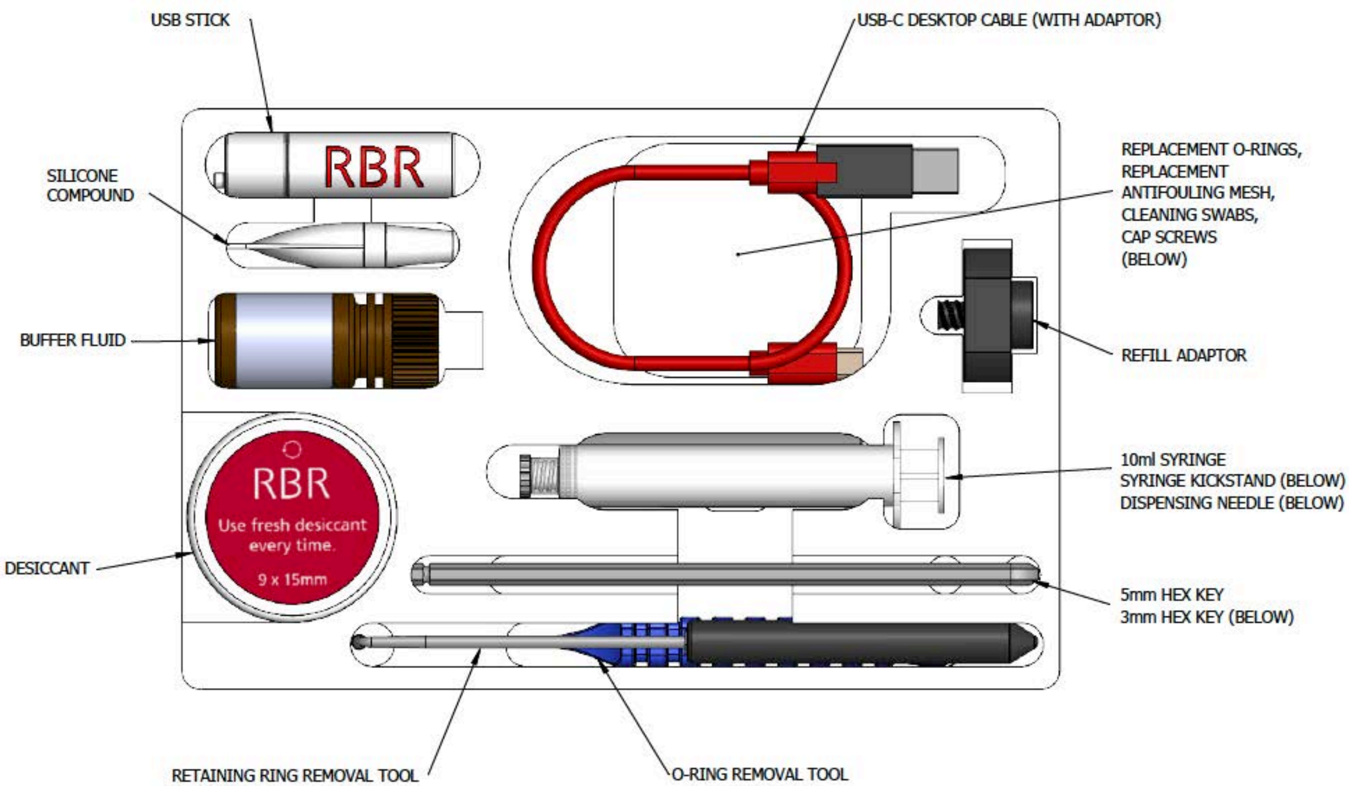
6.1 Support kit



RBR*quartz*[3] support kit

RBR provides one support kit per every three instruments ordered. If you need more units, contact RBR.

The RBR support kit contains an assortment of basic accessories and spare parts, as presented below.



RBR*quartz*[3] support kit diagram

6.2 Replacing the O-rings

> ⓘ Refer to Opening and closing the instrument for details on accessing the O-rings.
> The O-ring removal tool and silicone compound are available in the support kit.

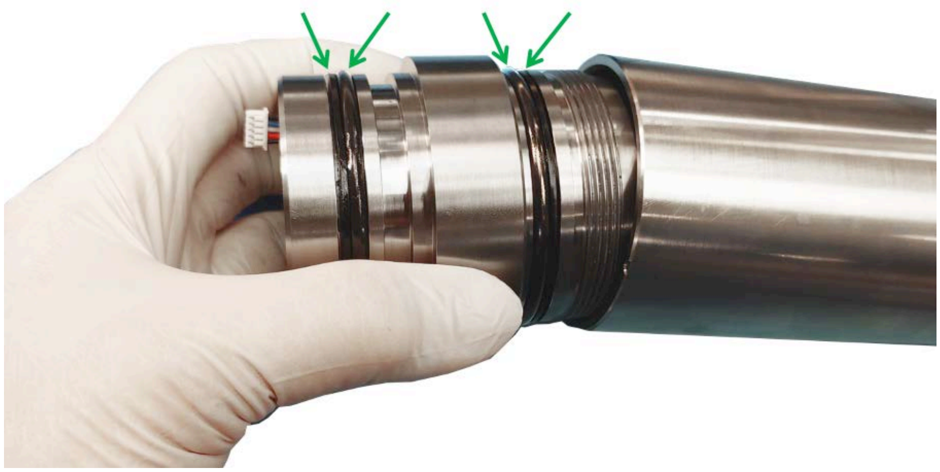
Care for the O-rings is the single most important item of maintenance on any submersible RBR instrument. A water leak can damage the circuit board beyond repair and cause complete data loss. Every instrument's seal depends upon its O-rings, not the end-cap tightness. Therefore, proper O-ring maintenance is crucial.

> ⓘ The O-ring may lose elasticity over time, even when the instrument is not deployed. RBR strongly recommends replacing the O-ring regularly.

O-rings on the RBR*quartz*³ APT

The RBR*quartz*³ APT instrument has a coupling piece, which connects the two halves of the instrument together. Each of the two joints uses two O-rings. One is the main O-ring, and the other is the backup. Both are required to protect the instrument from flooding.

Location of the coupling piece on the RBR*quartz*³ APT



Locations of the O-rings

Inspecting the O-rings

ⓘ Only the O-rings which were exposed during maintenance need to be checked before reassembly.

Visually inspect each new O-ring for nicks and scratches before installing it. Pay attention to the following areas:

- The surface of the O-ring itself
- The mating surface on the inside of the case between the threads and the open end
- The groove in the end-cap where the O-ring sits

.

When handling the O-rings:

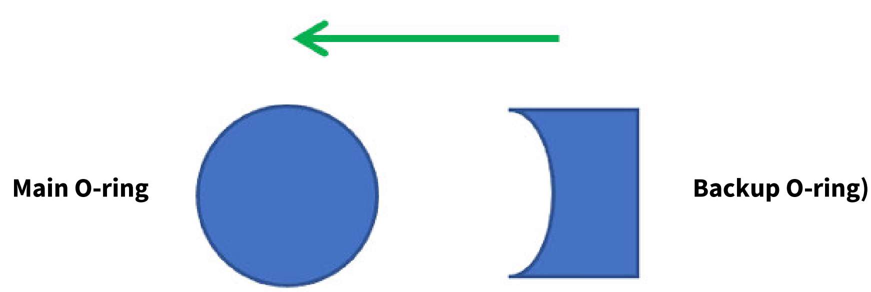
- Avoid using any object that could scratch the O-ring or any of its mating surfaces.
- If dirt is present in the O-ring groove, remove the O-ring as described below and thoroughly clean the groove.
- Do not return this old O-ring to the instrument! If you remove the O-ring from the instrument for any reason, always replace it with a new one.
- If the surfaces of the O-ring groove are scratched, pitted, or damaged, contact RBR for advice.

Orientation of the O-rings

Correct placement and orientation of the two O-rings are critical to maintaining depth rating integrity.

The main O-ring has a round profile. It must be installed first.

The backup O-ring is flat on one side, and concave on the other. When installed, the concave side must face the main O-ring.



Orientation of the O-rings

Replacing the O-rings

> Do not use metal screwdrivers or any other metal tool! They may scratch the O-ring groove and render the end-cap useless.

1. Use the plastic O-ring removal tool (included in the support kit) to remove the old O-ring from its groove. The O-ring may need to stretch quite a bit as it is pushed off. This requires some effort, but can be done by hand.
2. Clean the groove thoroughly with a soft, lint-free cloth and compressed air, if necessary.
3. Select a new O-ring and inspect it for damage.
4. Lubricate with a very light film of silicone compound (included in the support kit).
5. Install the main O-ring by pushing it into place and popping it into its groove.
6. Install the backup O-ring, making sure the concave side is facing the main O-ring.
7. Once in place, inspect the O-rings once more for scratches and debris, and wipe away any excess of silicone compound.
8. Remove electrical tape from the threads.
9. Close the instrument.

6.3 Replacing the batteries

RBR ships new instruments with lithium thionyl chloride batteries included. Replace the batteries before each deployment to maximise the operational time and prevent data loss.

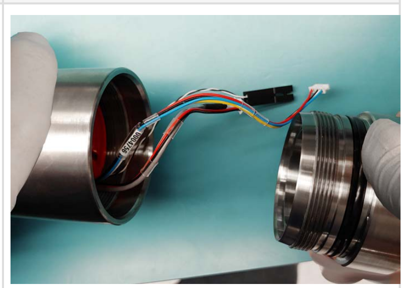
Ruskin software estimates the remaining battery life during deployment by tracking power consumption in mAh. When setting up your deployment on Ruskin, check "Fresh" to indicate that new batteries are installed.

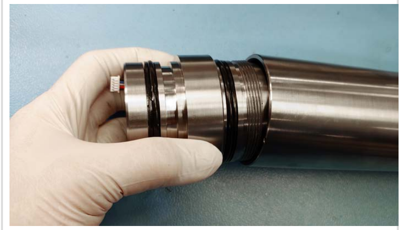
If using the same batteries for a subsequent deployment, do not check "Fresh" and continue power tracking from the previously recorded level.

See Ruskin User Guide: Standard Loggers[3] for more information on predicting battery life.

The half of RBR*quartz*^{3} APT with the battery carriage assembly

Replacing the batteries

Step	Description	Images
1	Open the instrument and disconnect the wiring. ⓘ The half of the instrument with the nose cone contains the battery carriage assembly.	

Step	Description	Images
2	Unscrew the coupling piece to expose the battery carriage assembly.	
3	Push on the arrow to open the battery door.	
4	Remove eight old batteries.	
5	Install eight new AA-type batteries, with the negative ends down.	

Step	Description	Images
6	Close the battery door.	
7	Replace the O-rings on the coupling section. Lubricate with a small amount of silicone compound.	
8	Inspect the threads on the housing and on the coupling piece to ensure they are clean and undamaged.	
9	Screw the coupling piece back onto the housing.	
10	Reconnect the wiring and close the instrument.	

Always remove the batteries from your instrument during long-term storage!
Doing so will prevent internal damage due to battery leakage and/or corrosion.

6.4 Replacing the desiccant capsules

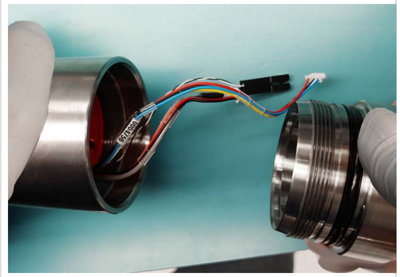
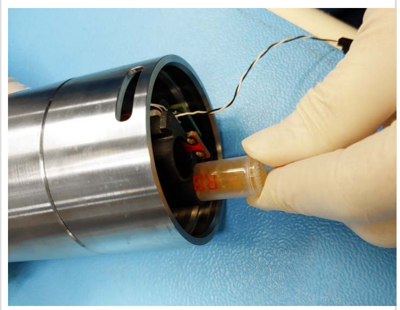
Replace desiccant capsules before each deployment.

Fresh desiccant will keep the instrument compartment dry and prevent malfunction. Water damage may occur if condensation forms inside the instrument.

As a preventative measure, RBR recommends servicing the instrument in a cool, dry place (when possible).

The half of RBR*quartz*^{3} APT with the desiccant capsules

Replacing the desiccant capsules

Step	Description	Images
1	Open the instrument and disconnect the wiring. ⓘ The half of the instrument with the MINK connector contains desiccant capsules.	
2	Pull the used capsules out of the desiccant socket.	
3	Insert two fresh desiccant capsules.	
4	Reconnect the wiring and close the instrument.	

6.5 Cleaning the instrument

Clean the instrument after each extended deployment to remove deposits that may have accumulated.

Type	Procedure	Notes
General/biofouling	To clean the exterior, soak in a mild detergent, then scrub the instrument with a soft brush.	Avoid scratching the plastic (scratches make future cleaning more difficult).
Sensor antifouling mesh	Scrub the antifouling mesh with a soft brush. Replace the antifouling mesh if needed.	See instructions on removing the antifouling mesh for more information.
Calcification	Soak in vinegar for six hours, then scrub the surface using a soft brush.	Soaking in vinegar for more than 24 hours may damage the O-ring and increase the chances of a leak.

6.6 Calibrating the instrument

Factory calibration coefficients are calculated for each sensor, and the coefficients are stored on the instrument.

RBR calibration certificates contain calibration equations, coefficients, and residuals for each sensor. Hard copies are provided with each shipment. RBR can replace lost or misplaced calibration certificates upon request.

RBR recommends calibrating your instrument before any critical deployment, periodically once a year, or if you suspect the readings to be out of specifications.

Discuss your calibration requirements with RBR. In some cases, the instrument will need to be returned to RBR to have it checked and recalibrated.

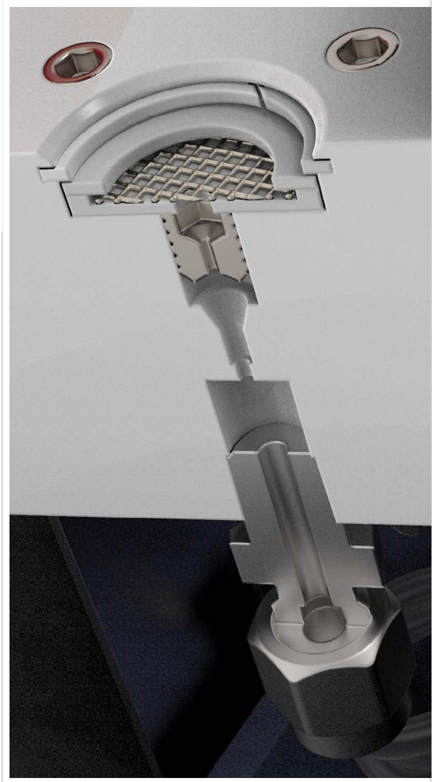
Please contact RBR for our current calibration fees.

7 Pressure sensor maintenance

7.1 Removing the antifouling mesh assembly

Removing the antifouling mesh assembly may be necessary for a variety of reasons, such as cleaning the instrument and its buffer tube, or installing the external pressure adaptor. Follow the steps below.

1. Remove the retaining ring using the removal tool. Hook the split in the ring at the opening and pull it out of the recess in the sensor end-cap.
2. The upper mesh insulator disk, nickel-copper mesh, and the lower mesh insulator disk will come out easily once the retaining ring is removed.

Item No.	Description	Part image	Assembled antifouling mesh	Buffer tube interface assembly
1	Lower mesh insulator disk			
2	Nickel-copper mesh			
3	Upper mesh insulator disk			
4	Retaining ring			

7.2 Filling the syringe and de-gassing the buffer oil

It is important to remove all gases from the system as they can form bubbles and cause anomalies in the data. Refill the system with de-gassed oil any time when cleaning it, or if it has had an oil leak for any reason.

Required materials

- Buffer fluid
- Syringe with a stopper and needle
- Syringe kickstand

Recommended handling materials

- Latex or nitrile gloves
- Lint-free tissues
- Protective coat

⚠ Buffer oil is not a hazardous substance, but it is recommended to practice good industrial hygiene and safety practices, and to use this material in a well-ventilated space.

Filling the syringe

Step	Description
1	Remove the stopper from the syringe.
2	Install the needle.
3	Draw 1-2ml of the oil into the syringe.

De-gassing the buffer oil

Step	Description	Image
1	Invert the syringe so that the needle is facing up and pull any remaining oil out of the needle into the syringe.	
2	Remove the needle.	
3	Gently push the plunger to purge the air from the syringe.	
4	Install the stopper.	
5	Reverse the syringe so that the stopper is facing down.	
6	Draw out the plunger of the syringe past the 10ml point.	
7	Install the syringe kickstand so that it cups the plunger and supports it in the drawn-out position. The syringe will brace against the flange on the plunger and the barrel.	
8	Leave the syringe in the reverse position for about an hour.	
9	Remove the kickstand.	
10	Invert the syringe so that the tip is facing up.	
11	Remove the stopper.	
12	Purge any air from the syringe	

7.3 Cleaning the buffer tube

ⓘ All required materials for this procedure are provided in the support kit.

Required materials

- Buffer fluid
- Syringe with a stopper and needle
- Syringe kickstand

Cleaning the buffer tube by aspirating the buffer oil

Step	Description	Images	
1	Remove the antifouling mesh assembly		
2	Clean the buffer tube assembly 1. Insert the needle into the buffer tube assembly, all the way 2. Draw out the plunger of the syringe past the 10ml point 3. Install the syringe kickstand so that it cups the plunger and supports it in the drawn-out position; the syringe will brace against the flange on the plunger and the barrel ⚠ The syringe will draw up oil and any particles until the assembly is empty, and then, it will draw air.		
3	Refill the buffer tube assembly		

Cleaning the buffer tube by purging with buffer oil

Debris can be removed from the buffer tube assembly by purging the assembly with buffer oil. This method will consume more oil, but it may be more effective in some situations.

Step	Description
1	Prepare the instrument and the syringe 1. Remove the antifouling mesh assembly 2. Remove the instrument from the foam stand and lay it on its side 3. Fill the syringe and de-gas the buffer oil
2	Clean the buffer tube assembly 1. Insert the needle into the buffer tube assembly, all the way 2. Depress the plunger and flush the buffer tube assembly 3. With the syringe still in the pressure port, stand the instrument with the port up 4. While depressing the plunger, remove the syringe
3	Refill the buffer tube assembly

7.4 Refilling the buffer oil

ⓘ All required materials for this procedure are provided in the support kit.

Required materials

- 3mm and 5mm hex keys
- O-ring
- Silicone compound
- Buffer fluid
- Syringe with a stopper and needle
- Syringe kickstand
- Refill adaptor
- Four socket head cap screws

Refilling the buffer oil

Step	Description	Images
1	Prepare the instrument 1. Remove the antifouling mesh assembly (see Removing the antifouling mesh assembly) 2. Remove the four set screws around the pressure port using the 3mm hex key	
2	Prepare the refill adaptor 1. Apply a thin film of silicone compound to the O-ring of the refill adaptor 2. Install the O-ring into the refill adaptor as shown in the image	

Step	Description	Images
3	Fill the buffer tube with oil 1. Remove the stopper from the syringe 2. Install the needle 3. Invert the syringe so that the needle is point up 4. Purge the air from the needle by depressing the plunger until a drop of oil comes out 5. Insert the needle into the buffer tube assembly and fill it with oil to the top of the set screw 6. When extracting the needle, continue to apply pressure to the plunger to maintain the oil level 7. Draw the oil out of the needle and remove the needle	
4	Refilling the oil 1. Install the refill adaptor to the syringe 2. Invert the syringe so that the refill adaptor is pointing up 3. Purge the air from the refill adaptor by depressing the plunger until a drop of oil sits at the adaptor opening ⚠ Ideally, the meniscus at the air-oil interface should be convex to minimise the air in the final assembly.	
5	Install the refill adaptor 1. Mate the refill adaptor to the pressure port 2. Install the four cap screws with the 5mm hex key ❗ Do not apply pressure to the plunger when the syringe is installed on the pressure port! Doing so may exceed the pressure rating of the sensor.	

Step	Description	Images
6	De-gas the system 1. Draw the plunger of the syringe just past the 10ml mark 2. Install the syringe kickstand so that it cups the plunger and supports it in the drawn-out position; the syringe will brace against the flange on the plunger and the barrel ⚠ Bubbles will be coming out of the system through the oil into the syringe, drawn into the rarefied air. The rate of bubbles coming out should quickly start to reduce. If it is not happening, tighten the syringe to the refill adaptor and tighten the four cap screws. 3. Leave the syringe in this position for about an hour 4. Remove the kickstand, while keeping the syringe in place ⚠ The plunger will drop back, almost to the surface of the oil, due to low pressure inside the syringe. 5. With everything still attached, draw the plunger of the syringe just past the 10ml mark again 6. Very gently pump the plunger up and down approximately 10 times, until no bubbles come out of the system after drawing the plunger .	
7	Clean up and reassemble 1. Remove the refill adaptor 2. Remove excess oil from the pressure port with a tissue or swab 3. Once cleaned, install the lower mesh insulator disk with the recess facing up 4. Place the nickel-copper mesh in the recess of the lower mesh insulator disk 5. Place the upper lower mesh insulator disk on top of the lower mesh insulator disk and nickel-copper mesh assembly 6. Open the split on the retaining ring and ease its middle into the sensor end-cap recession 7. Hold the retaining ring in place with one finger and feed the the rest of the ring into the sensor end-cap recession	

8 External pressure adaptor

The external pressure adaptor is designed for the RBR*quartz*³ instruments and can be used to verify or recalibrate the Paroscientific Digiquartz® pressure sensor.

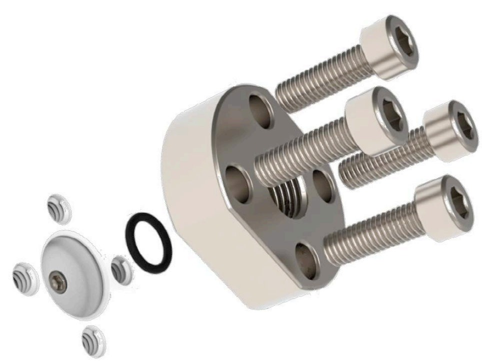
RBR provides the RBR*quartz*³ pressure adaptor kit with each instrument. It is not included in the RBR support kit and needs to be ordered separately. You can choose to receive this separate kit at the same time as the instrument, or to request it separately at a later date.

RBR*quartz*³ pressure adaptor kit includes:

- pressure adaptor
- four socket head cap screws
- 3mm and 5m hex keys
- five replacement O-rings

Pressure adaptor kit

Installing the adaptor

Step	Description	Image
1	Remove the antifouling mesh.	
2	Apply a thin layer of silicon compound to the O-ring.	
3	Install the O-ring into the O-ring groove of the external pressure adaptor.	
4	Position the external pressure adaptor over the exposed pressure port of the instrument.	
5	Install the four screws with a 5mm hex key and tighten them to 1/4 turn past snug (max 10 Nm torque).	

9 Repairs

RBR supports all our products. Contact us immediately at support@rbr-global.com or via the RBR website if there are any issues with your instrument. Please have the model and the serial number of the unit ready. Our support team will work to resolve the issue remotely. In some cases, you may have to return your instrument to RBR for further servicing.

> There are no user-repairable parts of the instrument. Any attempt to repair without prior authorisation from RBR will void the warranty. Refer to the RBR warranty statement.

To return a product to RBR for an upgrade, repair, or calibration, please contact our support team to obtain a return merchandise authorisation code (RMA) and review the detailed shipping information on the RBR website.

10 Revision history

Revision No.	Release Date	Notes
A	15-May-2022	Original
B	21-June-2024	Added the Ethernet commands section. Updated the Deployment section. Added a warning to the Replacing the batteries section.