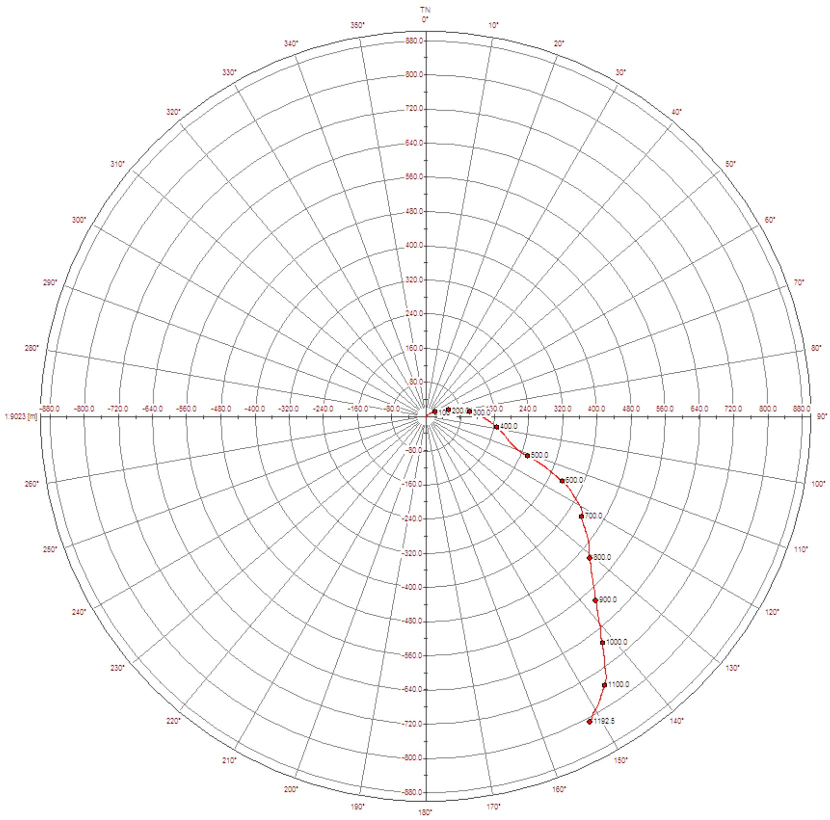

User Guide

QL40 DEV-2G – Borehole Deviation Probe

MOUNT SOPRIS INSTRUMENTS

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V05.21.19

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Table of Contents

1 General Information

1.1 Overview

The QL40 DEV-2G is the new generation of deviation probe. The new tool consists of a completely redesigned mechanical assembly and electronics. It implements the latest telemetry design to improve telemetry performance on long and multi-conductor wirelines when used in conjunction with Opal and scout acquisition systems.

The QL40 DEV-2G measures the direction relative to magnetic north, inclination and trajectory of the borehole. Measurements are based on the “Applied Physics Systems” 544 orientation sensor containing both a 3-axis fluxgate magnetometer and 3 accelerometers. Deviation parameters are calculated in real time and displayed as continuous logs during the measurement.

This QL40 DEV-2G middle sub has its own Telemetry board, Power supply element and A/D converter allowing the tool to be operated as a stand-alone probe (tool top and bottom plug necessary) or in combination with other subs of the QL family.

1.2 Dimensions

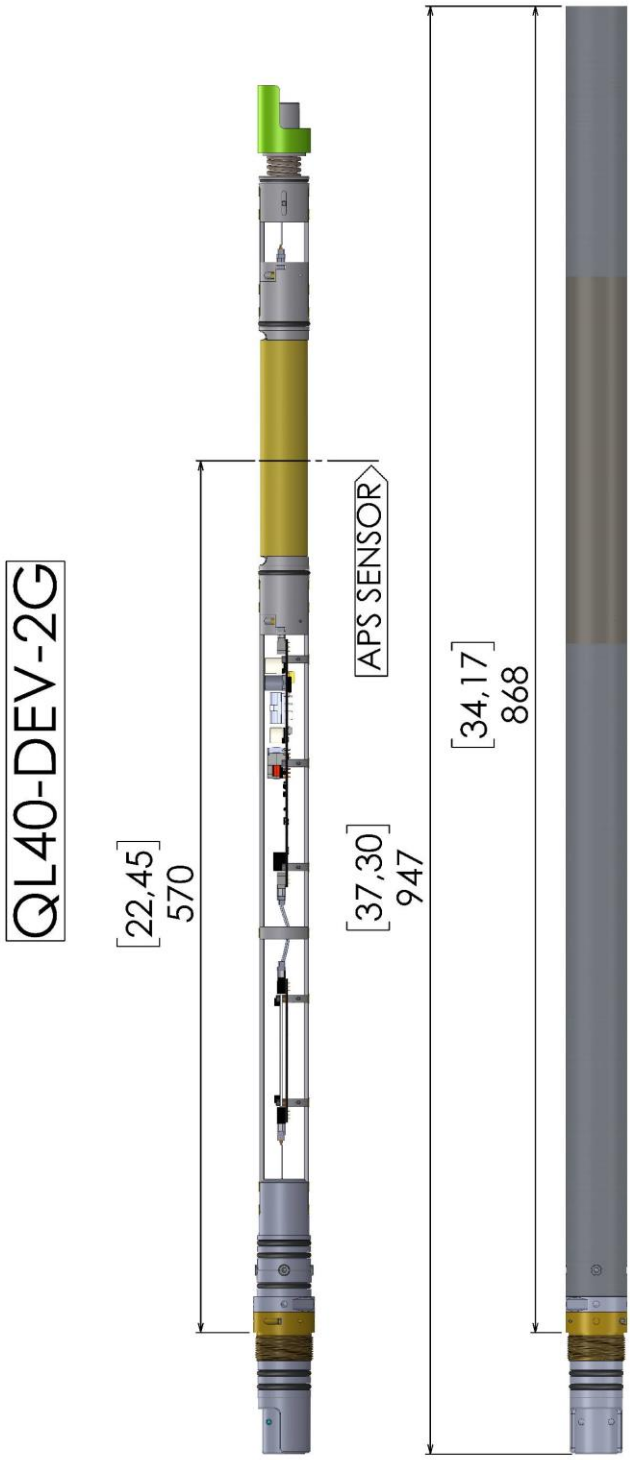


Figure 1-1 *QL40 DEV-2G Dimensions*

1.3 Technical Specification

Tool

Diameter:	40mm (1.57”)
Length:	0.868m (34.17”)
Measurement point:	0.434m (19.7”) - from bottom join
Weight:	3.4 kgs
Max. Temp:	70°C
Max.Pressure:	200bar

Cable:

Cable type:	Mono, Coaxial, 4 or 7 conductor
Digital data transmission:	Up to 500 Kbits per second depending on wireline
Compatibility:	OPAL- SCOUT – BBOX – MATRIX - ALTLOGGER

Orientation sensor:

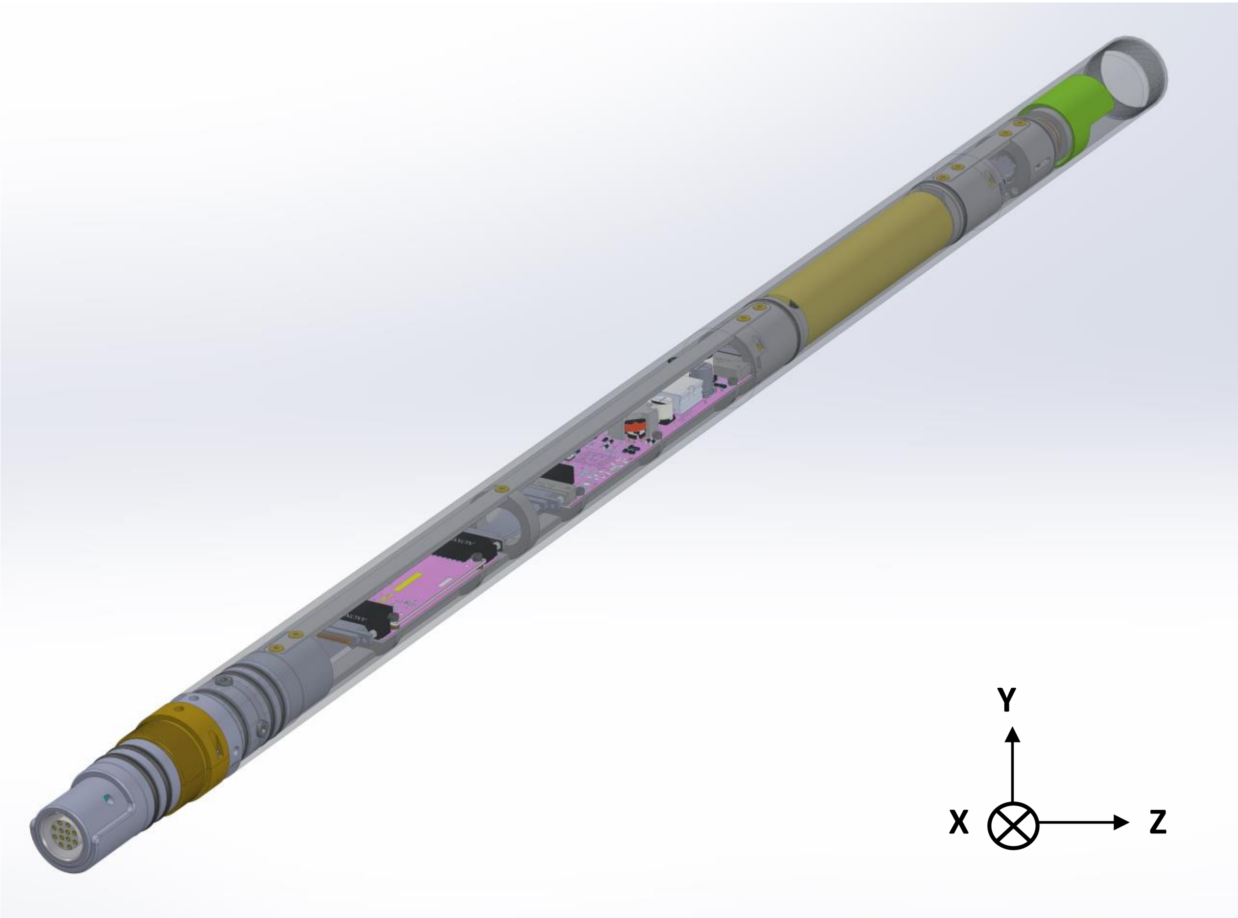
Sensor:	APS544
Location:	Middle point of sensor located at 57.0cm (22.45”) from tool bottom
Orientation:	3 axis magnetometer, 3 accelerometers
Inclination:	Range: 0-180 degree Accuracy: +/- 0.5 degree
Azimuth:	Range: 0-360 degree Accuracy: +/-1.2 degree

2 Measurement Principle

The orientation sensor implemented in the QL40 DEV-2G contains both a 3 axis fluxgate magnetometer and a 3 axis accelerometer. The combination of these two sensor systems enables the inclination, roll and azimuth angles of the sensor reference frame to be determined. Inclination and roll angles are determined from the accelerometer subsystem, which measures the pull of gravity. After inclination and roll are known, the magnetometer subsystem is used to determine system azimuth angle. Knowledge of the inclination and roll angles enable determination of the horizontal components of the earth's local magnetic field; this information defines the azimuth angle.

The probe measures the magnetic field and acceleration in three different directions that is along the 3 axes of a right handed Cartesian coordinate system. The X-axis is parallel to the tool axis and points towards the bottom of the tool while the Y - and the Z- axis are perpendicular to the tool axis. Figure 2-1 provides a sketch of the axis orientation.

***Figure 2-1** QL40 DEV-2G Reference Axis System*



3 Notes on QL tool assembly

QL stands for **Q**uick **L**ink and describes an innovative connection between logging tools (subs) allowing to build custom tool stacks. QL40 describes a specific family of logging tools. Each sub is equipped with its own Telemetry board, Power supply element and A/D converter allowing an operation as stand-alone tool or as a stack in combination with other subs of the QL product family.
The QL40 probe line deals with two types of subs - Bottom Subs and Mid Subs.

Bottom Sub
A bottom sub is a tool that must have one or more sensors located at the bottom. It can be operated in combination with other QL subs connected to the top but it is not possible to connect another sub below. When used in stand-alone mode the bottom sub only needs a QL40 tool top adaptor, which fits the cable head.

Mid Sub
A mid sub is a tool that can be integrated anywhere within a stack of tools. When used at the bottom of a tool string a QL40 bottom plug must be used to terminate the string. If the mid sub is used as a stand-alone tool it needs a QL40 bottom plug at the lower end and a QL40 tool top adaptor at the top.

3.1 QL40 stack assembly

QL40 tool stacks are terminated by either a QL40 bottom sub or a QL40 bottom plug. At the top of the stack a QL40 tool top is required to connect the tool string to the cable head. Several tool tops are already available, special ones can be made on request.

To assemble and disassemble the subs the C-spanner delivered with the tool must be used (Figure 3-1). It is recommended that before each assembly the integrity of the O-rings (AS216 Viton shore 75) is verified. Prime the O-rings with the silicon grease that was supplied with the subs.

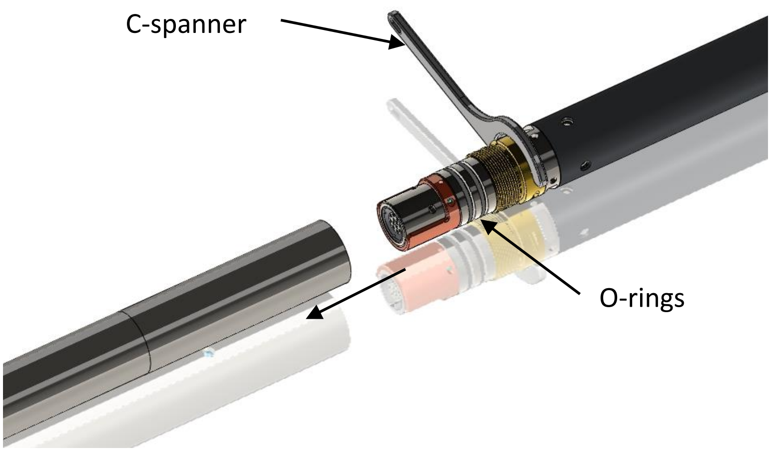


Figure 3-1 *C-spanner and O-rings of QL connection*

The following example of a QL40-ABI, QL40-GR and QL40-GO4 (Figure 3-2) describes how to replace the QL40-ABI with a QL40-Plug in order to run the QL40-GR sub stand-alone.

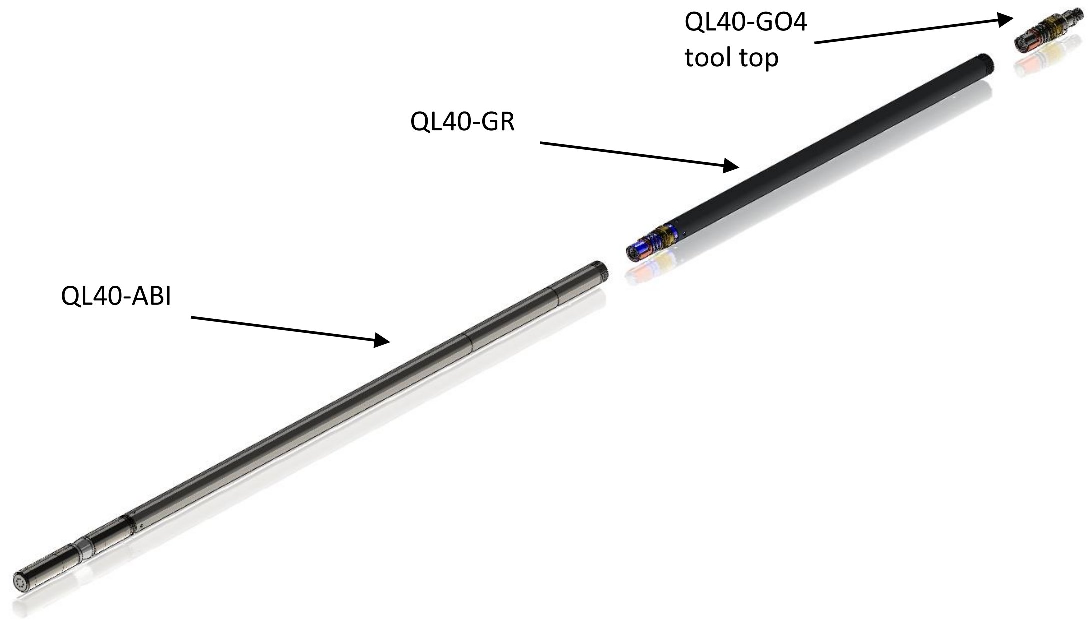


Figure 3-2 *Tool stack example*

To remove the QL40-ABI bottom sub attach the C-spanner to the thread ring as shown in Figure 3-3, unscrew the thread ring and remove the QL40-ABI bottom sub.

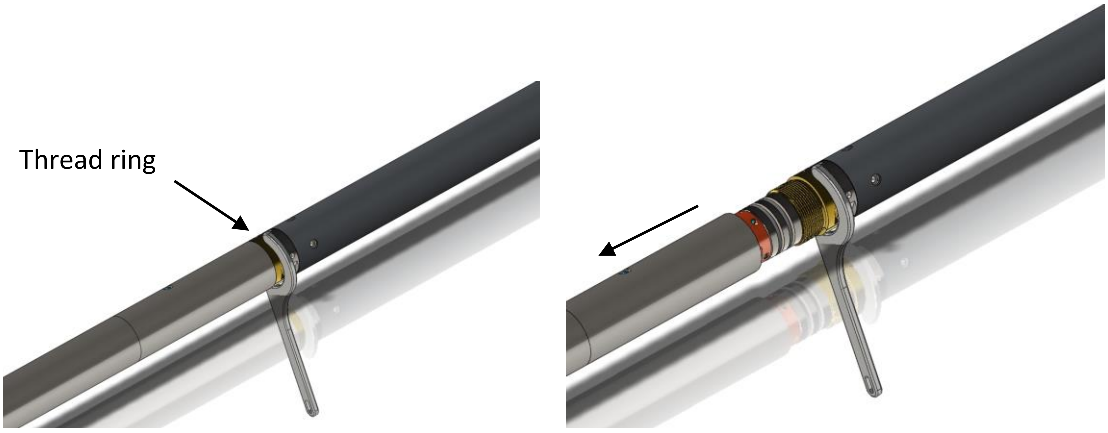


Figure 3-3 *Unscrewing the thread ring and removing the bottom sub*

After checking the O-ring integrity slip the QL40-Plug over the exposed QL connector (Figure 3-4) attach the C-spanner and screw the thread ring until the plug fits tight.

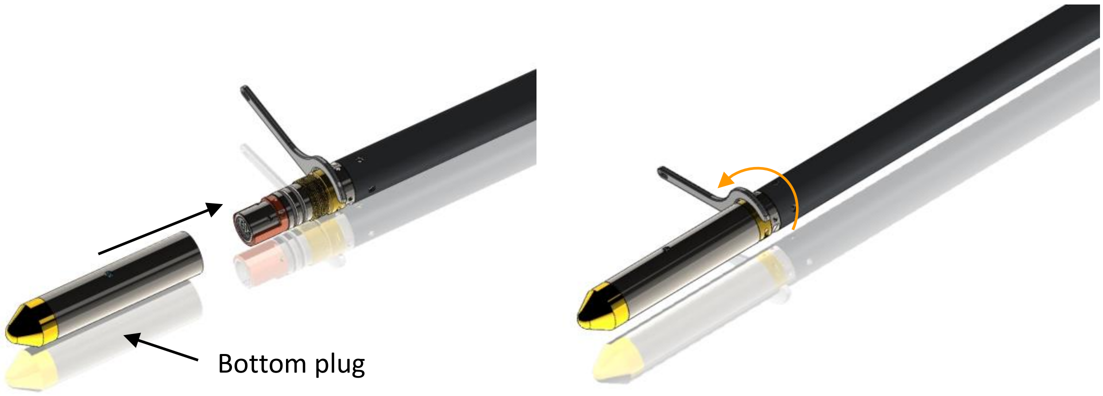


Figure 3-4 *Attaching the QL40-Plug*

The QL40-GR can now be run stand-alone (Figure 3-5).

Figure 3-5 *QL40-GR mid sub with tool top and bottom plug*

4 Operating Procedure

Note: Parts of the topics discussed in these sections below assume that the user is familiar with the acquisition software. Refer to the corresponding operator manuals for more details. Information about assembly and configuration of tool stacks can be found in the same manuals.

4.1 Quick Start

1. Connect the QL40 DEV-2G to your wireline and start the data acquisition software.

2. Select the relevant QL40 DEV-2G tool from the drop down list (Figure 4-1) in the software's **Tool** panel (if your tool is not listed check that your tool configuration file is stored in the designated folder on your computer).

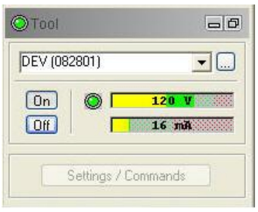


Figure 4-1 *Tool panel*

3. In the **Tool** panel switch on the tool (click the **On** button) and verify that the power indicator shows a valid (green) level. The system goes through a short initialization sequence which sets the default parameters and communication settings held in the tool configuration file. The configuration returned by the tool is also checked during this procedure. (Setup tool communication as explained in chapter **4.2** if error message is displayed.)

4. In the **Acquisition** panel (Figure 4-2) select the sampling mode (depth or time). Click on **Settings** and specify the corresponding sampling rate. Switch on the sampling (click the **ON** button).

Figure 4-2 *Acquisition panel*

5. Press the **Record** button in the **Acquisition** panel (Figure 4-2), specify a file name and start the logging.

6. During logging observe the controls in the **Telemetry** panel (Figure 4-3):
   - Status must be valid (green light);
   - Bandwidth usage in green range;
   - Memory buffer should be 0%;
   - Number of **Data** increases and number of **Error**s negligible.

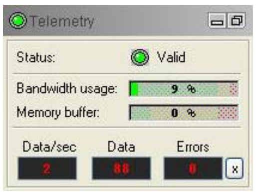


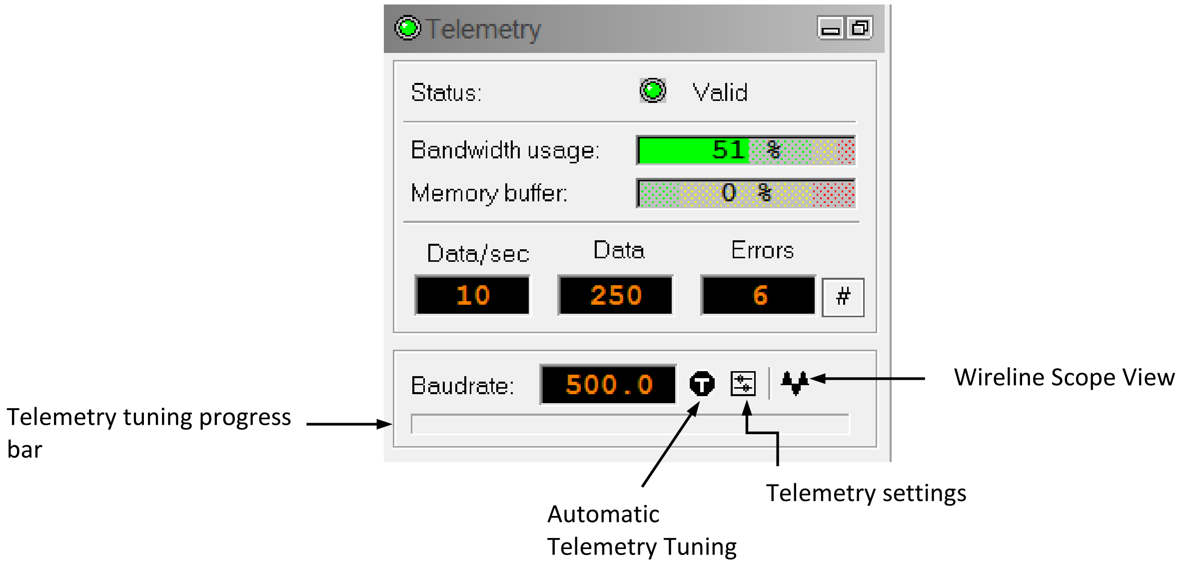
Figure 4-3 *Telemetry panel*

7. To end the logging procedure press the **Stop** button in the **Acquisition** panel and turn off the sampling (click **OFF** button).

8. In the **Tool** panel power off the tool.

4.2 Tool Communication with OPAL/SCOUT (ALT MODEM)

The telemetry provided through the **OPAL-SCOUT** systems implementing the **ALT MODEM** controls and configures **AUTOMATICALLY** the telemetry settings for any wireline. In case communication status is not valid the user has different options to adjust manually the telemetry settings from the telemetry panel of the dashboard:



Baud rate:
Indicates the default baud rate or optimal baud rate in kbps found by the system for the selected winch/telemetry scheme

Automatic Telemetry Tuning:

The Tune button resets the telemetry tuning automatically. This process defines:

- the optimum baud rate for the winch configuration selected
- a transfer function and a filter to re-construct at the surface the shape of the pulse trains distorted by the wireline.

A **progress bar** at the bottom of the telemetry window shows the progression of the telemetry tuning. At the end of the process the baud rate display is refreshed with the optimal baud rate value.

Refer to **Appendix** at the end of this manual for more information on the **advanced telemetry settings**.

4.3 Tool Communication with ALT Logger

The telemetry provided through the ALTLogger is self-tuning**.** In case communication status is not valid the user can manually adjust the settings. In the **Telemetry** panel (Figure 4-3) of the dashboard click on **Settings** to display the **Configure Tool Telemetry** dialog box (Figure 4-4).

A procedure to achieve valid communication is given below:

- Change the **Baudrate** to 41666 kbps.
- Verify that the **Downhole Pulse width** knob is set on 20 (default value). This value is the preferred one and is suitable for a wide range of wirelines. For long wireline (over 2000m), increasing the pulse width could help to stabilize the communication. The reverse for short wireline (less than 500m).
- Set the **Uphole** discriminators in the middle of the range for which the communication status stays valid.
- Increase the **Baudrate**, check the communication status stays valid and the **Bandwidth usage** (in **Telemetry** panel of the dashboard) is below the critical level.
- When **Uphole** discriminators are properly set, store the new configuration as default. The tool should go through the initialisation sequence the next time it is turned on.

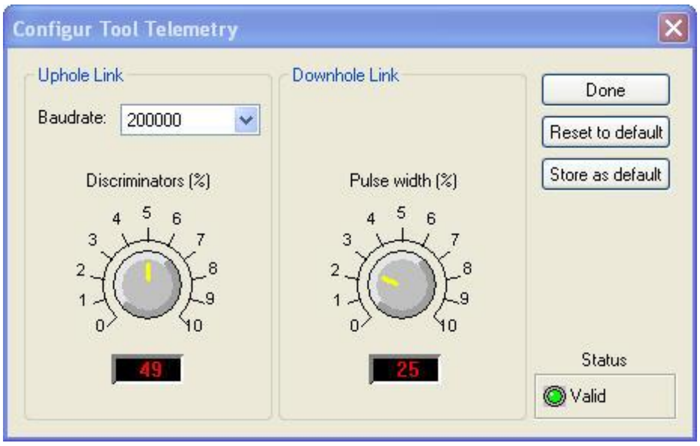


Figure 4-4 *Tool communication settings*

4.4 Tool Communication with MATRIX

The tool telemetry can be configured through the **Telemetry** panel of the data acquisition software's dashboard. By clicking on **Settings**, the operator has access to the **Configure ALT Telemetry** dialog box (Figure 4-5) providing various controls to adjust the telemetry settings and monitor its current status.

The **Analysis View** displays the current discriminator levels (vertical yellow lines) and a histogram of the up-hole data signal. The scales of the **Analysis View** can be adjusted using the **Vertical Scale** and **Horizontal Scale** knobs and the **lin**ear / **log**arithmic scale buttons.

The status of the configuration should be flagged as Valid (indicated by the LED being green). In any other case (LED red) the telemetry should be adjusted (we assume a pulse signal is displayed in the analysis view). Click on the **Advanced** button to display additional controls to tune the telemetry.

The Automatic settings option is the preferred mode and should allow the telemetry to be configured for a wide range of wirelines without operator input. For wirelines with a more limited bandwidth, the operator might need to turn off the automatic mode and adjust the telemetry settings manually.

For each wireline configuration, the discriminators (vertical yellow lines) for the **positive** and **negative** pulses must be adjusted in order to obtain a valid communication status (see Figure 4-5) for an example of a suitable discriminator position). There is also the option to alter the **baudrate** in order to optimize the logging speed. The input **gain** can be increased (long wirelines) or decreased (short wirelines) in order to set up the discriminator levels correctly.

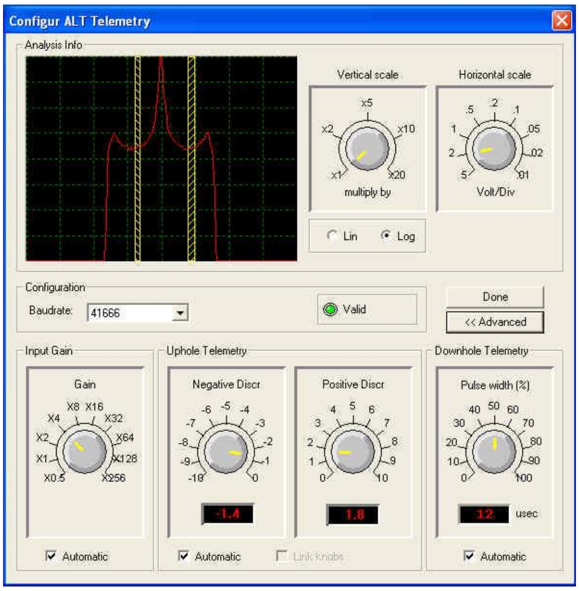


Figure 4-5 *Matrix telemetry settings*

Once the telemetry is correctly set, store the new settings as default. The tool should go through the initialization sequence in “Valid” status the next time the power is turned on.

4.5 Configuring Tool Parameters

The QL40 DEV-2G tool does not have any configuration options.

4.6 Recorded Parameters and Browsers

4.6.1 Recorded parameters

The following data channels will be recorded by the tool:

Azimuth	Azimuth from Magnetic North - deg
Tilt	Inclination from verticality - deg
MRoll	Tool relative bearing calculated from magnetometers - deg
Roll	Tool relative bearing calculated from accelerometers - deg
MagField	Total Magnetic field strength at measurement point - µT
Grav	Absolute value of the earth gravity - g
TDev	Temperature at deviation sensor - °C
Voltage	Deviation sensor voltage - V
MX	Magnetometer X-component - µT
MY	Magnetometer Y-component - µT
MZ	Magnetometer Z-component - µT
AX	Accelerometer X-component - g
AY	Accelerometer Y-component - g
AZ	Accelerometer Z-component - g
Temperature	Temperature (CPU) - °C
Time	Sampling time - s

4.6.2 MChNum Browser Window

Figure 4-6 and Figure 4-7 show typical examples of the numerical values displayed in the MChNum browser window during logging.

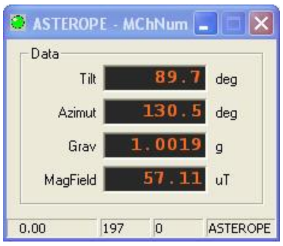


Figure 4-6 *Multi Channel Browser for Numerical Data (MChNum)*

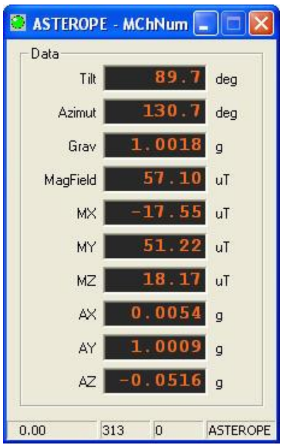


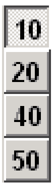
Figure 4-7 *Multi Channel Browser for Numerical Data (MChNum)*

4.6.3 MCHCurve Browser Window

The MChCurve browser displays in real time the recorded parameters by means of curves. The user is allowed to modify the curve presentation by double clicking on the log title (colours, column position, scale, filter,gridding,….)

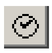
Figure 4-8 *QL40 DEV MCHCurve Browser Window*

Vertical scales and grids:

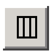


Depth mode display and pre-defined depth scales

Operator defined depth scales, interval spacings and settings



Time mode display



Vertical grid settings

Horizontal grid settings

5 Performance Check & Calibration

5.1 Testing the Deviation System

The QL40 DEV-2G deviation system is factory calibrated and does not require further calibration.

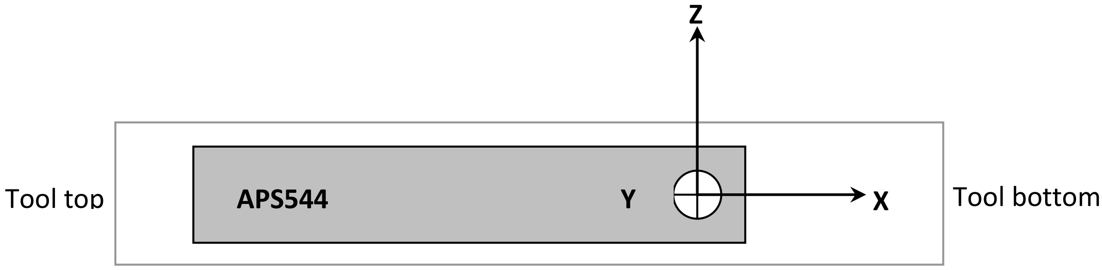


Figure 5-1 *Deviation sensor reference axis system*

The functionality test described hereafter has to be executed to check that the tool is giving the correct deviation outputs:
To check Roll and Tilt outputs, place the probe on a flat surface with the Y mark engraved on the tool housing pointing up (Y axis of the coordinate system is pointing down, Figure 5-1).
Verify that the Roll and Tilt outputs are as follows:
Roll = 90° ± 0.5°
Tilt = 90° ± 0.5°
Next, roll the probe counterclockwise (looking towards the tool bottom) about its X axis in increments of 90° and verify that for each position the roll angle increments in succession to 0°, 270° and 180° while the tilt remains 90° ± 0.5°.
To verify inclination at 0° and 90°, position the probe so that the X axis is pointing down (0° inclination) and horizontal (90°).
To verify azimuth accuracy, a good compass and an area free from magnetic materials should be used. Use a compass to orient the probe horizontal and North and verify that the azimuth reading is 0° ± 1°. Repeat the procedure for East, South and West directions.

5.2 Rolling Test – Azimuth And Tilt Check

Azimuth and tilt can be tested by rotating the tool about its long axis while maintaining both a constant inclination to the vertical, say 15°, and a fixed azimuth. The data imported into WellCAD should show a deviation of the azimuth less than the limit of ±2.5° and a deviation of the tilt less than the limit ±0.5°.

6 Maintenance

6.1 General Tool Maintenance

The QL40 DEV-2G should require no maintenance than a few salient points.
Keep the probe and the tool top connector clean.

- When the probe is transported, it needs to be contained in a vibration damped container to minimize stress on the sensor.
- The probe top connector should be periodically cleaned with oil free contact cleaning solvent.
- As mentioned in the operating procedure section, the probe should be kept away from strong magnetic fields, and repeated proximity to material with a high magnetic permeability such as iron and steel.

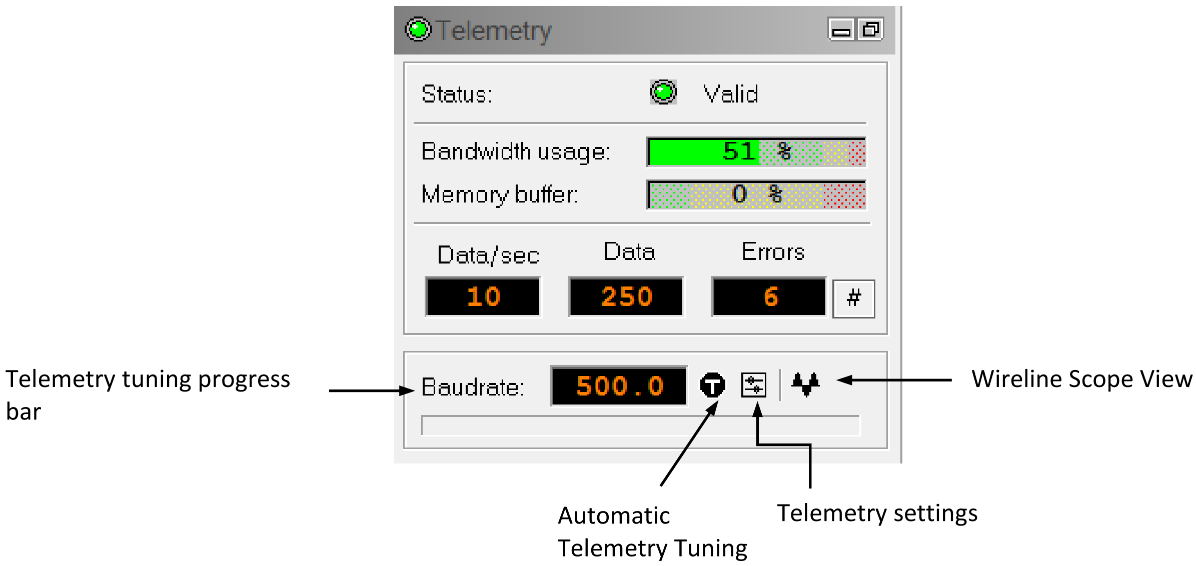
7 Troubleshooting

Observation	To Do
Tool not listed in Tool panel drop down list.	- Do you have a configuration file? - Has the configuration file been copied into the …/Tools folder (refer to acquisition software manual for details of the directory structure)?
Tool configuration error message when powering on the tool.	- Check all connections. - Adjust the telemetry settings for your wireline configuration (see chapter 4.2 or 4.3) and store the new settings as default.
Tool panel - No current.	- Verify that the wireline armour is connected to the logging system. Test your interface cable between winch and data acquisition system. - Verify cable head integrity. - Verify voltage output at the cable head (it should be 120V).
Tool panel - Too much current (red area).	**! Immediately switch off the tool !** **-**Possible shortcut (voltage down, current up): Check for water ingress and cable head integrity - wireline continuity. - Verify the interface cable between winch slip ring and data acquisition system is not loose at the connectors. Check for possible source of a shortcut. - If the above shows no issues, use test cable provided by ALT to verify tool functionality. - If the problem still occurs, please contact service centre.
Telemetry panel - status shows red.	- Verify the telemetry settings for your wireline configuration (see chapter 4.2 or 4.3). - If problem cannot be resolved contact support@alt.lu .
Telemetry panel - memory buffer shows 100%.	- Indicates that the systems internal memory buffer is full. PC can't receive incoming data streams fast enough. Ensure your PC has enough resources available.
Telemetry panel – bandwidth usage shows 100%. *(Overrun error message.)*	- Set the baudrate to highest value allowed by your wireline configuration. - Reduce logging speed, decrease azimuthal resolution and/or increase vertical sample step.
Telemetry panel - large number of errors.	- Verify the telemetry settings for your wireline configuration (see chapter 4.2 or 4.3). - Check bandwidth usage and telemetry error status.

8 Appendix

8.1 Tool Communication with OPAL/SCOUT

The telemetry provided through the OPAL-SCOUT systems implementing the ALT MODEM adapter is self-tuning. In case communication status is not valid the user has different options to adjust manually the telemetry settings from the telemetry panel of the dashboard:



Baud rate:
Indicates the default baud rate or optimal baud rate in kbps found by the system for the selected winch/telemetry scheme

Automatic Telemetry Tuning:

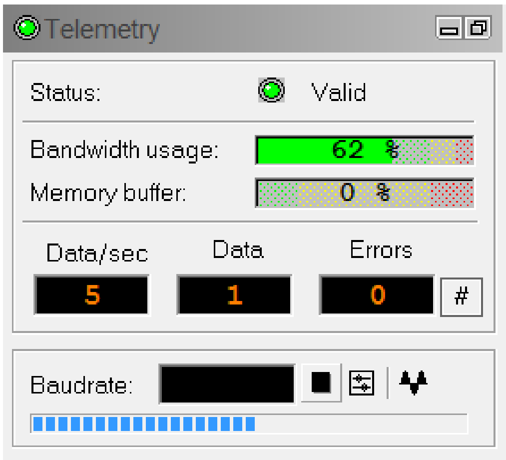
The Tune button  resets the telemetry tuning automatically. This process defines:

- the optimum baud rate for the winch configuration selected
- a transfer function and a filter to re-construct at the surface the shape of the pulse trains distorted by the wireline.[1] Refer to the **Equalizer** paragraph for more details.

The Automatic Tuning is very useful on wireline over 1000m length to optimize the telemetry performance and logging speed.

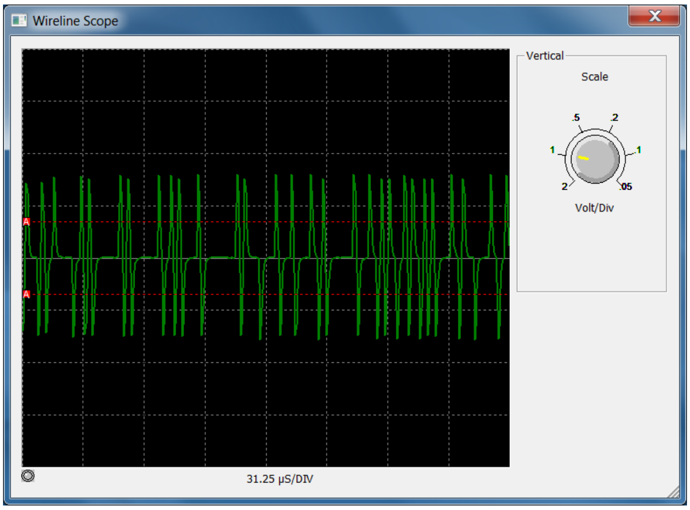
A **progress bar** at the bottom of the telemetry window shows the progression of the telemetry tuning. At the end of the process the baud rate display is refreshed with the optimal baud rate value.

[1] The transfer function and filter concept are only valid for tools implementing the latest generation of ALT MODEM telemetry board (i.e. QL40-ABI2G, ABI-GR-2G, QL40-OBI2G, OBI-GR-2G, QL43-ABI2G,…)



Scope:

Pressing the scope button  on the **Telemetry Panel** brings up a **Wireline Scope** view (Figure x), which displays the pulse strings transmitted through the wireline and received by the system at the surface.



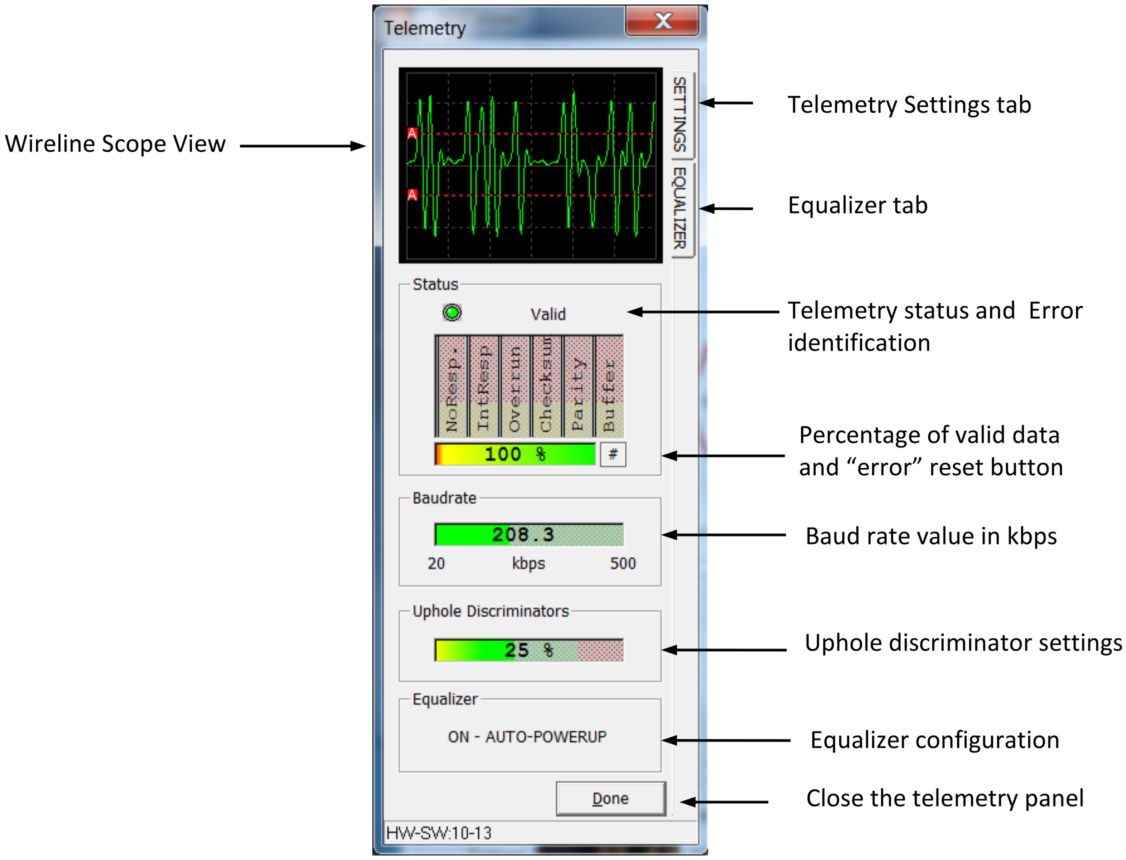
The two red-dashed horizontal lines help to visualize the position of the discriminator levels set for detecting the pulses at the surface. Discriminator levels can be tuned in the **Telemetry Settings** dialog – refer to section 3.6.1 for more information.

The Scale knob can be adjusted to show more or less vertical details. This view has no effect on the communications and is a visual aid only.

Telemetry Settings:

The Telemetry Settings button  opens a **Telemetry** control panel summarizing the telemetry status and configuration.

If the system cannot establish a stable communication with the tool, the **Settings and Equalizer tabs** allow the user to modify the telemetry settings and to apply a telemetry filter (Equalizer option)

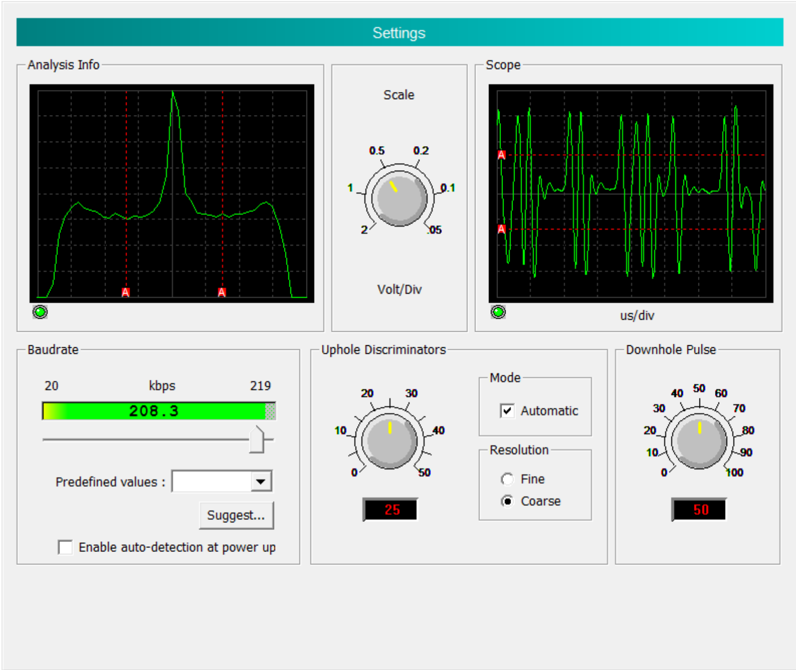


Adjusting the Telemetry Settings:

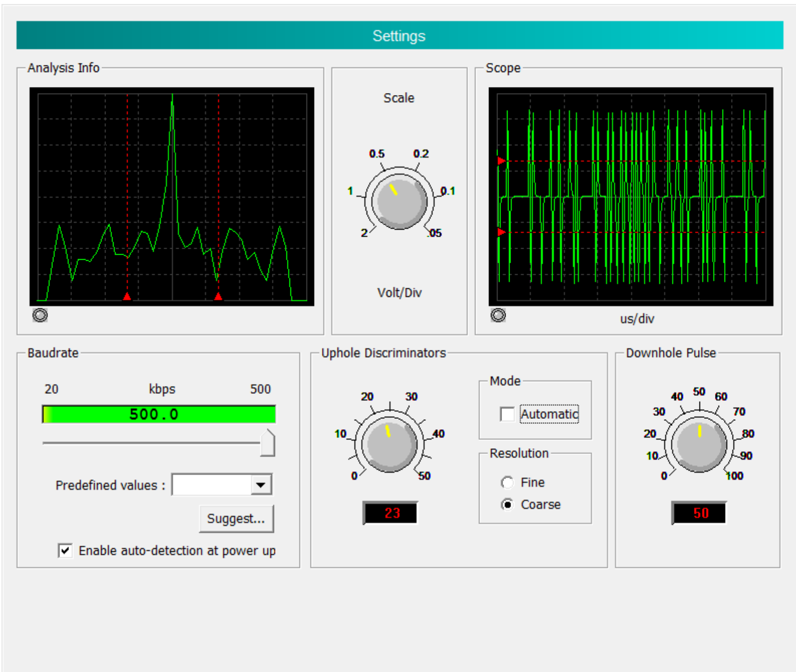
By default the telemetry settings are set to Automatic mode and should stay in this configuration. When more advanced tuning is required (i.e. long wirelines having a limited bandwidth) the manual mode can be activated.

In Automatic mode the uphole discriminators are set automatically to detect the pulse strings.
The position of the discriminator levels are visible on the Scope and Analysis views and are represented by two red dashed lines – one for the positive pulses and the other for the negative pulses.
The "A" letter on the red square means that the discriminators are set in automatic mode.
The **Scale knob** controls the scale for the Analysis and Scope displays.

<u>Position of the discriminator lines should be set as illustrated below.</u>



When the automatic mode is unchecked user has the option to adjust manually the uphole discriminators using either the discriminator knob or by moving interactively the red dashed lines in the Analysis and Scope displays. The red triangles located at the extremities of the red dashed lines refer to manual mode. For fine tuning of the discriminators the **Fine resolution** can be chosen.



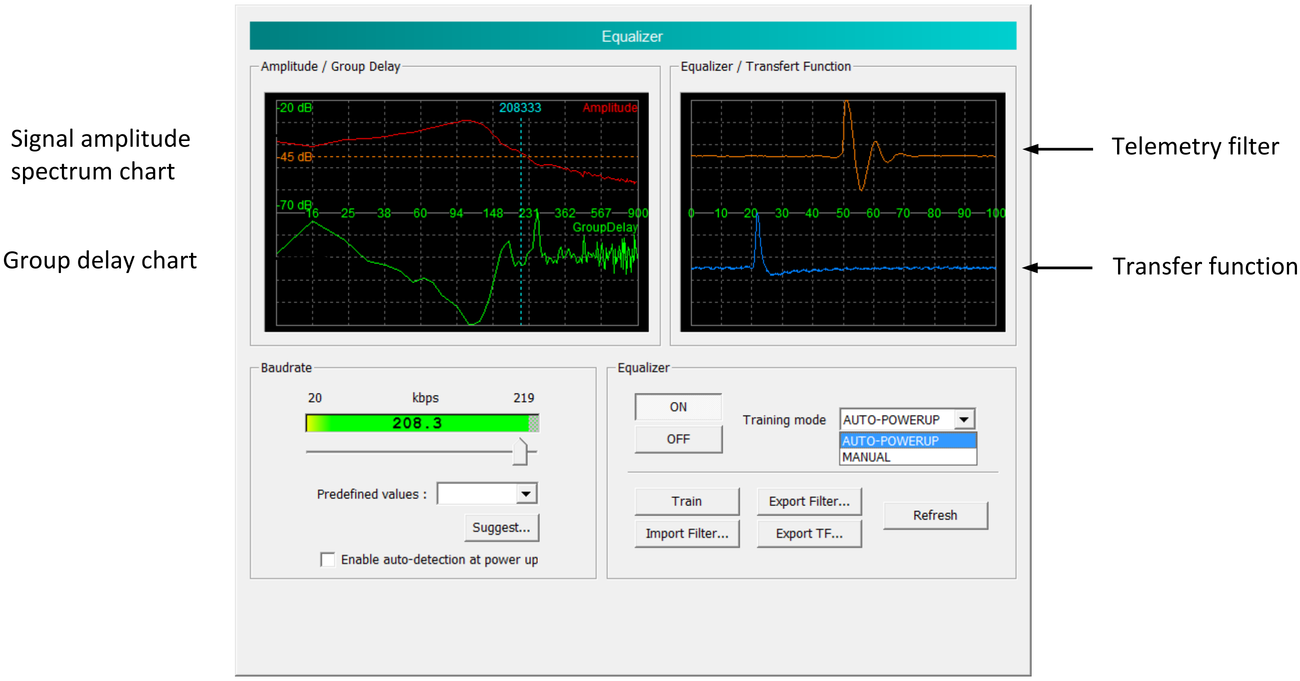
The **Downhole Pulse knob** controls the width of the pulse commands sent to the tool. It is set on 50 as a default value. This value is the preferred one and is suitable for a wide range of wirelines. For long wireline increasing the pulse width could help to stabilize the communication. The reverse for short wireline.

The **Baudrate** is generally set to the maximum value for which the communication status stays valid in order to optimize the logging speed for the wireline configuration.
The baudrate can be adjusted by moving the cursor below the baudrate bar meter or by selecting a predefined baudrate value from the select box.

When clicking the **Suggest** button the system is searching for the optimum baudrate value and keeps this value for the data transmission.

The **Enable auto-detection at power-up** configures the system such a way that the baudrate is reset to its optimum value each time a tool is powered up.

Applying the Equalizer



The **Equalizer** dialog provides some advanced telemetry settings described hereafter.

- The **Train** button computes the transfer function of a wireline - refer to the blue signal.
  When clicking on Train the tool sends a pilot pulse frame to the surface. The received signal at the surface is compared with the original pilot pulse frame to measure the distortion of the signal through the wireline. The result of this process is the definition of a transfer function specific to the wireline used.

  A filter is then derived from the transfer function - refer to the orange signal. The filter will be applied on the telemetry signal to counteract the distortion of the pulse strings through the wireline.
  Applying the filter will thus improve the telemetry performance of the system and logging speed on wirelines with unfavorable band width.

- The **Equalizer ON/OFF** buttons enables or disables the filter. The activation of the equalizer can be configured to **MANUAL** mode or to **AUTO-POWERUP**.

The AUTO-POWERUP feature applies the telemetry filter upon tool power-up.

- The **Export TF** option exports the **Transfer Function** defined by the wireline training process in a ASCII file format

- The **Export Filter** option exports the **Filter** derived from the transfer function in a ASCII format

- The **Import Filter** option loads a saved filter configuration

- The **refresh** button is refreshing the Equalizer/transfer function display

The **Amplitude/Group Delay** charts are mostly used by ALT developers for telemetry signal and performance analysis.

The Equalizer dialog repeats the **Baudrate** settings already discussed in the previous paragraph “Adjusting telemetry settings”.

8.2 Parts list

8.2.1 Tool delivery kit QL40-xxx (ref. 209-016)

Item No.	Qty	Part No.	Description
1	1	210-002	Silicone grease Molykote111
2	2	211-004	C-spanner 40-42 (QL40-43)
3	6	AS215-V-75°	Oring-V 26.57 x 3.53 75°
4	1	210-003	Grease Lubriplate L0034-086

8.3 Technical drawings

The following technical drawings are available on request:

- QL40 DEV-2G Wiring Diagram.

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