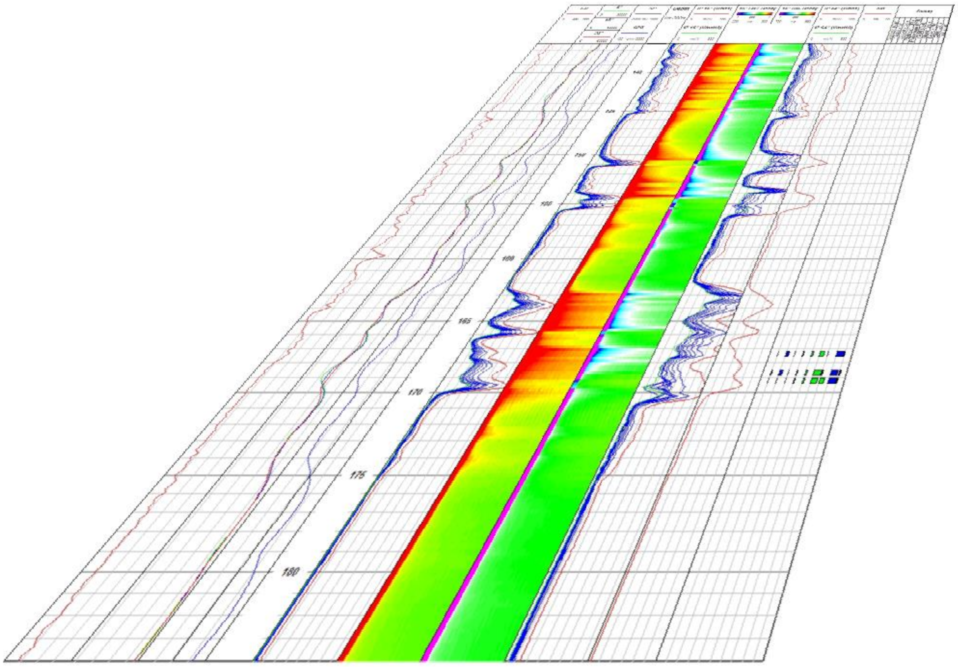

User Guide

QL40 ELOG/IP – Normal Resistivity and Induced Polarization Probe

MOUNT SOPRIS INSTRUMENTS

Advanced Logic Technology

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1 General Information

QL stands for Quick Link and describes the latest line of stackable logging tools. This development is a joint venture of Mount Sopris Instruments (MSI) and Advanced Logic Technology (ALT). Innovative connections between tool elements (subs) allow users to build their own tool strings in the field.
The Tool Stack Factory – a sophisticated extension of the acquisition software – provides a convenient way to configure tool strings for operation.
Each sub has a Telemetry and Power supply element, the TelePSU, allowing them to operate individually without a separate telemetry sub. As a result all QL subs can be operated as standalone probes or in combination with other subs.

The **QL40-ELOG** sub provides four normal resistivity measurements, plus spontaneous potential (SP) and single point resistance (SPR). The QL40-ELOG can be operated as a stand-alone probe with isolation bridle and bottom sub or can be stacked above or below another sub. In general, the isolation bridle must be located directly above the QL40-ELOG sub. Isolation from armor is a critical requirement that cannot be overemphasized when running any resistivity probe. Incorrect measurements will result if isolation is not adequate.

The **QL40-ELOG** sub can be upgraded to a **QL40-ELOG/IP** sub upon request.
In this configuration, the **QL40-ELOG/IP** provides four normal resistivity measurements, spontaneous potential (SP) and single point resistance. In addition, the tool measures the induced polarization in the time domain. The IP uses the 16 inch and 64 inch electrodes as receivers, and the current electrode as an IP charging source. The probe measures the entire time series of the current and the voltage as a function of time. This measurement is digitized and presented as 10 channels of time based data per depth interval for each spacing. From this data the chargeability is derived. In addition, a high resolution A/D further breaks each channel into 10 more discrete samples, providing a “full wave” presentation of the injection and relaxation decay. The digitized full wave of the voltage enables to calculate the relaxation time distribution (RTD) of the voltage decay curves, allowing for a more detailed analysis of the IP signal of the formation.

1.1 Dimensions

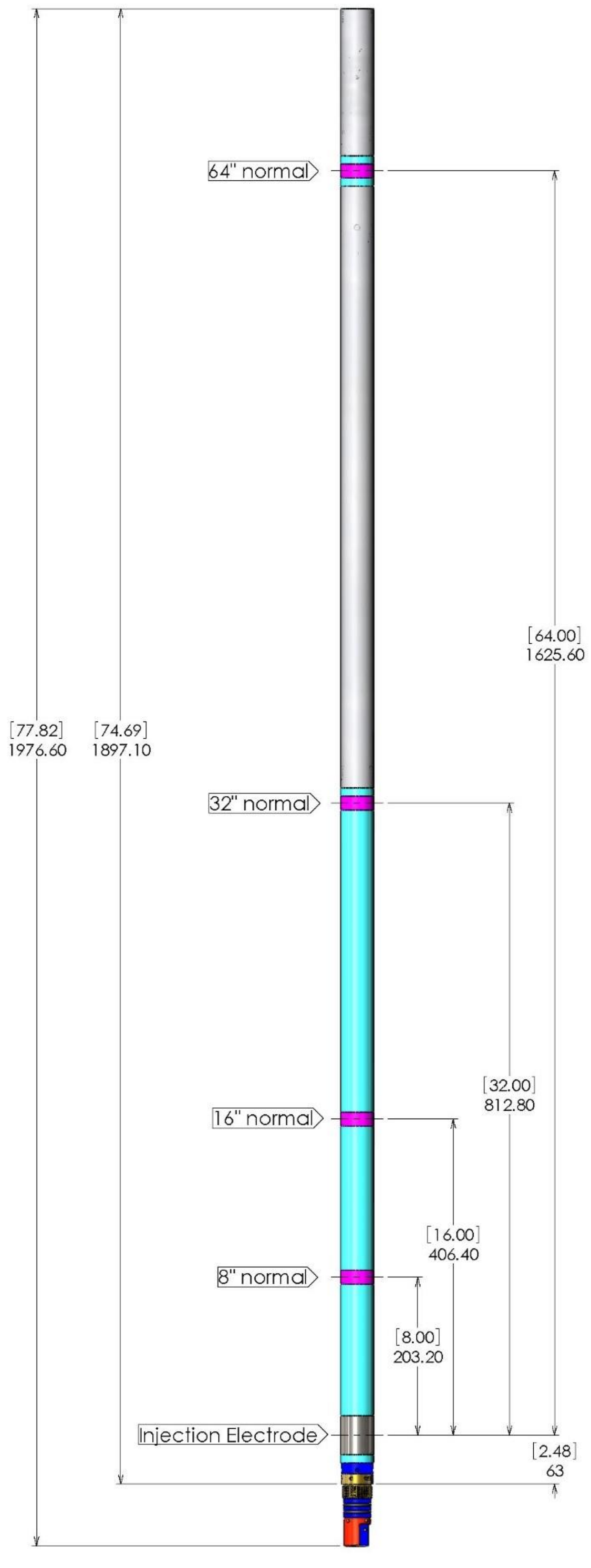


Figure 1-1-1 Tool general arrangement

1.2 QL40-ELOG/IP Technical Specifications

Tool

Diameter:	43mm (1.7”) with neoprene heat shrink
Length:	1.9m (74.8”)
Weight:	9 Kg (19.8 lbs)
Max. Temp:	70°C (158°F)
Max.Pressure:	200bar (2900 PSI)

Power requirements:

DC voltage at probe top	Nominal 120 VDC - Min.80 VDC – Max. 160 VDC
Current source	32V pp square wave (+:-16V) at up 500 mA

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

Electrode details:

Current electrode	50mm 304 stainless steel
Measure electrodes	18mm 304 stainless steel

Electrode reference measuring point (from bottom of bronze knurled ring):

Spontaneous Potential (SP)	1.69m
8” Normal	0.16m
16” Normal	0.26m
32” Normal	0.47m
64” Normal	0.87m
Single Point Resistance (SPR)	0.06m

Measurement specifications:

Spontaneous Potential (SP)

- Range: +/- 18V
- Resolution: 0.5 mV
- Accuracy: +/- 2.5 mV

8”-16”-32”-64”Normal Resistivities and Single Point Resistance

- Range: 0.1 to 100.000 Ohm.m
- Resolution:
  <0.04% of measured value (24 bits/0.5 ms)
  ADC with real time downhole digital filtering
- Accuracy:
  <1% of measured value from 1 to 5.000 Ohm.m
  <5% of measured value from 5.000 to 50.000 Ohm.m

Induced Polarization (IP) measured on 16" and 64" electrodes

- User selectable standard injection/release times (100ms–250ms- 500ms) or custom selectable injection/release times (between 100 ms and 2000 ms).
- Chargeability measured at both spacings
- Digitally controlled 8 watt downhole current generator
- Simultaneous full-wave digitizing of electrode voltages for both spacings
- 24 bit/0.5 ms ADC with downhole real-time filtering and processing
- Resolution: 1.2µV
- Input impedance: 1.4 M-Ohm

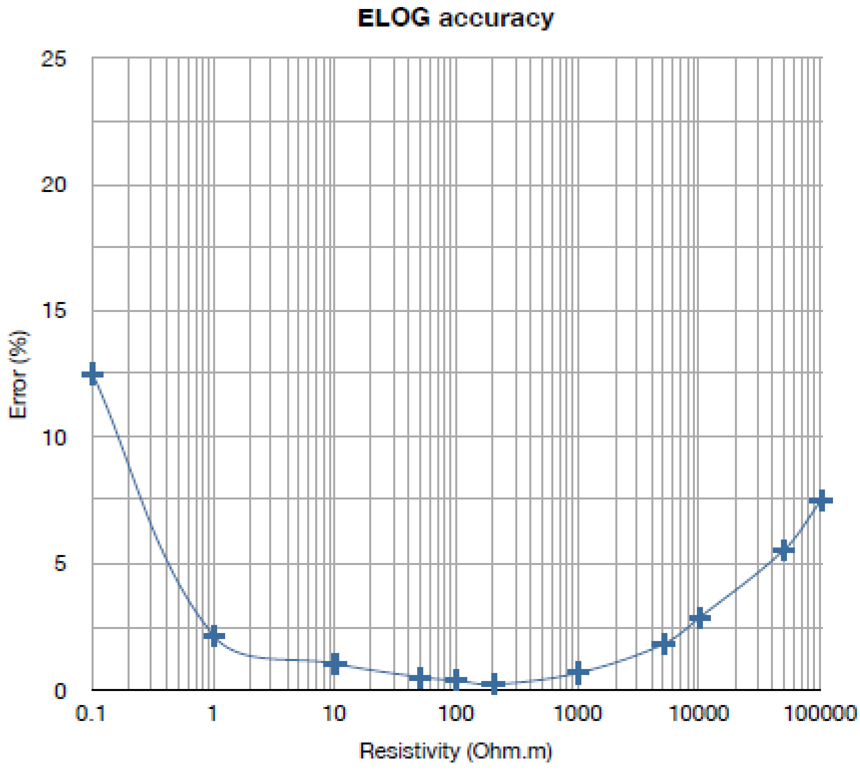


Figure 1-2 Accuracy versus resistivity

2 Measurement Principle

The **QL40-ELOG/IP** has 5 electrodes which are used for measuring normal resistivity at 4 spacings, spontaneous potential, and single point resistance. The QL40-ELOG/IP sub **must have** an isolation bridle placed above it to provide a remote reference electrode for the normal resistivity channels, and a remote return for the injection current.

The **SP** (spontaneous potential) is measured between the 64" normal measure electrode and armor. The data recorded as SP or VSP measures the natural voltages sensed by this electrode. These voltages can be related to both electrochemical and electrokinetic forces in the borehole. The electrochemical SP is developed when there is a difference between the formation fluid and borehole fluid salinities, and occurs normally when the measure electrode passes a clay or shaly zone, which acts as an ion selective membrane. The resulting current flow in a "cell" comprised of those three elements provides a negative SP if the borehole fluid is less conductive than the formation fluid. In fresh water zones, the SP is often positive. The electrokinetic SP can occur when borehole fluid mechanically invades porous and permeable formation, causing a current flow.

The **SPR** is measured between the **"A"** current injection electrode on the bottom of the probe and the isolated cable armor above the bridle. This SPR is a qualitative indication of the electrical resistance of the formation material immediately adjacent to the current electrode. The principal of measurement follows Ohm's law, where R=V/I. As the current flows toward the armor return, the current density (I/cross-sectional area) decreases dramatically. This means that the majority of the resistance measured is influenced by the material closest to the current electrode. For this reason, the SPR is very sensitive to small changes in resistance close to the borehole.

The four **Normal Resistivity** measurements are made at the halfway between the "A" current injection electrode and each of the 4 "M" normal resistivity electrodes. The normal resistivity measurement includes a reference electrode, called "N", which is assumed to be at electrical infinity compared to the measure electrodes. In this special application of Ohm's law, V=IR still applies, but is re-written as R=V/I,

$$\frac{V}{I} = R = \frac{\rho \cdot l}{A} \quad \text{or} \quad \rho = \frac{A \cdot V}{l \cdot I} \quad \text{or} \quad \rho = G \cdot \frac{V}{I}$$

where G is called the geometric factor, and is related to the A-M spacing between electrodes. In metric units, G is approximately 12.5 * AM spacing. Note that for normal resistivity measurements, the result is true resistivity, ρ, expressed in ohm-m^2/m. It is important to remember that this application of Ohm's law assumes that the formation is homogenous and infinite. Corrections for borehole size, borehole/formation fluid ratio, and bed thickness should be applied to get true formation resistivity. See appendix for references.

The SPR and normal resistivity measurements are made using a 50 ms long +/-16V square wave downhole current generator, which can supply up to 500 mA of survey current. The polarity of the current is alternated between + and – relative to armor to prevent polarization of the electrodes.

In the **IP mode** the **QL40-ELOG/IP** uses the 16 and 64 inch electrodes as receivers, and the current electrode as an IP charging source. The IP measurement is divided into two cycles with opposite polarity. At the start of each cycle, during the so-called injection period, current is injected and then switched off in the subsequent release period. This same procedure is repeated once with opposite polarity of the current.

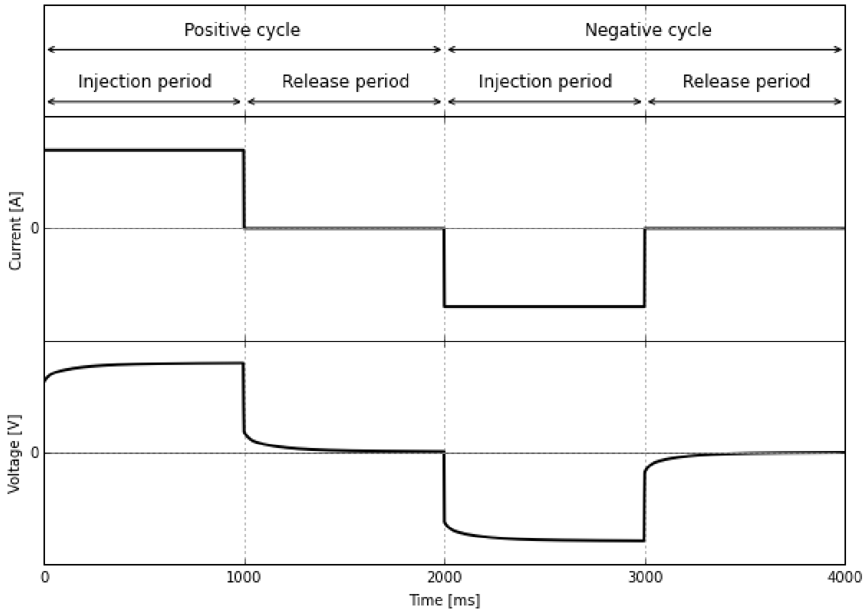


Figure 2-1 *IP measurement cycles*

The probe measures the entire time series of the current and the voltage as a function of time. This measurement is digitized and presented as 10 channels of time based data per depth interval for each spacing. From this data the chargeability is derived. In addition, a high resolution A/D converter further breaks each channel into 10 more discrete samples, providing a “full wave” presentation of the injection and relaxation decay. The digitized full wave of the voltage enables to calculate the relaxation time distribution (RTD) of the two voltage decay curves (16” and 64” spacing), allowing for a detailed analysis of the IP signal of the formation.

3 QL40 ELOG/IP assembly and set up

The QL40 ELOG/IP sub is delivered with the following accessories:

- Isolation bridle

Figure 3-1 *QL40 Isolation bridle*

- Isolated bottom plug

Figure 3-2 isolated *Bottom Plug*

- Calibration box, with a set of cables and clamps
  The calibration box is used to perform a calibration check before a logging operation. Refer to chapter 5 for *"Performance and calibration check"*.

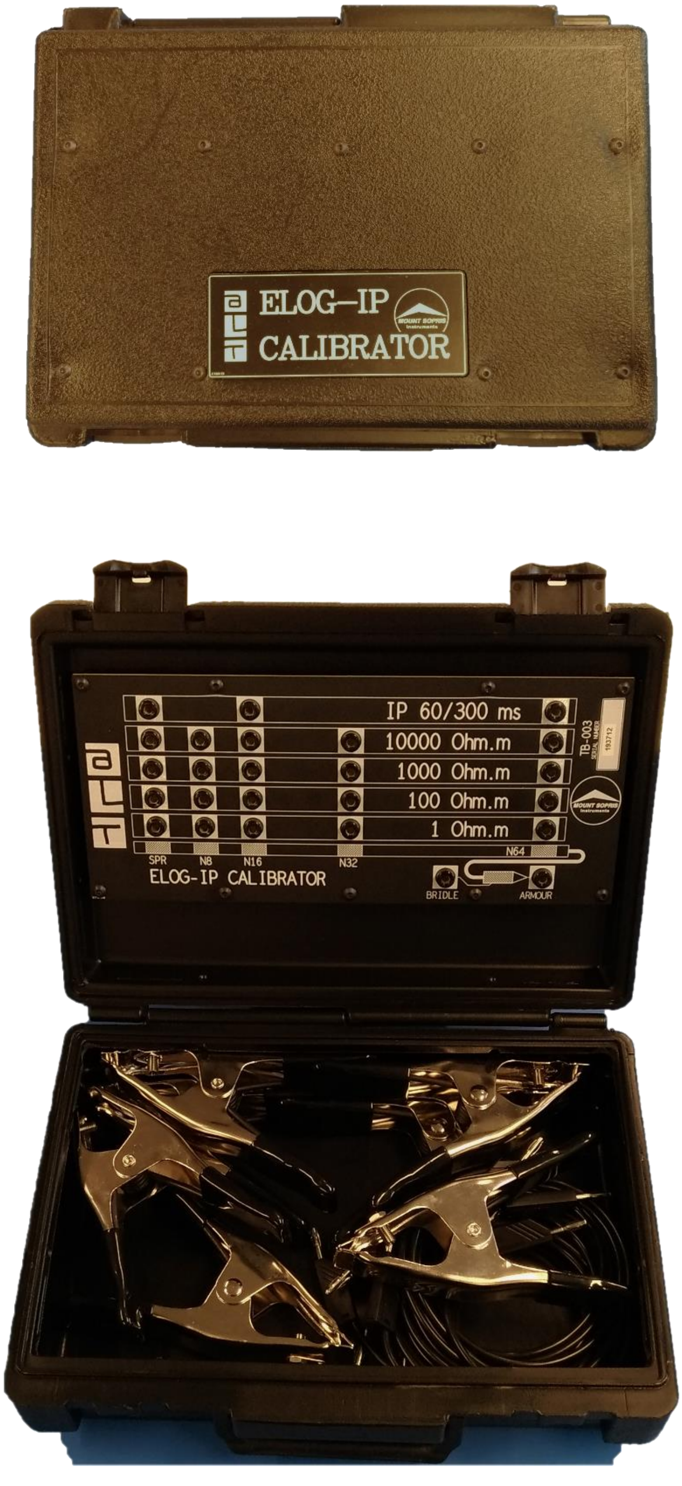


Figure 3-3 *ELOG-IP Calibrator, cables and clamps*

3.1 Note on use of the bridle

The bridle is comprised of 8 meters of insulated cable with a remote electrode located at the top called the “reference potential electrode” or “fish”. The standard bridle is provided with a GO4 male or MSI single connection at the top end and QL40 female connection at the sub end. The bridle is electrically and mechanically compatible with the **QL40 ELOG/IP** and **QL40 DLL3** subs.

The function of the bridle is to maintain a separation between the source of current - the injection electrode ” A” and the reference potential electrode in order to force the injected current to travel into the formation. The injected current returns to the cable armor beyond the bridle section.

In most configurations, the QL40 ELOG/IP should be operated with an isolation bridle. Refer to the table below to review the different valid configurations:

Acquisition system	Single conductor wireline	4 or 7 conductor wireline
Matrix	**Always** use the bridle	**Always** use the bridle
ALTlogger **BBOX** **SCOUT** **SCOUTPRO** **OPAL**	**Always** use the bridle	**Optional** - 8m of insulated wireline and surface fish (also called mud fish) can be used as a substitution of the bridle

3.2 QL40 ELOG/IP set up

The QL40 ELOG/IP sub can be used as a standalone tool or in a tool string when combined with other subs.

When used as a standalone tool, follow the assembly procedure below **:**

1. Screw the QL40 isolated bottom plug at the bottom end of the QL40 ELOG/IP sub

Figure 3-4 *Attaching the QL40-Bottom Plug*

2. Attach the isolation bridle at the top of the QL40 ELOG/IP sub

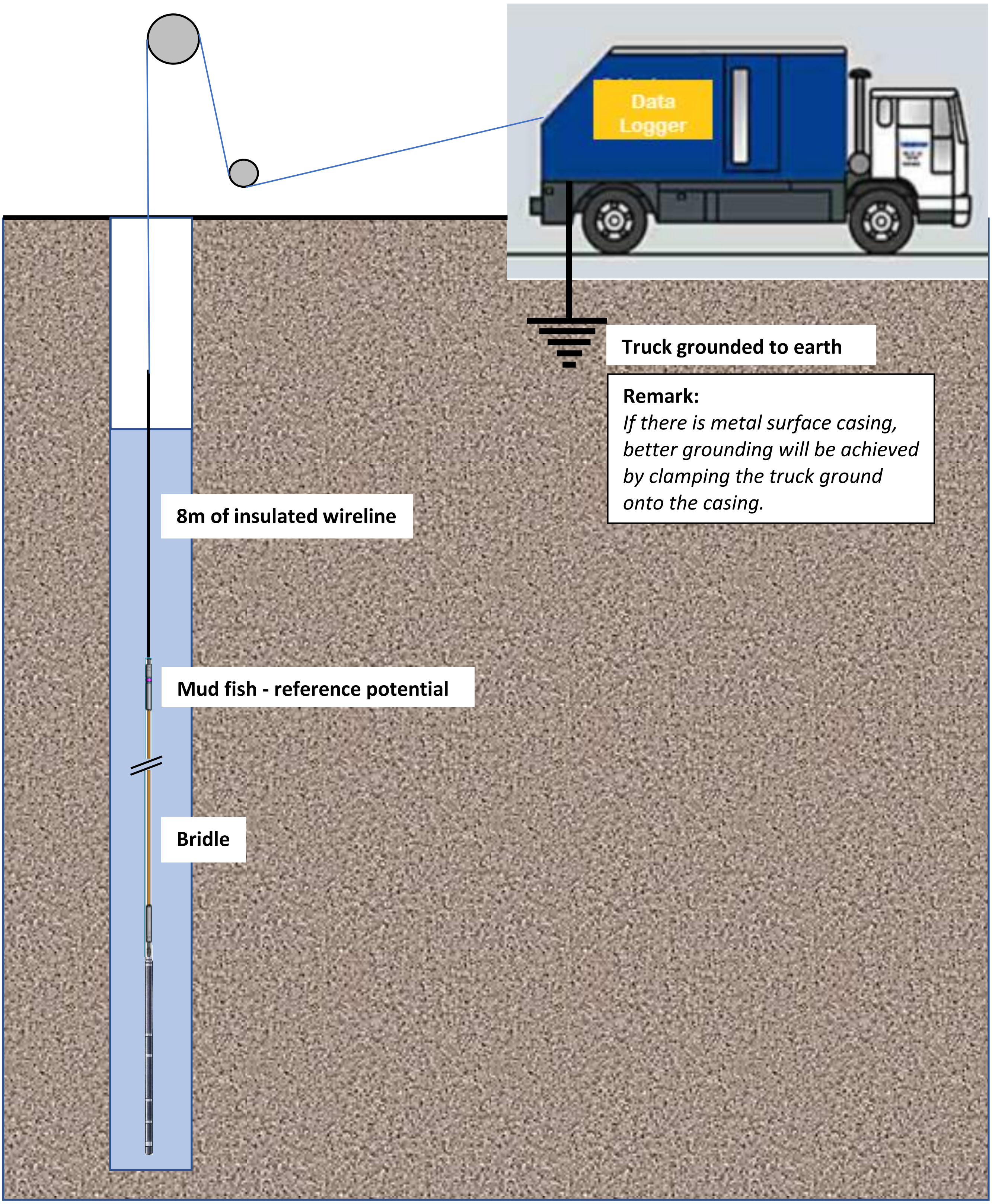
3. **Insulate with tape the mechanical joint between the sub and bridle .**
   It is important that all metal parts are covered with tape (at the exception of the injection and measuring electrodes!) to prevent a direct current return to this point rather than to the cable armor .

Figure 3-5 *bridle connection and isolation*

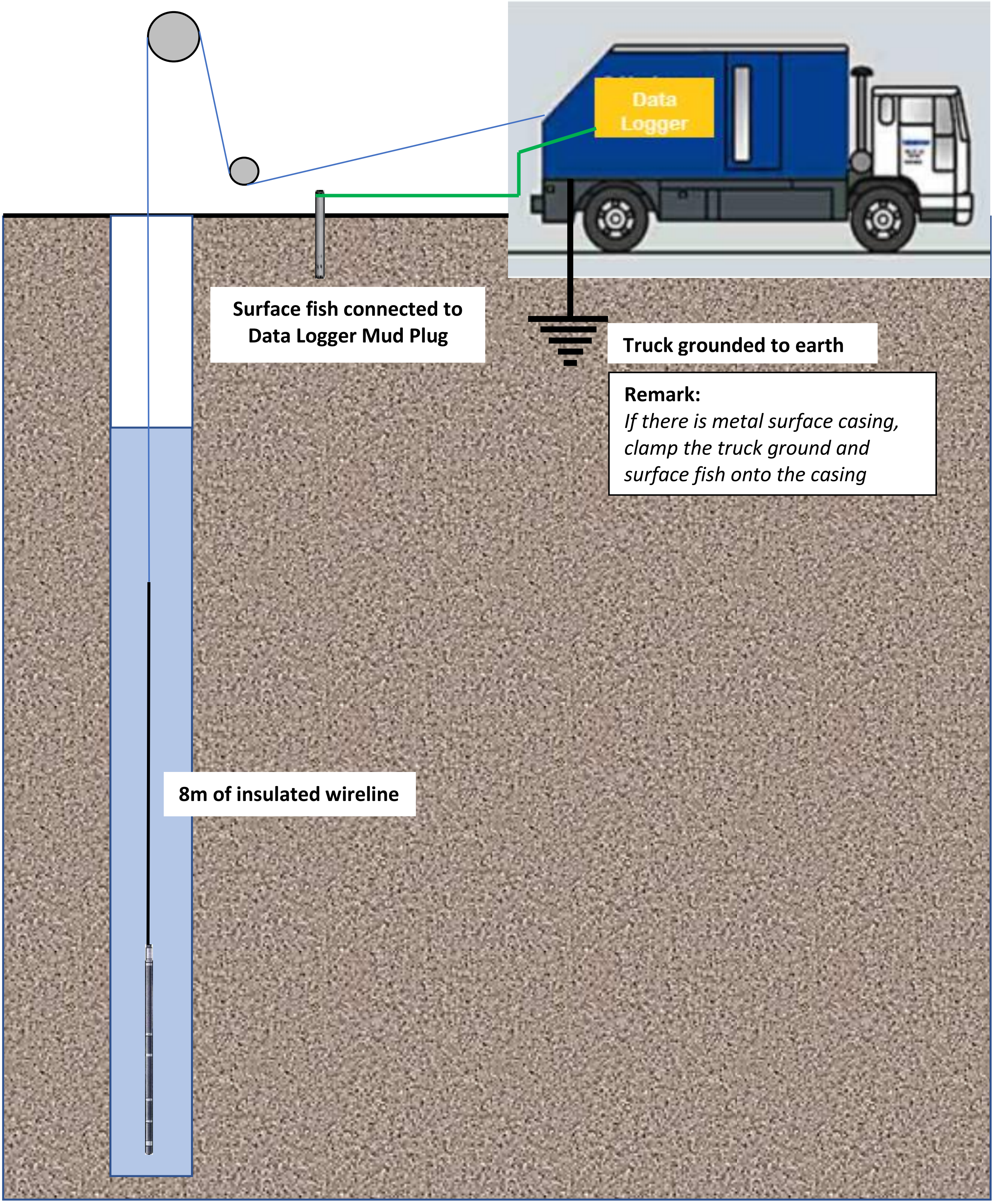
4. **<u>Insulate the bridle/cable head connection above the fish and 8 meters of wireline above the cable head</u>**

When the QL40 ELOG/IP is used in combination with other subs, the bottom and top subs <u>must be fully covered with an insulating sleeve or tape</u>. Refer to chapter 3.3 below for complementary information on the QL tools assembly.

3.3 Setup description with the bridle configuration



3.4 Setup description with the surface fish



3.5 Notes on QL tool assembly

QL stands for **Q**uick **L**ink and describes an innovative connection between logging tools (subs) allowing the assembly of 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, permitting operation either as a stand-alone tool or stacked in combination with other subs of the QL product family.
The QL40 probe line accommodates two types of sub - Bottom Subs and Mid Subs.

Bottom Sub
A bottom sub is a tool that has at least one sensor that must be located at the bottom of the stack. 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 the addition of a QL40 tool top adaptor that mates with 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.

3.6 QL40 stack assembly

A QL40 tool stack may be 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.

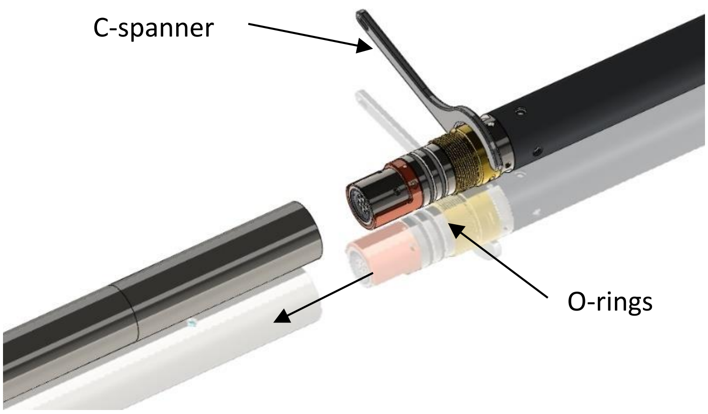


Figure 3-6 *C-spanner and O-rings of QL connection*

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

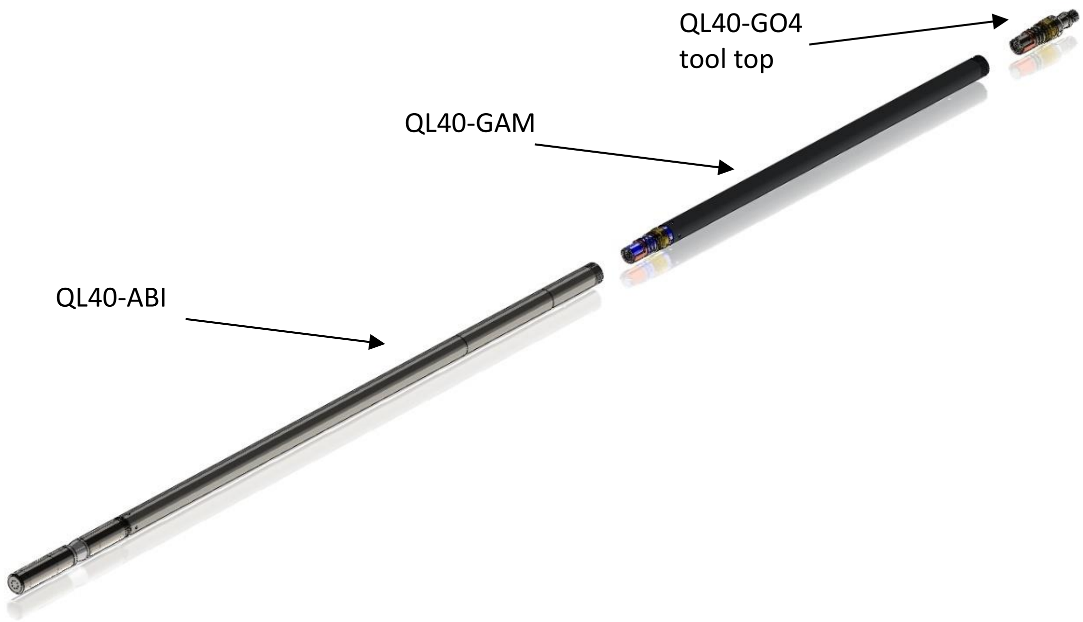


Figure 3-7 *Tool stack example*

To remove the QL40-ABI bottom sub attach the C-spanner to the thread ring as shown in Figure 3-3, unscrew the threaded ring, (anticlockwise about the tool axis when looking towards the bottom of the tool), and remove the QL40-ABI bottom sub.

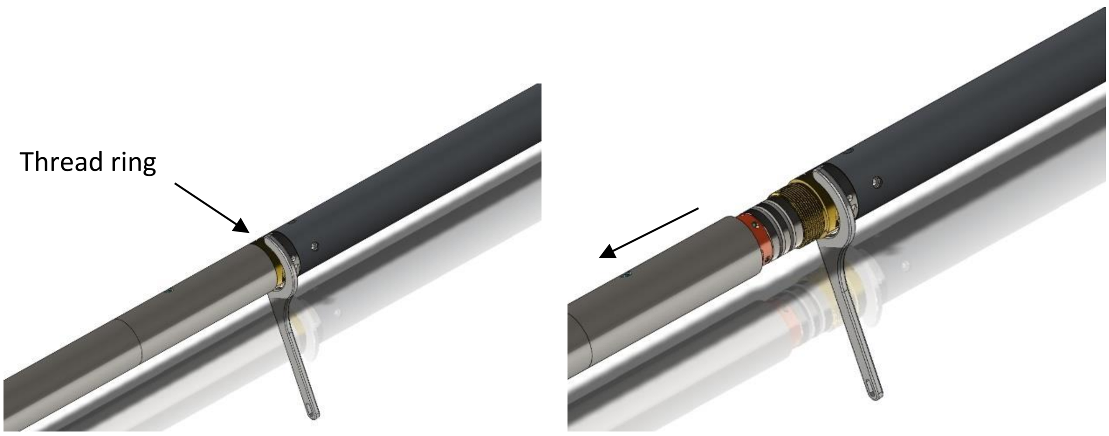


Figure 3-8 *Unscrewing the thread ring and removing the bottom sub*

After checking the O-ring integrity, align and slip the QL40-Plug over the exposed QL connector (Figure 3-4), attach the C-spanner and screw the threaded ring until the plug draws up tight to the ring.

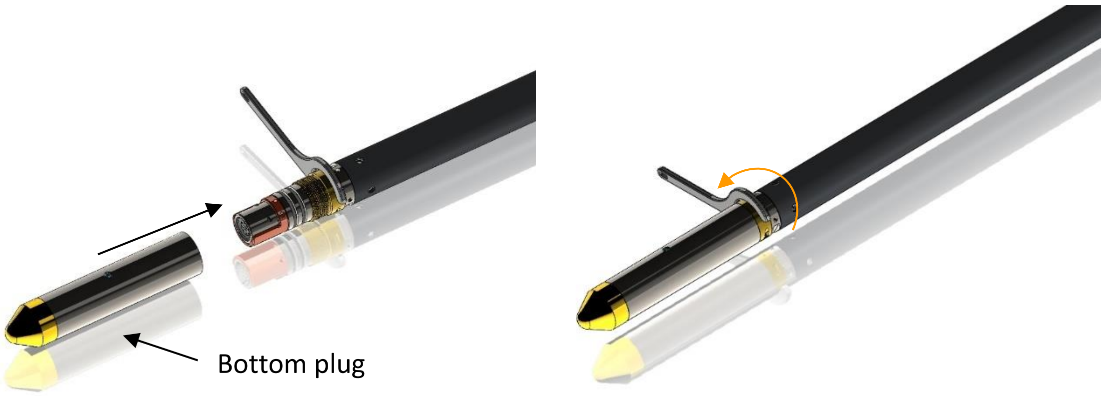


Figure 3-9 *Attaching the QL40-Plug*

The QL40-GAM can now be run stand-alone (Figure 3-12).

Figure 3-10 *QL40-GAM 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 **LoggerSuite** 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 ELOG/IP to your wireline and start the data acquisition software.

2. Select the relevant ELOG/IP tool from the drop down list (***Figure 4-4-1***) 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).

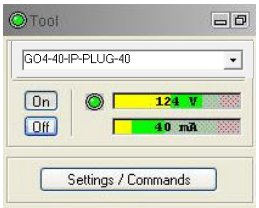


Figure 4-4-1 *Tool panel*

3. In the **Tool** panel switch on the tool (click **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 **4.5** if error message is displayed.)

4. On the **Tool** panel (***Figure 4-4-1***) click the **Settings / Commands** button to configure your tool for the ELOG and/or IP modes (see chapter **3.4** for details).

5. In the **Acquisition** panel (***Figure 4-4-2***) 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 4-4-2 *Acquisition panel*

6. Press the **Record** button in the **Acquisition** panel (***Figure 4-4-3***), specify a file name and start the logging.

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

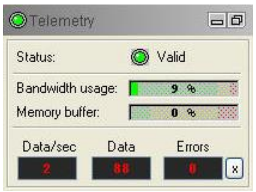


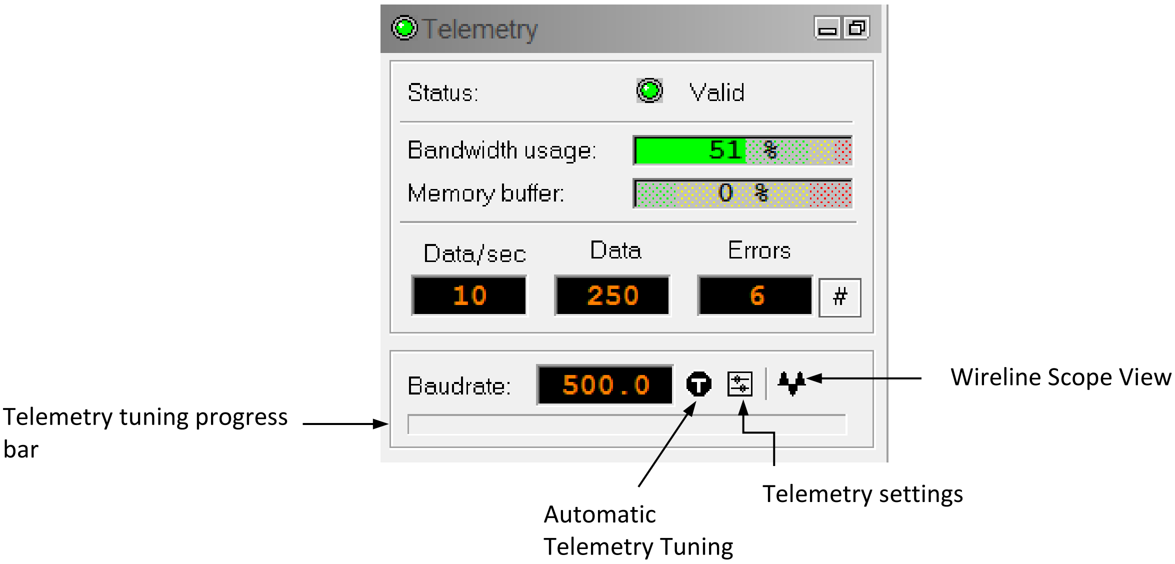
Figure 4-4-3 *Telemetry panel*

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

9. 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 of the dashboard click on **Settings** to display the **Configure Tool Telemetry** dialog box (***Figure 4-4-3***).
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 is true 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** to the desired value and observe that 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 successfully the next time it is turned on.

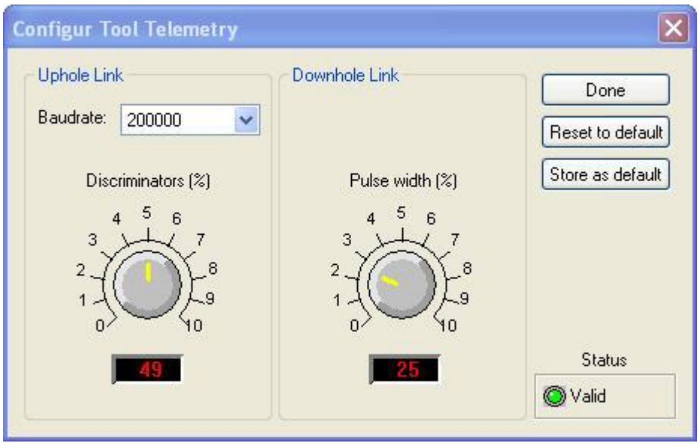


Figure 4-4-4 *Tool communication settings*

4.4 Tool Communication with MATRIX

The tool telemetry can be configured through the **Telemetry** panel of the Matrix dashboard. By clicking on **Settings**, the operator has access to the **Configure ALT Telemetry** dialog box (***Figure 3-5***) 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. In general, the gain setting should not be left in the automatic mode once a valid setting has been determined. Uncheck the box to disable automatic gain.
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 4-4-5) 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.

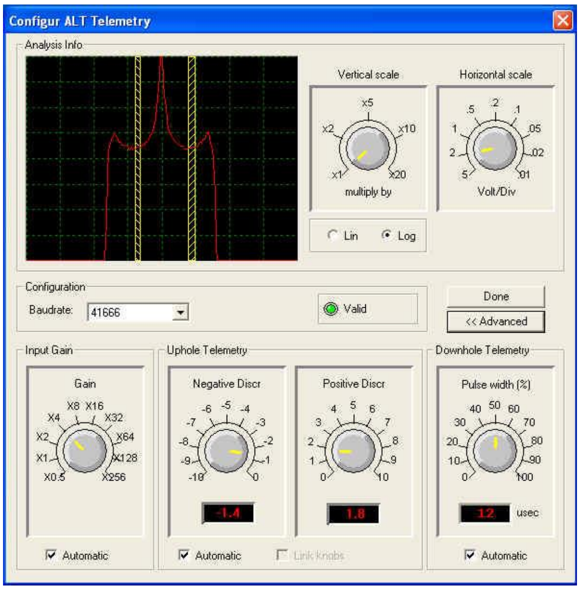


Figure 4-4-5 *Matrix telemetry settings*

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 **Configure IP Tool Parameters** dialog box can be opened by clicking on the **Settings/Commands** button in the **Tool** panel of the dashboard.

The **QL 40 ELOG/IP** tool can be operated in two modes by turning the knob control on the **Mode** section:

- The "**Resis.Only**" mode records the 8", 16", 32", 64" normal resistivity, SP and SPR
- The "**IP-100-250-500-custom**" modes record both the normal resistivity, SP, SPR and the IP responses on the 16" and 64" measure electrodes

For IP measurements, the downhole current generator supplies a +/- 16VDC square wave pulse at up to 500 mA to each electrode. The user can select from three predefined injection/release times: 100ms, 250ms and 500ms. Moreover the user can select individual injection/release times between 100ms and 2000ms for each period. Each measurement cycle consists of an injection phase of the selected time with a positive current followed by a release period of the same length during which the first set of 10 measurements is made, a second injection period of the selected time with a negative current followed by a release period during which the second set of 10 measurements is made. E.g. a complete measurement cycle at 250 ms injection/release time will take 1 sec.

Shorter injection/release times can be chosen for high conductivity formations. When the chargeability of the rock is expected to be poor, a longer injection/release time can be chosen.
In order to see the curves in the preview window, **turn ON** the **Sampling** in the Acquisition panel of the dashboard.
When in IP mode the **Full wave** preview window shows the potential difference measured between short spaced (SS - 16", blue curve) and respectively long spaced (LS -64", red curve) electrodes and the reference during the two injection and release times. Controls on the left of the preview window provide options to zoom in/out, fit preview to window, scale the display linear/logarithmic and enable/disable the display of short spaced and long spaced curves.

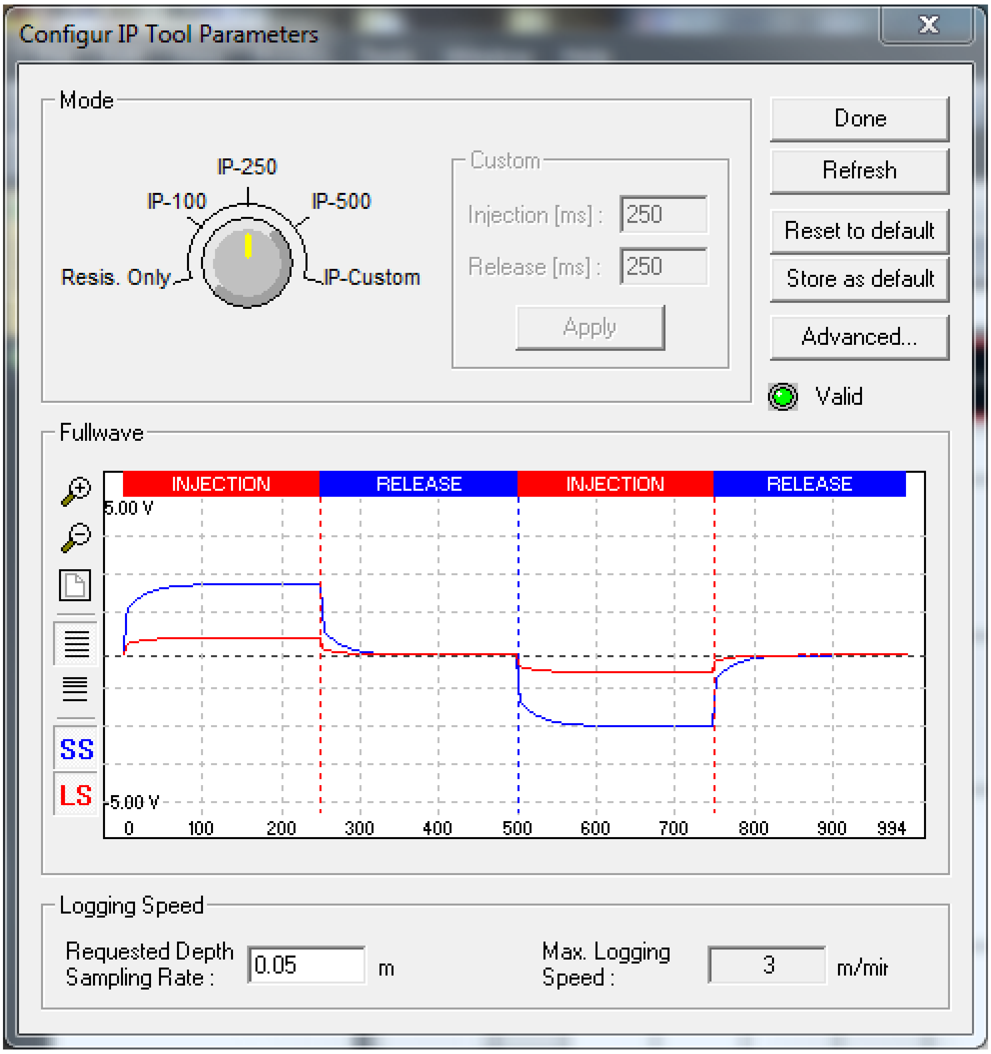


Figure 4-6 *IP Tool Parameters*

For the data acquisition the maximum logging speed will be function of the injection/release time and vertical sampling rate. To get a recommended logging speed the user can edit the vertical sampling rate in the "Logging Speed" section at the bottom of the dialog box.

The Advanced Settings dialog box (**7**) can be displayed by clicking on the **Advanced** button.

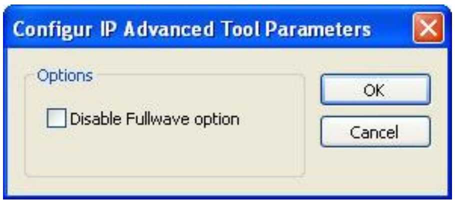


Figure 4-7 *Advanced Settings Dialog Box*

If this box is checked, the recorded data file will not include the full wave information. The default setting is to leave the box unchecked to enable the full wave recording.

4.6 Recorded Parameters, Processors and Browsers

4.6.1 Recorded parameters

When measurements are made in IP mode each Release period is subdivided into ten time windows. The measurements made during the same time window in both Release periods will be combined into the final IP response output.
The following data channels are recorded by the **QL40 ELOG/IP** tool (***Table 1***). Depending on the mode – IP or Resistivity – in which the tool is operated, different channels are recorded.

Time	[sec]
Temperature	Tool CPU temperature [°C]
VSP	Voltage Self Potential Sensor [mV]
VSPR	Voltage Single Point Resistance Sensor [V]
I	Injection Current [mA]
V8	Potential difference at 8” electrode [V]
V16	Potential difference at 16” electrode [V]
V32	Potential difference at 32” electrode [V]
V64	Potential difference at 64” electrode [V]
Vinj16	Potential difference at 16” during injection period
Vinj64	Potential difference at 64” during injection period
NbWinlin	Number of windows used for measurement during Release period
Tlin.n *(n=1 to 10)*	Time for measurement in each window [ms]
WLin16.n *(n=1 to 10)*	Average reading from same time windows during the two 16” Release periods.
WLin64.n *(n=1 to 10)*	Average reading from same time windows during the two 64” Release periods.
Tinj	Injection time [sec]
TRel	Release time [sec]
SPR	Single Point Resistance [Ohm]
N8	8” normal resistivity [Ohm-m]
N16	16” normal resistivity [Ohm-m]

N32	32” normal resistivity [Ohm-m]
N64	64” normal resistivity [Ohm-m]
IPlin16.n *(n=1 to 10)*	Ratio of potential differences (Release over Injection) from each window at 16” electrode [mV/V]
IPlin64.n *(n=1 to 10)*	Ratio of potential differences (Release over Injection) from each window at 64” electrode [mV/V]
IPFW16	Fully digitized voltage curve measured at the 16” spacing [V]
IPFW64	Fully digitized voltage curve measured at the 64” spacing [V]
IPFWVSPR	VSPR full wave
IPFWISPR	ISPR full wave
Ma16	Apparent Chargeability measured at the 16” spacing [ms]
Ma64	Apparent Chargeability measured at the 64” spacing [ms]

Table 1 *Recorded data channels*

4.6.2 MChNum Browser

Figure 4-8 shows a typical example of the numerical values displayed in the MChNum browser

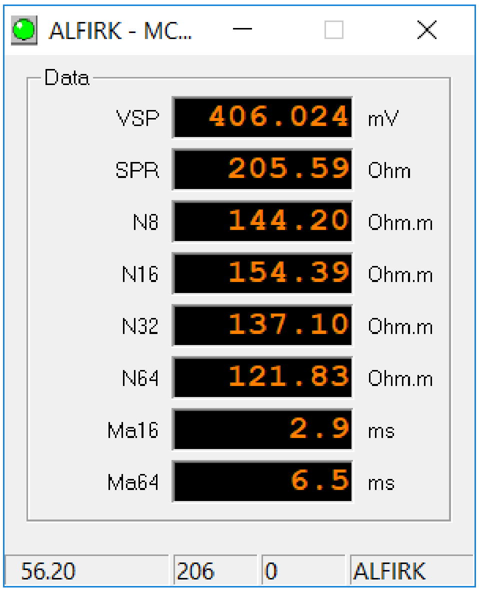


Figure 4-8 *MCHNum Browser Window*

VSP	Spontaneous Potential [mV]
SPR	Single Point Resistance [Ohm]
N8	8” normal resistivity [Ohm-m]
N16	16” normal resistivity [Ohm-m]
N32	32” normal resistivity [Ohm-m]
N64	64” normal resistivity [Ohm-m]
Ma16	Apparent Chargeability measured at the 16” spacing [ms]
Ma64	Apparent Chargeability measured at the 64” spacing [ms]

The other parameters listed in **Table 1** can be displayed in real time if required. Right click on MChNum browser and click on “Display options” from the menu.

Select in the "Display options properties" dialog box and add the additional channels to display.
It is possible to change the format of decimal digits displayed for a channel. Select the channel and click on "Settings" to configure the number of digits after the period.

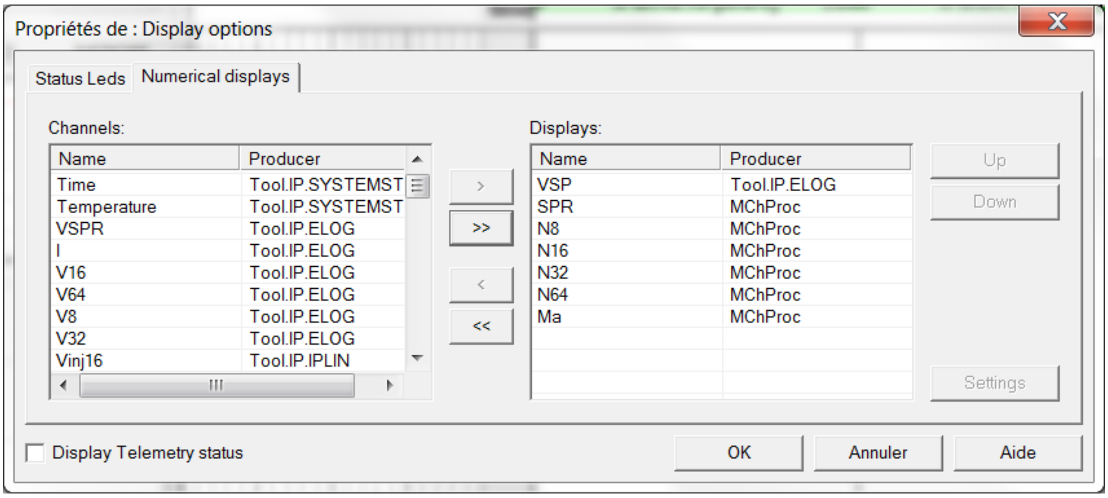


Figure 4-9 *Display options properties*

4.6.3 IpWave Browser

The IpWave Browser window consists of 2 panes displaying the full time series of the current I and the voltages VSPR, V16 (IPFWV16) and V64 (IPFWV64).

The pane on the top displays the voltage measured between the 16" electrode and the reference electrode - in blue (SS) and the voltage measured between the 64" electrode and the reference electrode - in red (LS) for each IP measurement. The self potential VSP is indicated by the dotted line and the corresponding values are displayed in blue and red for the self potential measurement at the 16" and 64" electrode. In addition, the computed chargeabilities Ma_{16} and Ma_{64} are displayed on the upper right corner.

The pane on the bottom displays the current (in red) and voltage measured between the current injection electrode and the reference electrode (in blue).

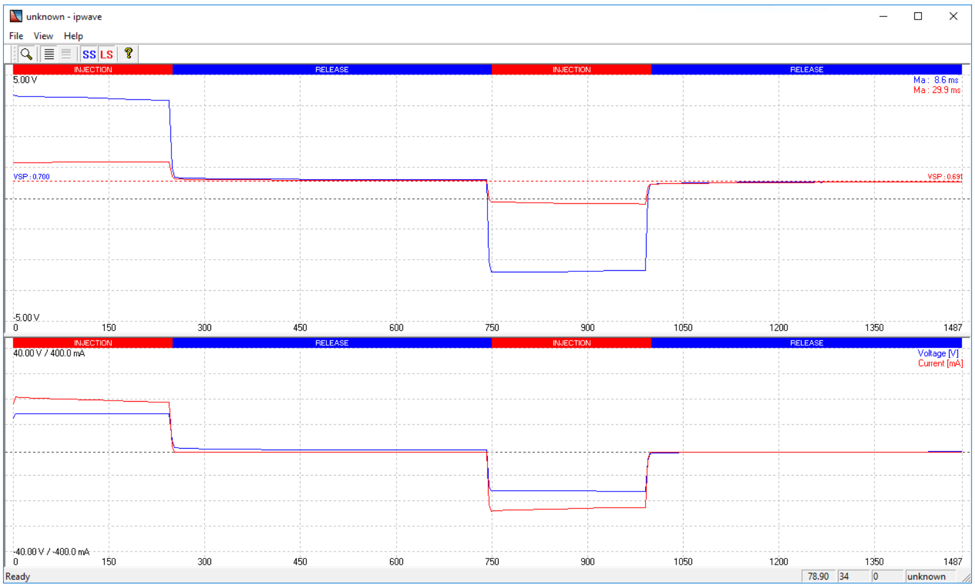


Figure 4-10 *IpWave Browser*

Controls in the toolbar of the window provide options to zoom, scale and enable / disable the curves.

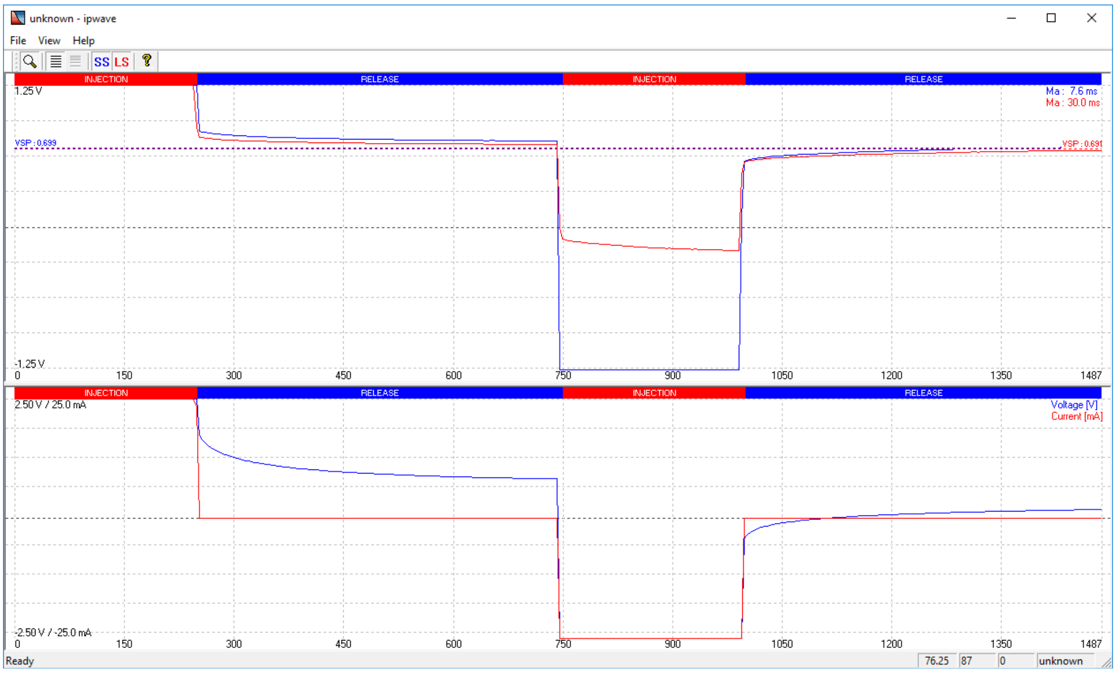


Figure 4-11 *IpWave Browser toolbar – zoom option*

Note that the display of especially the current I_{SPR} and the potential difference V_{SPR} as full wave (entire time series) are useful tool for the data quality control on the field.

In order to get good results from the RTD processing make sure to record the entire decay curve (both the positive and negative decay curve should asymptotically decay to the same value).

4.6.3.1 Calculation of IP Chargeability Response

The chargeability, labelled Ma, is calculated by integrating the surface below the release voltage decay curve normalized by the injection voltage. The release voltage decay is therefore divided into 10 equal time windows as shown in figure 4-12. The chargeability is computed for the voltage measured at the 16” spacing (Ma16) and the voltage measured at the 64” spacing (Ma64).

Calculation of Ma, Chargeability

The chargeability for the 16” and 64” channel is calculated using the following formulae:

$$Ma_{16} = \frac{1}{V_{inj16}} \cdot Tlin1 \cdot \sum_{i=1}^{10} WLin16.i$$

$$Ma_{64} = \frac{1}{V_{inj64}} \cdot Tlin1 \cdot \sum_{i=1}^{10} WLin64.i$$

where *Tlin1* is the time of the release time window (e.g. 25 ms for a 250 ms inj/rel setting),

and WLin16.1 – Wlin16.10 (resp. Wlin64.1 – Wlin64.10) are the average voltage values for each time window, normalized by V_{inj} the injection voltage.

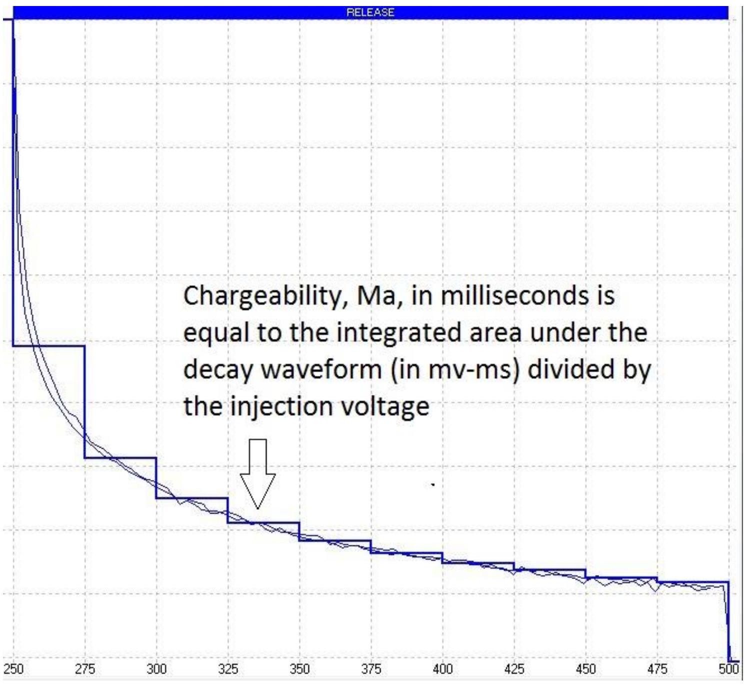


Figure 4-12 *Release Decay Waveform – Chargeability (Ma) calculation*

4.6.4 IpProc and IpInversion Browsers

IpProc applies a new processing technique implemented in LoggerSuite 12.1.2388 or higher to analyze the induced polarization data. The basic concept is that the IP response of the formation - the release voltage decay curve - is considered as being composed of multiple numbers of relaxation processes which can be described by an exponential decay:

$$V(t) = V_{S,peak} \cdot \sum_i \left[a_i \exp\left(-\frac{t}{\tau_i}\right)\right] + VSP$$

Where V(t) is the voltage measured during the release period, $V_{s,peak}$ is the voltage value at the beginning of the decay and VSP the self potential. The range of the relaxation time constants τ_i are predefined (logarithmically evenly spaced) and the coefficient a_i is the weighting factor corresponding to each relaxation time constant.

The default parameters of the RTD inversion are the following – some of them can be edited:

Parameter	Default	User definable
Vs,peak	1	No
τ_{min}	10^0	Yes
τ_{max}	10^4	Yes
i (nbr of *τ*)	64	Yes
a_{min}	0	Yes
a_{max}	20	Yes
VSP_{min}	Automatic	Yes
VSP_{max}	Automatic	Yes

The results of the processing are displayed in the IPInversion browser. On the left side, the positive release voltage decay curve (rawdata) of the 16” and 64” measurement are displayed with the dotted data points. The fit of the computed model is displayed by the line. On the right side, the relaxation time distribution is plotted with their corresponding weighting factors – the coefficients a.

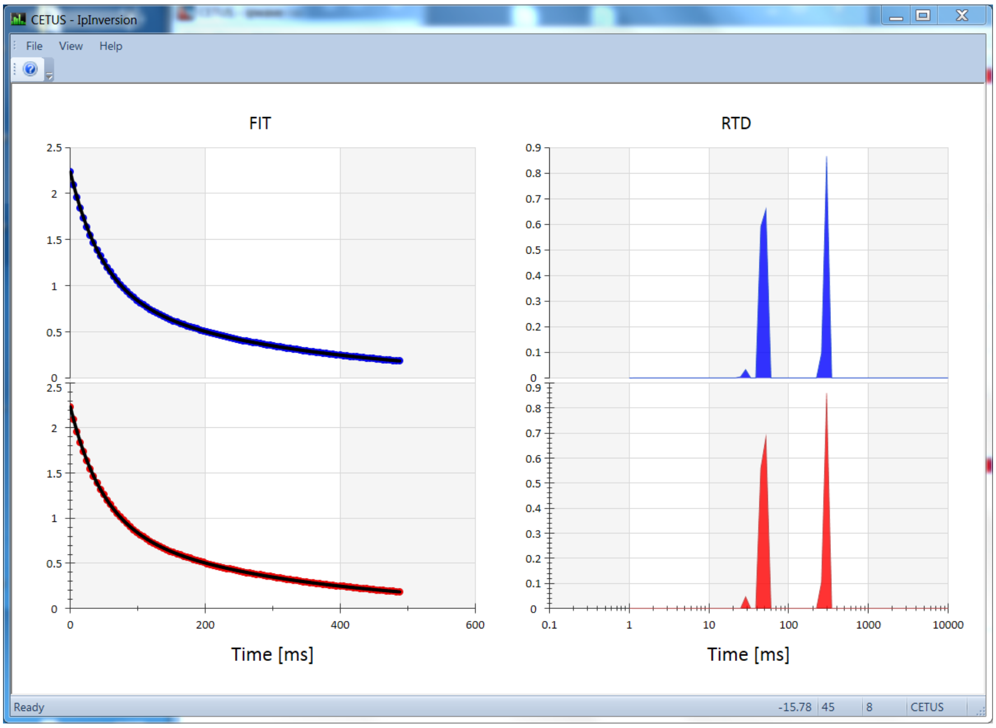


Figure 4-13 *IP Inversion browser*

Additional parameters are computed by the IpProc in real time. They are summarized in the table below:

IPFW16_POSREL	Positive digitized voltage curve measured at the 16” spacing [V]
IPFW16_NEGREL	Negative digitized voltage curve measured at the 16” spacing [V]
IPFW64_POSREL	Positive digitized voltage curve measured at the 64” spacing [V]
IPFW64_NEGREL	Negative digitized voltage curve measured at the 64” spacing [V]
IPFW16_POSREL_FIT	Fit on the positive digitized voltage curve measured at the 16” spacing
IPFW16_NEGREL_FIT	Fit on the negative digitized voltage curve measured at the 16” spacing
IPFW64_POSREL_FIT	Fit on the positive digitized voltage curve measured at the 64” spacing
IPFW64_NEGREL_FIT	Fit on the negative digitized voltage curve measured at the 64” spacing
RTD16POS	RTD computed on the 16” spacing – positive cycle [ms]
RTD16NEG	RTD computed on the 16” spacing – negative cycle [ms]
RTD64POS	RTD computed on the 64” spacing – positive cycle [ms]
RTD64NEG	RTD computed on the 64” spacing – negative cycle [ms]
RTD16POS_V_{SP}	V_{SP} computed from the positive digitized voltage curve measured at the 16” spacing [V]
RTD16NEG_V_{SP}	V_{SP} computed from the negative digitized voltage curve measured at the 16” spacing [V]
RTD64POS_V_{SP}	V_{SP} computed from the positive digitized voltage curve measured at the 64” spacing [V]
RTD64NEG_V_{SP}	V_{SP} computed from the negative digitized voltage curve measured at the 64” spacing [V]

RTD16POS_RSS	Residual Sum of Squares between IPFW16_POSREL_FIT and IPFW16_POSREL
RTD16NEG_RSS	Residual Sum of Squares between IPFW16_NEGREL_FIT and IPFW16_NEGREL
RTD64POS_RSS	Residual Sum of Squares between IPFW64_POSREL_FIT and IPFW64_POSREL
RTD64NEG_RSS	Residual Sum of Squares between IPFW64_NEGREL_FIT and IPFW64_NEGREL
Ma'16	Apparent Chargeability [ms] measured at the 16" spacing normalized by V_{SPR}: [1] $$Ma'_{16} = \frac{1}{V_{SPR}} \cdot Tlin1 \cdot \sum_{i=1}^{10} WLin16.i$$
Ma'64	Apparent Chargeability [ms] measured at the 64" spacing normalized by V_{SPR}: $$Ma'_{64} = \frac{1}{V_{SPR}} \cdot Tlin1 \cdot \sum_{i=1}^{10} WLin64.i$$

4.6.5 MChCurve Browser

By default the MchCurve Browser window displays the curves shown in **Figure 4-14** – SP, SPR, normal resistivity and the IP responses from 16" and 64" electrodes.

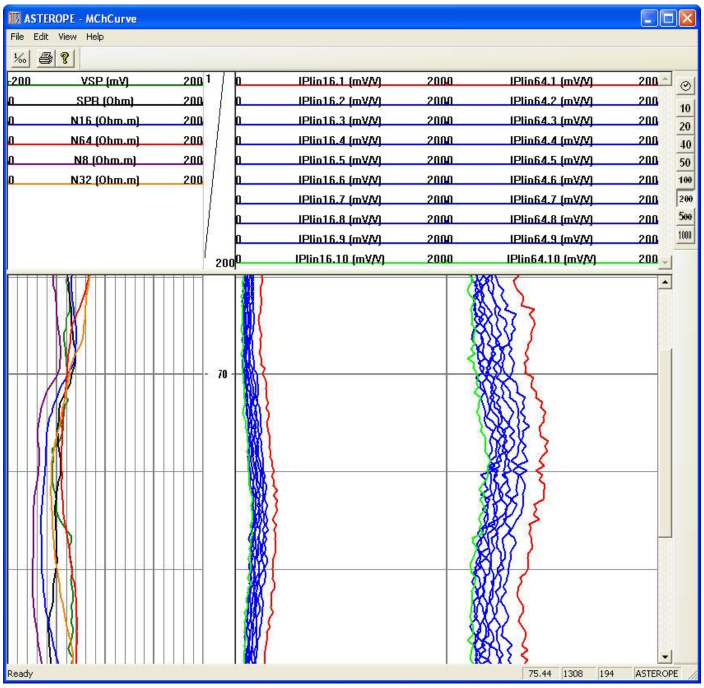


***Figure 4-14** MchCurve Browser window*

[1] Normalizing by V_{SPR} may help to minimize discrepancies that might occur on the computed chargeability measured on the 16" and 64" sensing electrodes and integrates tool geometrical factors.

4.6.6 WellCAD Browser

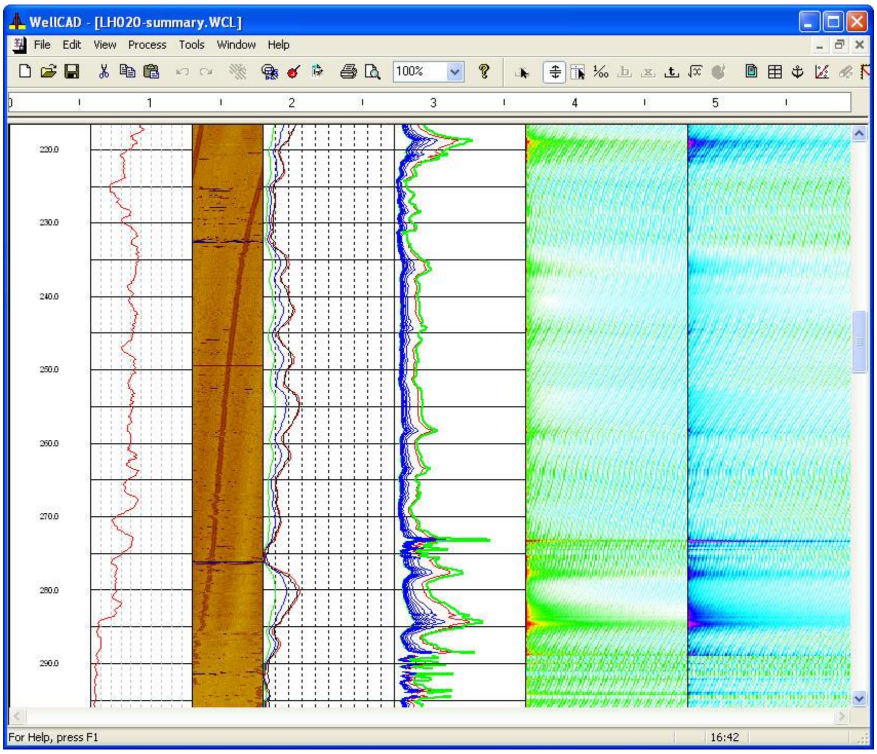


Figure 4-15 *WellCAD browser*

5 Performance Check & Calibration

Calibrations are performed at the factory. Each QL40-ELOG/IP is delivered with a calibrated "sub" file that must be used for that specific tool. It is also possible to calibrate the tool before a field operation using the suitable **ELOG Calibrator** – see below:

Figure 5-1 *ELOG Calibrator*

5.1 Calibration procedure

A calibration box is supplied with the QL40 ELOG/IP to verify the tool performance. Refer to the procedure described below:

1. Assemble the tool sub(s) and connect to the wireline
2. Connect the cables and clamps between the ELOG Calibrator and QL40 ELOG/IP tool as per the diagram shown on the box:

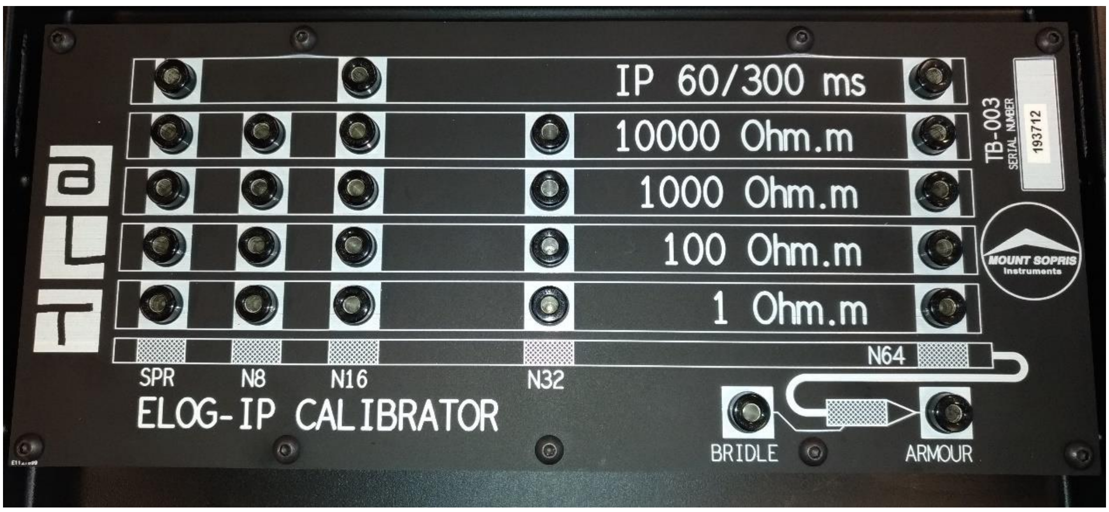


Figure 5-2 *ELOG Calibrator configuration diagram*

3. In the **Tool Panel**:
   Select the proper tool/stack;
   Turn tool power **On**
4. In the **Acquisition Panel** select **Time** and turn it **On**.
5. Verify the telemetry status in the **Telemetry Panel**. The LED must be green and status valid
6. Right click on MChNum browser
7. From the menu, uncheck "Use calibration" and click on "Calibration Settings"
8. **For each resistivity channel (SPR, N8, N16, N32 and N64)**, follow the steps below:

   - From the "**Calibration Settings**" dialog box select the calibration page of the resistivity channel to calibrate

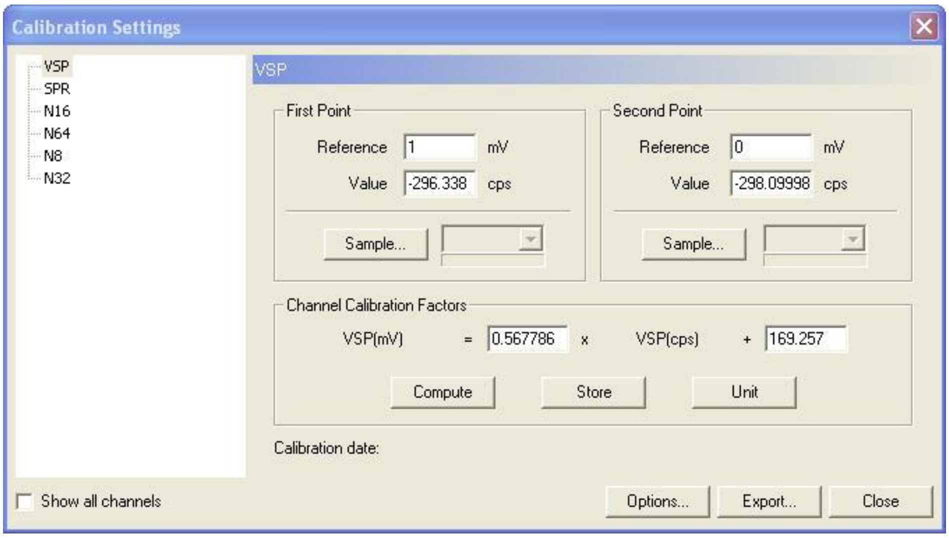


***Figure 5-3** Example of calibration page*

   - Edit the first reference value (say 100 ohm.m)
   - Connect the measuring electrodes on the ELOG Calibrator for this first reference resistivity value (100 ohm.m)
   - Click on **SAMPLE** to get the corresponding value in cps
   - Edit the second reference value (say 10,000 ohm.m)
   - Connect the measuring electrodes on the ELOG Calibrator for this first reference resistivity value (10,000 ohm.m)
   - Click on **SAMPLE** to get the corresponding value in cps
   - Click on **COMPUTE** and then on **STORE** to save the calibration factors of the measured channel

9. The "**IP**" response can also be checked by connecting the injection (SPR), 16" and 64" electrodes for the **IP measurement configuration.** A **chargeability of 60 ms and 300 ms** should be read in **the IpInversion browser – Relaxation Time Distibution (RTD)** plot (Figure 4-13).

6 Maintenance

Warning: Removing the electronic chassis from pressure housing without prior consultation with ALT/MSI will void the tool warranty.

The QL40 series tools require periodic maintenance. Make sure the threads on the brass nut on the sub bottom are free of sand, mud or other dirt. A thin layer of anti-seize is recommended. When disassembling the sub string, dry the joint as it is separated to prevent fluid from entering the sub top and getting into the electrical connector inside.
After replacing top and bottom protectors it is good to wash the probe off after each use. ***Never take the probe apart. This probe is very difficult to disassemble and requires special steps to be taken in order to gain access to the inside of the probe without damaging the electronics. If you have read this after attempting to disassemble the probe chances are the probe has experienced damage and will need to be sent to the factory to be repaired.*** Inspect o-rings occasionally and keep the threads on both ends of the probe clean, to minimize problems in the future.

6.1 Upgrading firmware

In accordance with the ALT policy of continuous development the tool has been designed to allow firmware upgrades.

Firmware upgrade procedure is as follows:
1. Confirm that the communication is valid.
2. Upgrade firmware

6.1.1 Checking the communication

1. Connect the tool to your acquisition system.
2. Start ALTLog/Matrix software.
3. In the **Tool** panel select the appropriate tool and turn on the power.
4. In the **Communication** panel, select **Settings**. Check **baud rate** is set to **41666** and **communication status** is **valid** (Figure 6-1 or Figure 6-2).

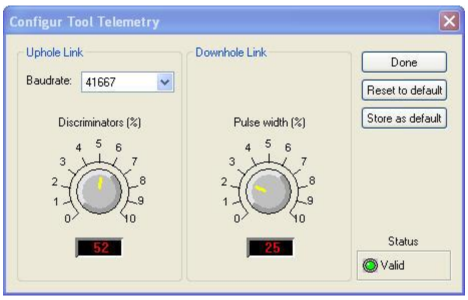


Figure 6-1*Tool communication settings - ALTLog*

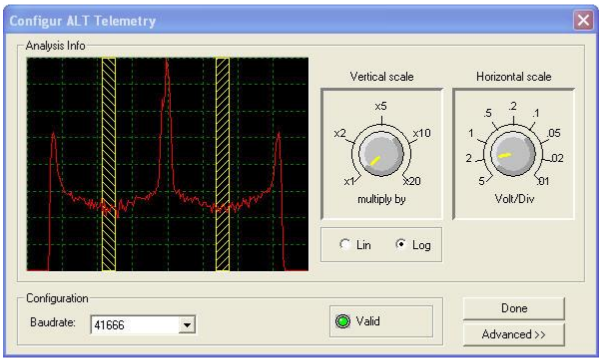
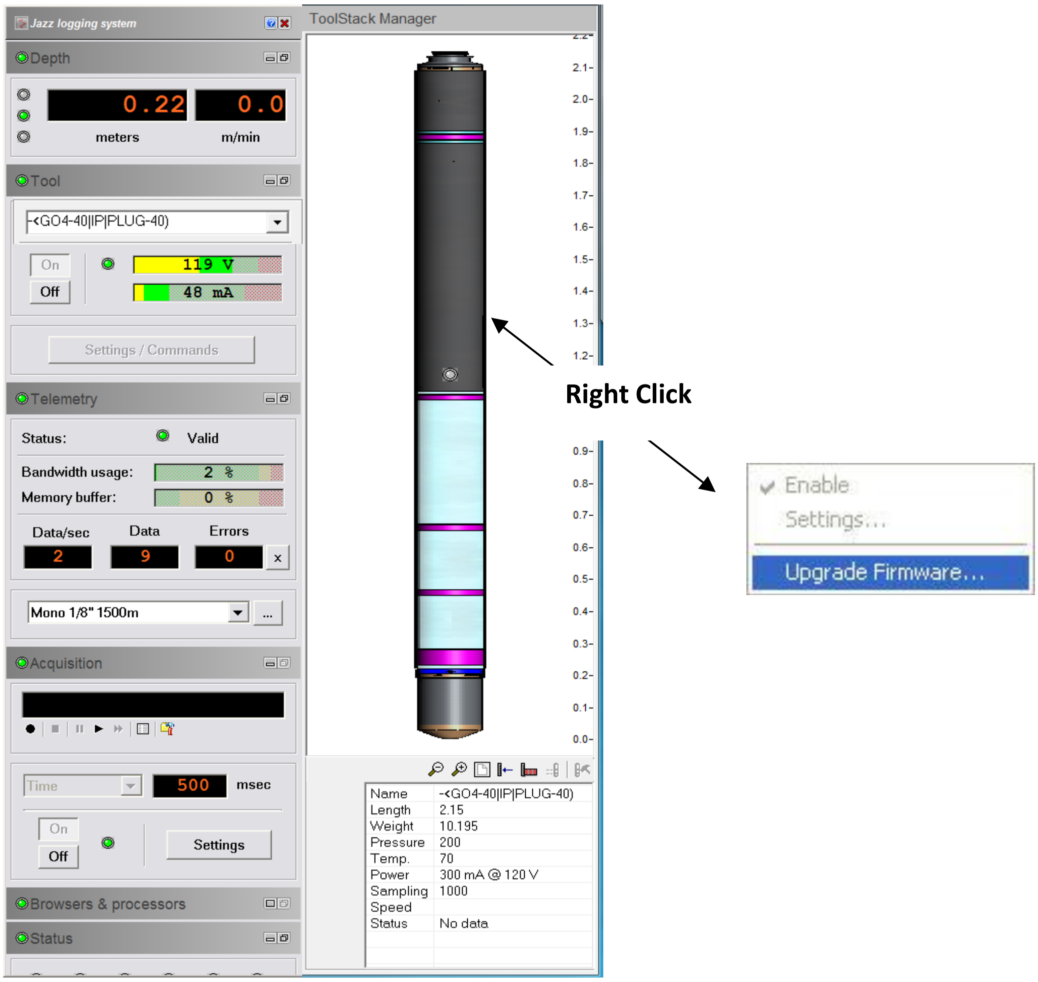


Figure 6-2 *Tool communication settings - Matrix*

Warning: Telemetry must be tuned properly. Bad communication may abort the upgrade of the firmware!

6.1.2 Upgrading the firmware

1. **Right Click** on the tool preview in the **ToolStack Manager** view and select **Upgrade Firmware** from the context menu.



2. The following message will appear (Figure 6-3). Click **Yes** to validate your choice.

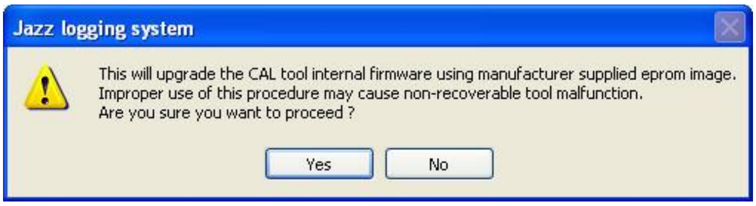


Figure 6-3 *Warning Message during firmware upload*

3. Select and open the appropriate **.hex** file provided. The upgrade will start.
4. During the upgrade procedure, the following message is displayed:

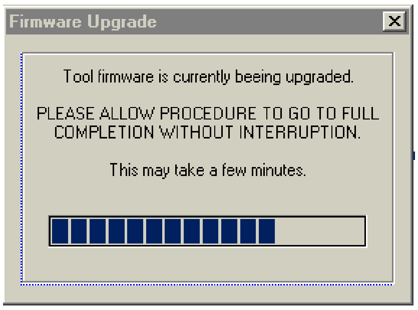


Figure 6-4 *Firmware upgrade progress window*

5. Once the upgrade has been successfully completed (Figure 6-5), click on **OK** to turn off the tool.

Figure 6-5 *Successful upgrade*

6. Power on the tool to start the upgraded firmware.

Note that the following error message (Figure 6-6) will appear at the end of the procedure when the tool firmware upgrade has failed or has been aborted. Verify the tool communication settings in this case.

Figure 6-6 *Error message*

7 Troubleshooting

The **QL40ELOG/IP** probes require a proper current return to armor, and a proper isolation for approximately 7 meters above the probe for correct operation. The downhole tool current (I) must be a reasonable value to insure correct measurements are being made. This value will fluctuate from 10 mA in very high resistivity rock, to as much as 500 mA in very conductive rock. If such values are not obtained during logging, there may be a problem with the cable armor connections at the winch or logger.

NEVER DIS-ASSEMBLE THE PROBE WITHOUT CONSULTING THE FACTORY FIRST

Disassembly Instructions

The **QL40-ELOG/IP** Probe should **<u>never be disassembled</u>** unless service is necessary. This is a very difficult probe to disassemble, and is highly recommended that any service be performed by Mount Sopris, ALT or a qualified technician.

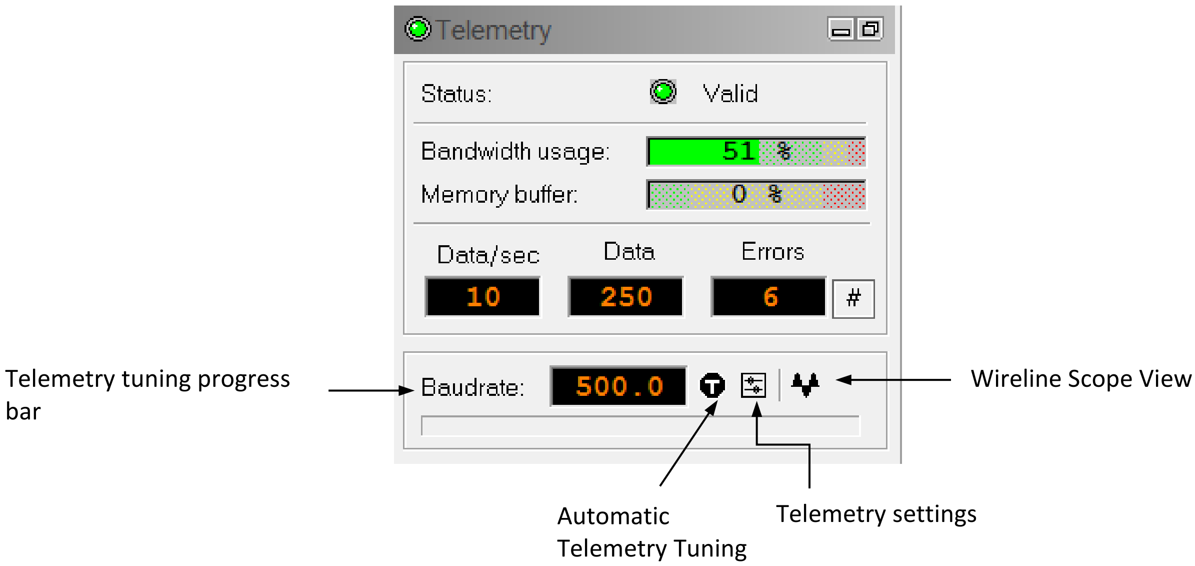
Observation	To Do
Tool not listed in Tool panel drop down list.	- Do you have a configuration file? - Has the configuration file been installed with the LoggerSettings application (refer to LoggerSettings and LoggerSuite manuals for more information)
Tool configuration error message when powering on the tool.	- Check all connections. - Adjust the telemetry settings for your wireline configuration (see chapter 3.2 or 3.3) and store the new settings as default. Apply the appropriate tool settings for your logging run (see chapter 3.4).
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 low, current high): 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 the short circuit. - 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 3.2 or 3.3). - If problem cannot be resolved contact support@alt.lu or tech.support@mountsopris.com
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 or increase vertical sample step.
Telemetry panel - large number of errors.	- Verify the telemetry settings for your wireline configuration (see chapter 3.2 or 3.3). - 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:

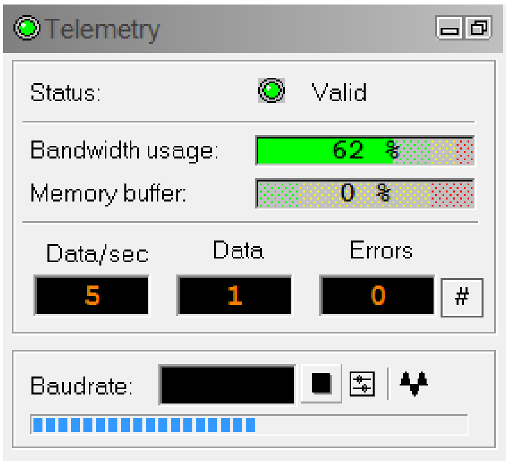
The Tune button  resets the telemetry tuning automatically. This process defines:

- 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.[2] 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.

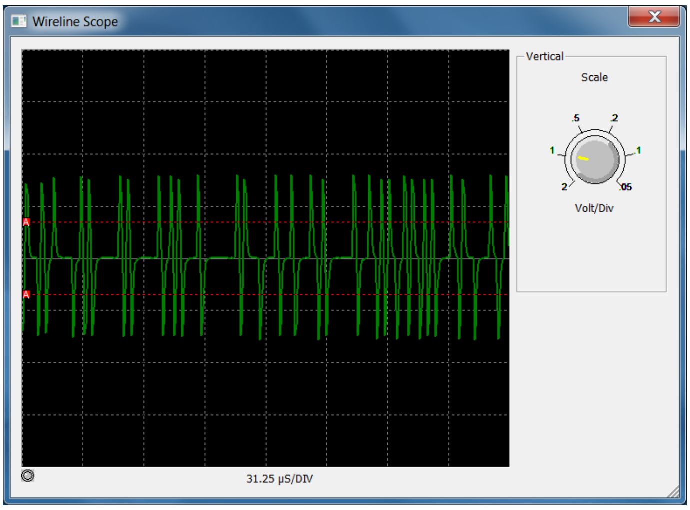
A **progress bar** at the bottom of the telemetry window shows the progression of the telemetry tuning. At the end of the process the baud rate display is refreshed with the optimal baud rate value.

[2] 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.



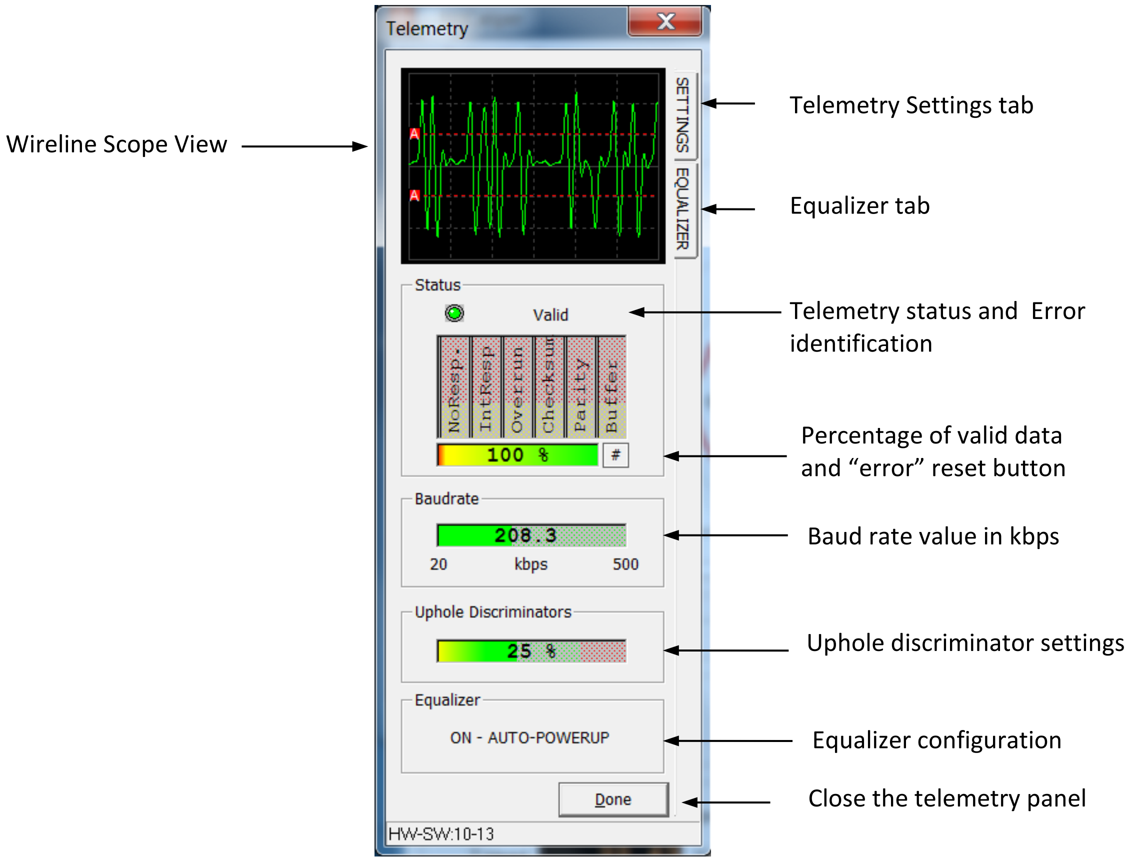
The two red-dashed horizontal lines help to visualize the position of the discriminator levels set for detecting the pulses at the surface. Discriminator levels can be tuned in the **Telemetry Settings** dialog – refer to section 3.6.1 for more information.

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)

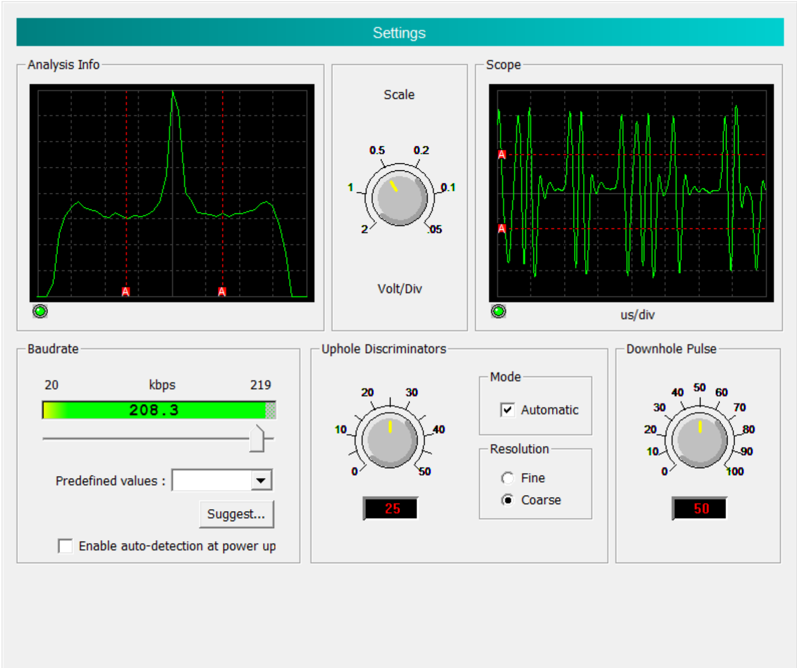


Adjusting the Telemetry Settings:

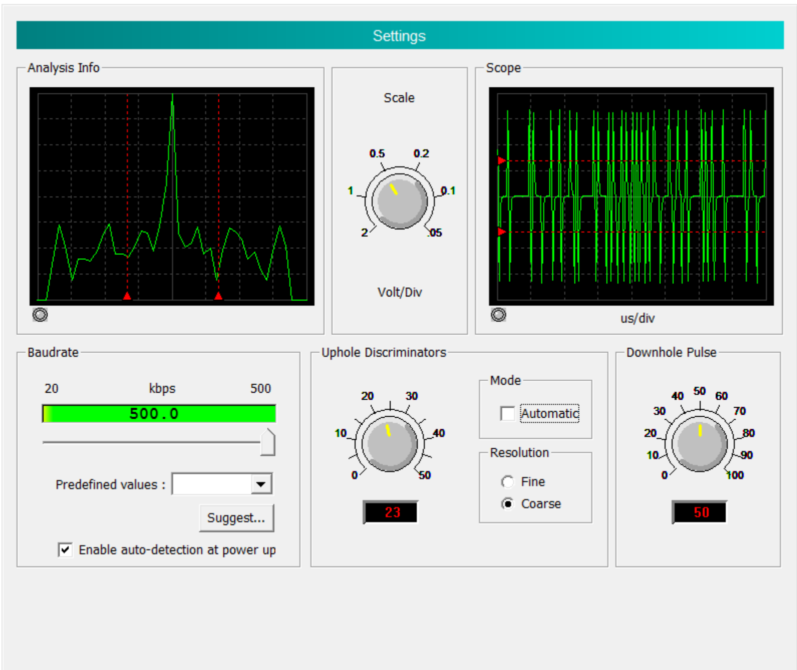
By default the telemetry settings are set to Automatic mode and should stay in this configuration. When more advanced tuning is required (i.e. long wirelines having a limited bandwidth) the manual mode can be activated.

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.

Position of the discriminator lines should be set as illustrated below.



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.



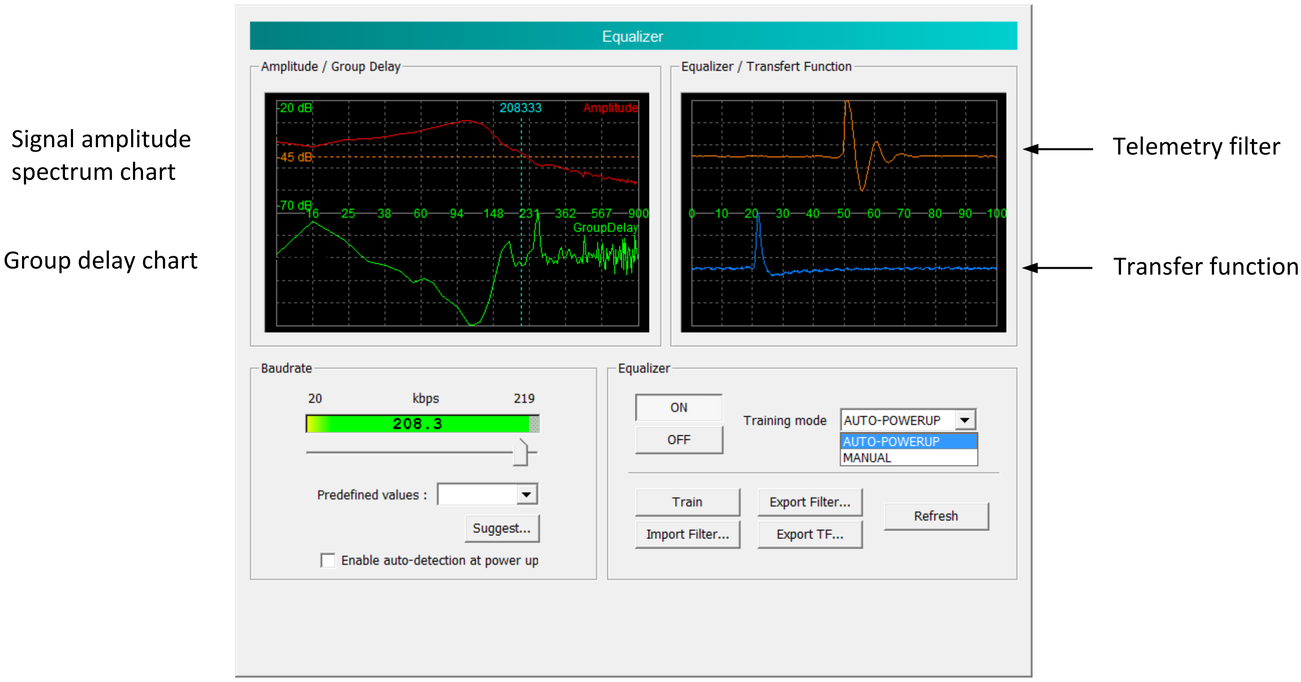
The **Downhole Pulse knob** controls the width of the pulse commands sent to the tool. It is set on 50 as a default value. This value is the preferred one and is suitable for a wide range of wirelines. For long wireline increasing the pulse width could help to stabilize the communication. The reverse 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 QL40-Elog/IP - Resistivity correction charts

Correction charts were computed for the ALT QL40-Elog/IP tool. Two sets of charts are available. The first set is applicable when the QL40-Elog/IP tool was used in combination with an isolation bridle – the reference potential in this case is the mud fish electrode located at the top of the bridle. The second set is applicable when a surface fish was used for the reference potential.

The correction charts allow the conversion of an apparent measured resistivity (R_a) into a true formation resitivity (R_t) versus borehole diameter.

The use of the correction charts requires that the borehole fluid resistivity (R_m) is known or ideally is measured with the ALT QL40-FTC probe.

For each measuring electrode the correction charts plot a R_a / R_m ratio versus borehole diameter and provides the corresponding R_t / R_m ratio.

Example of correction – N8 electrode (bridle configuration)

- *Borehole diameter: 300 mm*
- *Borehole fluid resistivity (R_m): 50 Ohm.m*
- *Formation apparent resitivity measured by the tool (R_a): 1000 Ohm.m*

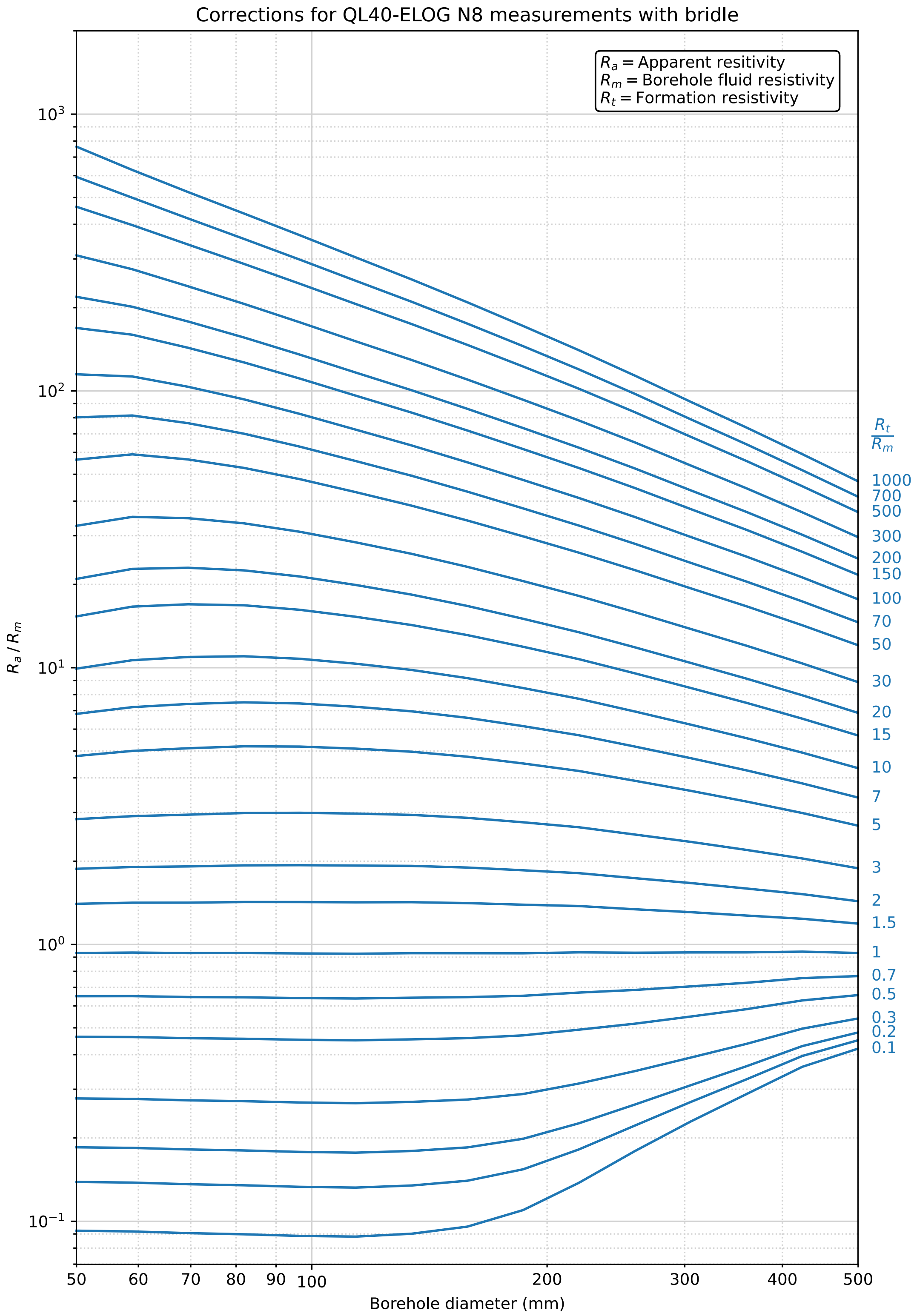
➔ $R_a/R_m = 1000/50 = 20$

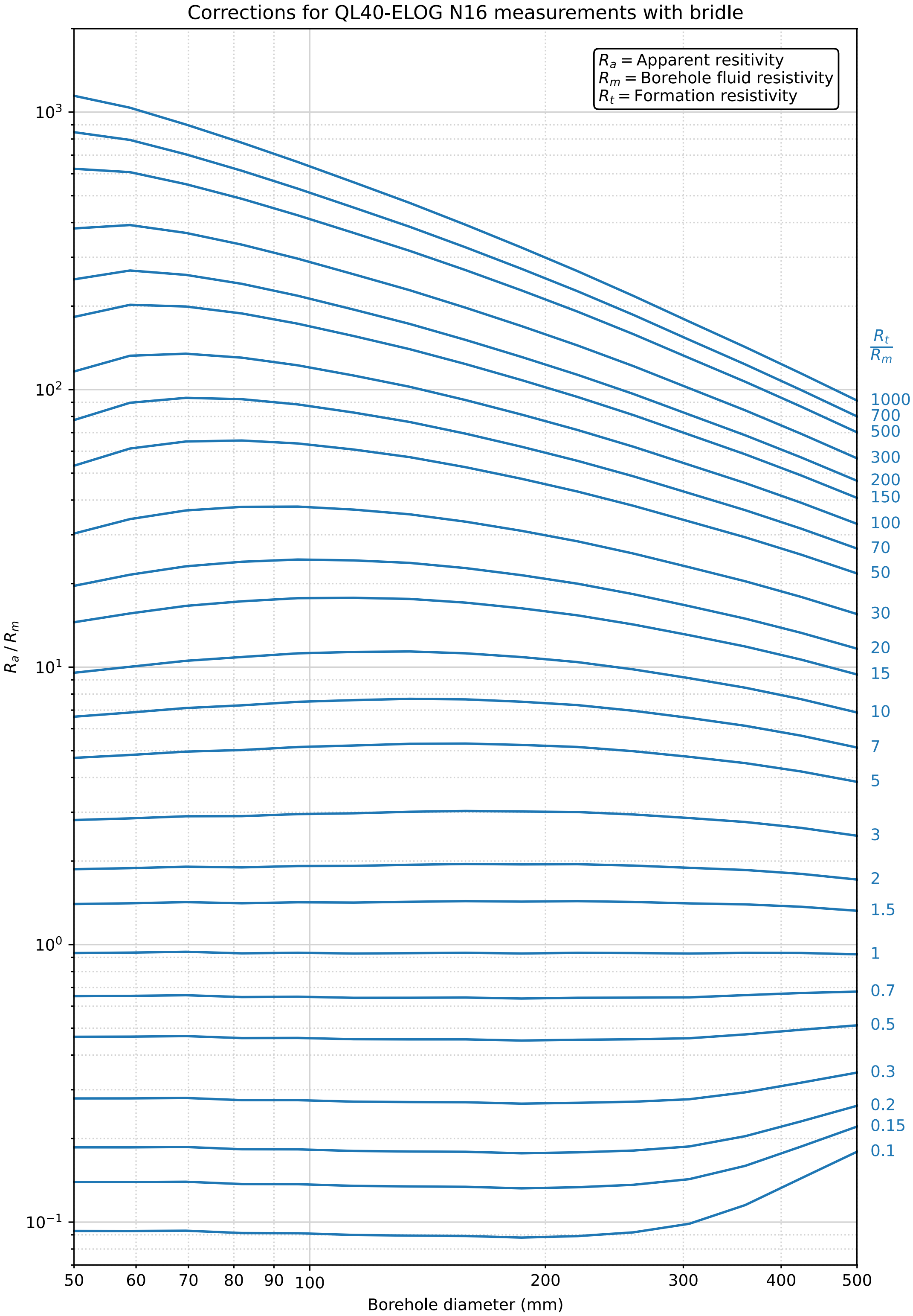
For a 300mm borehole and for a R_a/R_m equal to 20, R_t/R_m is 50

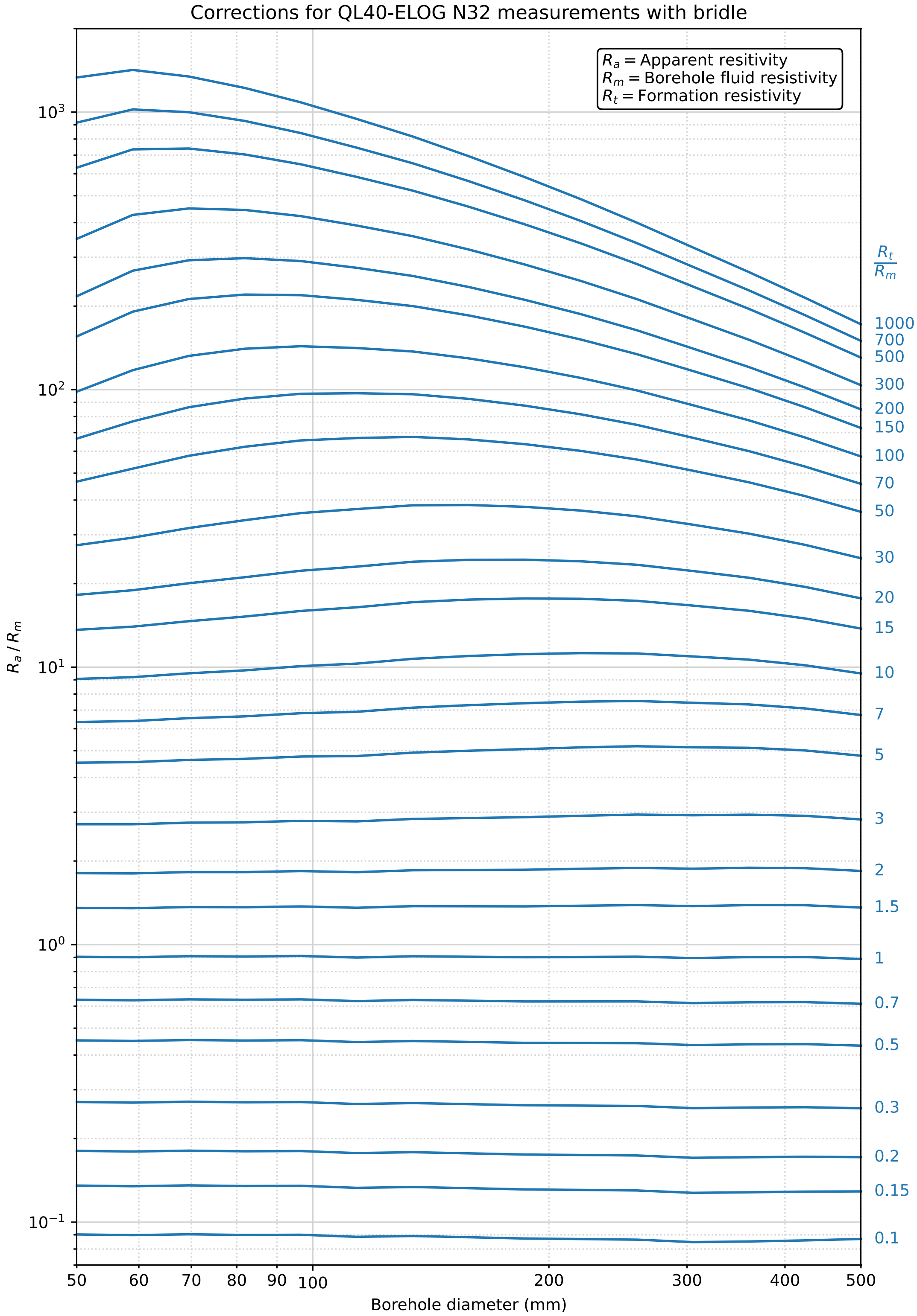
➔ $R_t = 50 * 50 = 2500$ *Ohm.m*

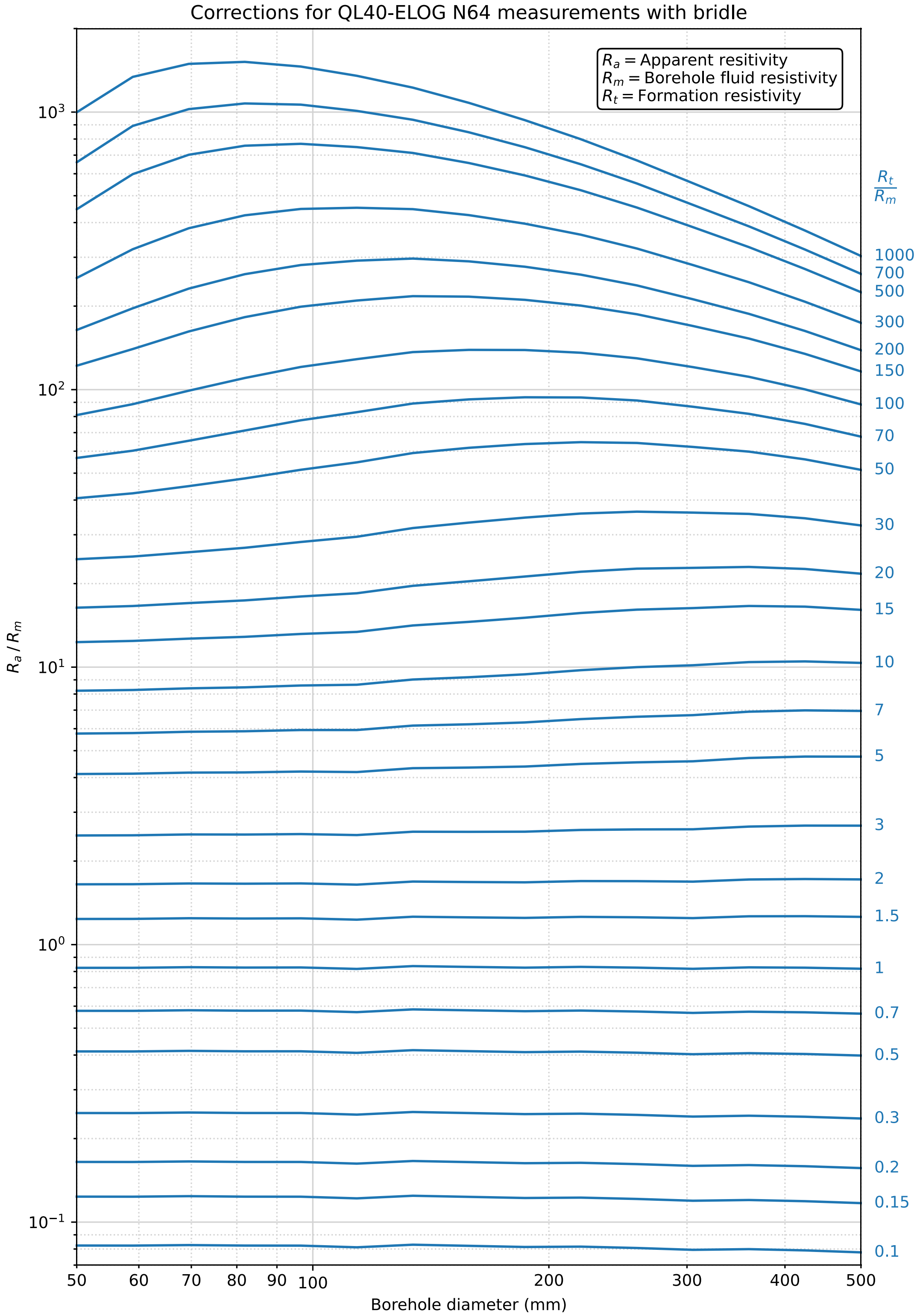
These corrections are available as an automated process in WellCAD.

8.2.1 Correction charts – Bridle configuration

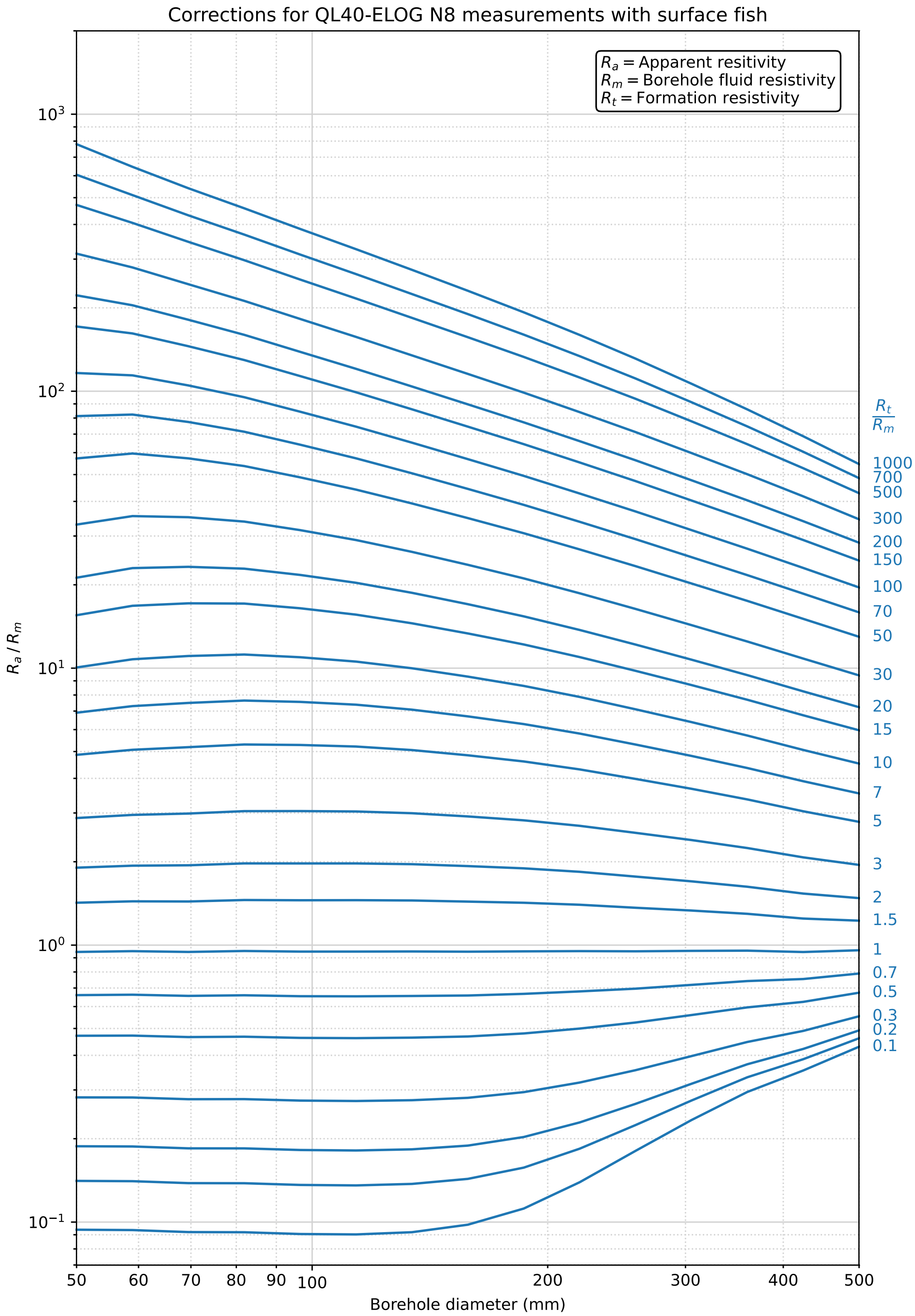


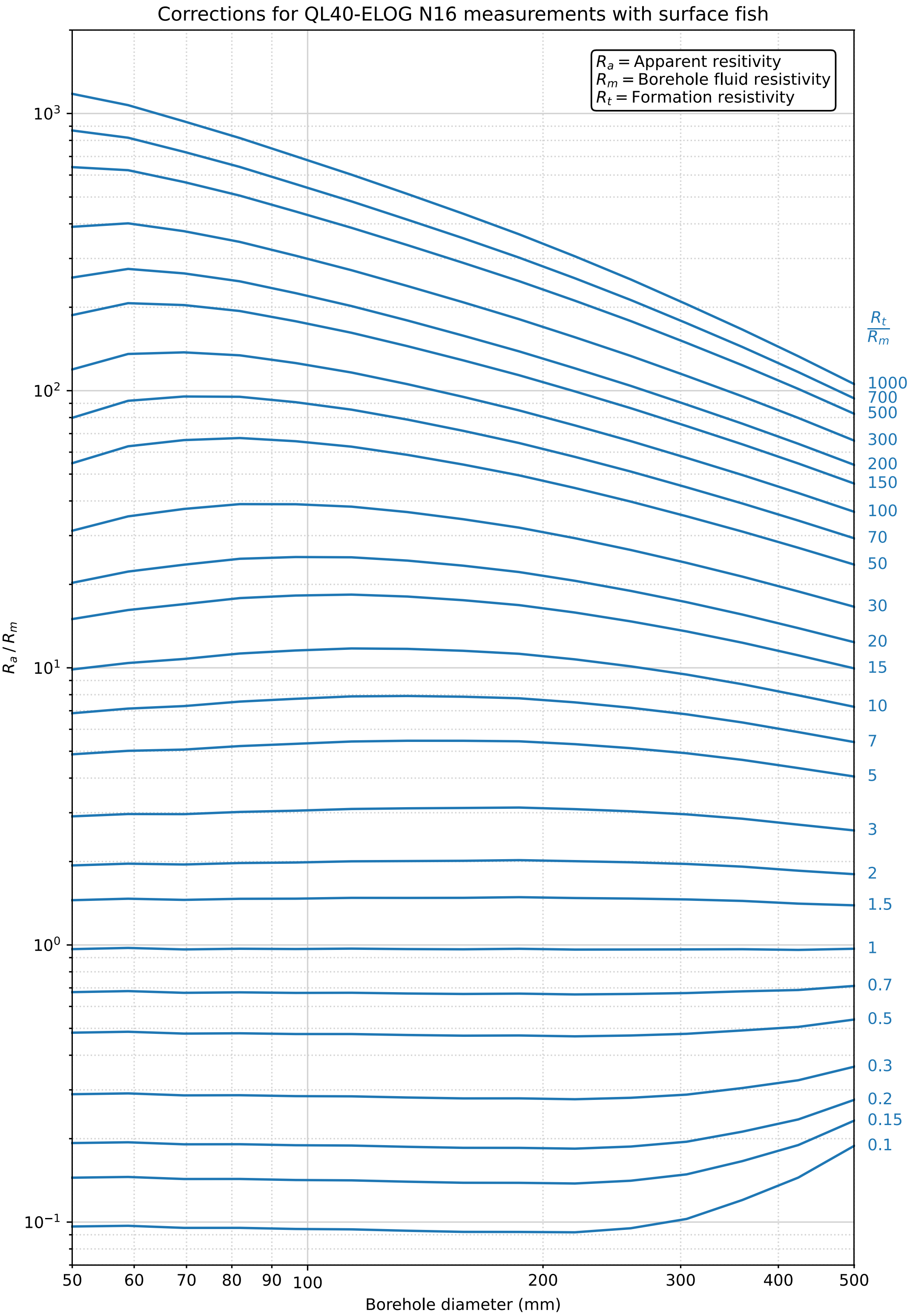

Corrections for QL40-ELOG N16 measurements with bridle
R_a = Apparent resitivity
R_m = Borehole fluid resistivity
R_t = Formation resistivity
R_a / R_m
10^3
10^2
10^1
10^0
10^{-1}
$\frac{R_t}{R_m}$
1000
700
500
300
200
150
100
70
50
30
20
15
10
7
5
3
2
1.5
1
0.7
0.5
0.3
0.2
0.15
0.1
50
60
70
80
90
100
200
300
400
500
Borehole diameter (mm)

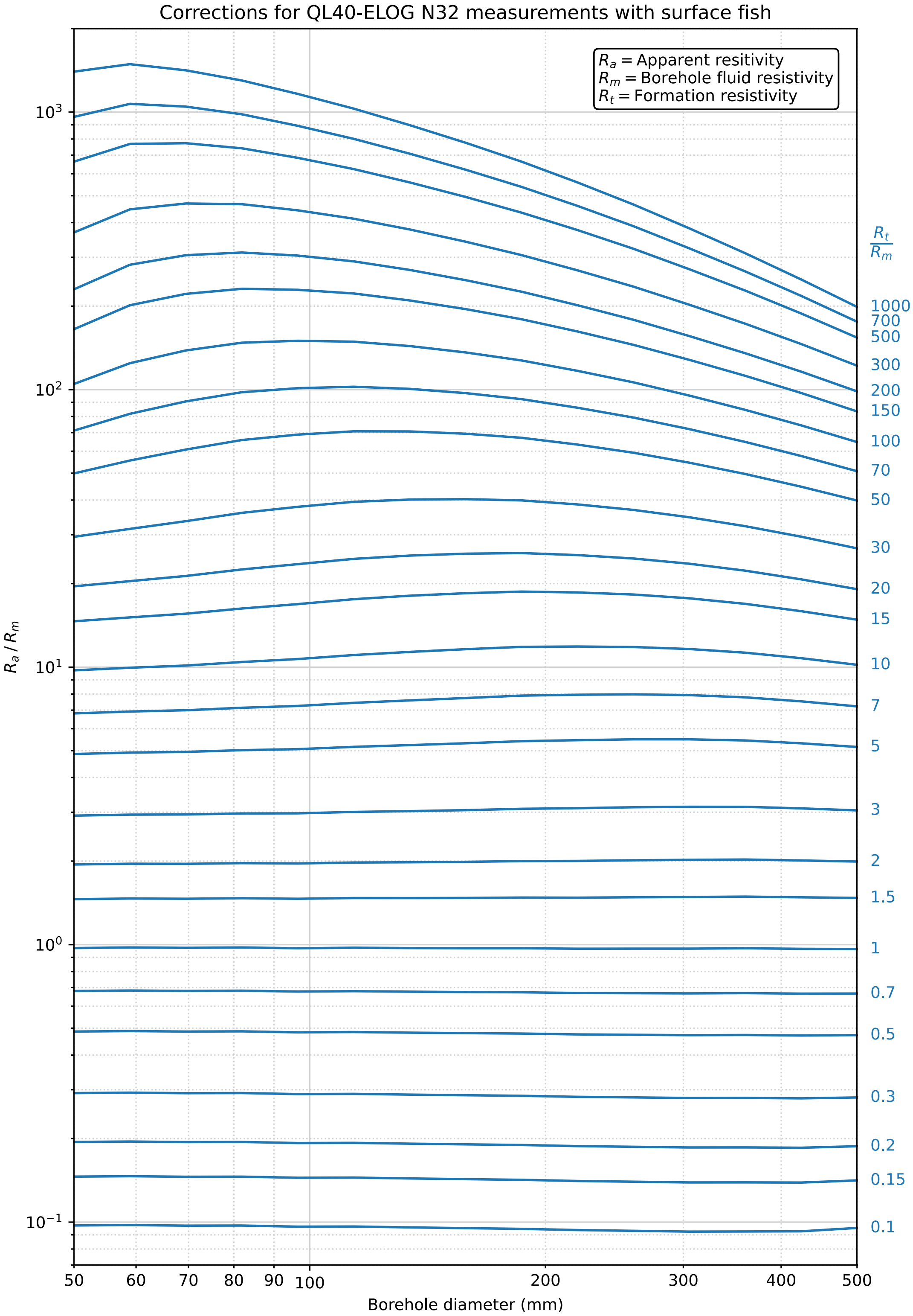

Corrections for QL40-ELOG N32 measurements with bridle
R_a = Apparent resitivity
R_m = Borehole fluid resistivity
R_t = Formation resistivity
R_a / R_m
10^3
10^2
10^1
10^0
10^{-1}
$\frac{R_t}{R_m}$
1000
700
500
300
200
150
100
70
50
30
20
15
10
7
5
3
2
1.5
1
0.7
0.5
0.3
0.2
0.15
0.1
50
60
70
80
90
100
200
300
400
500
Borehole diameter (mm)

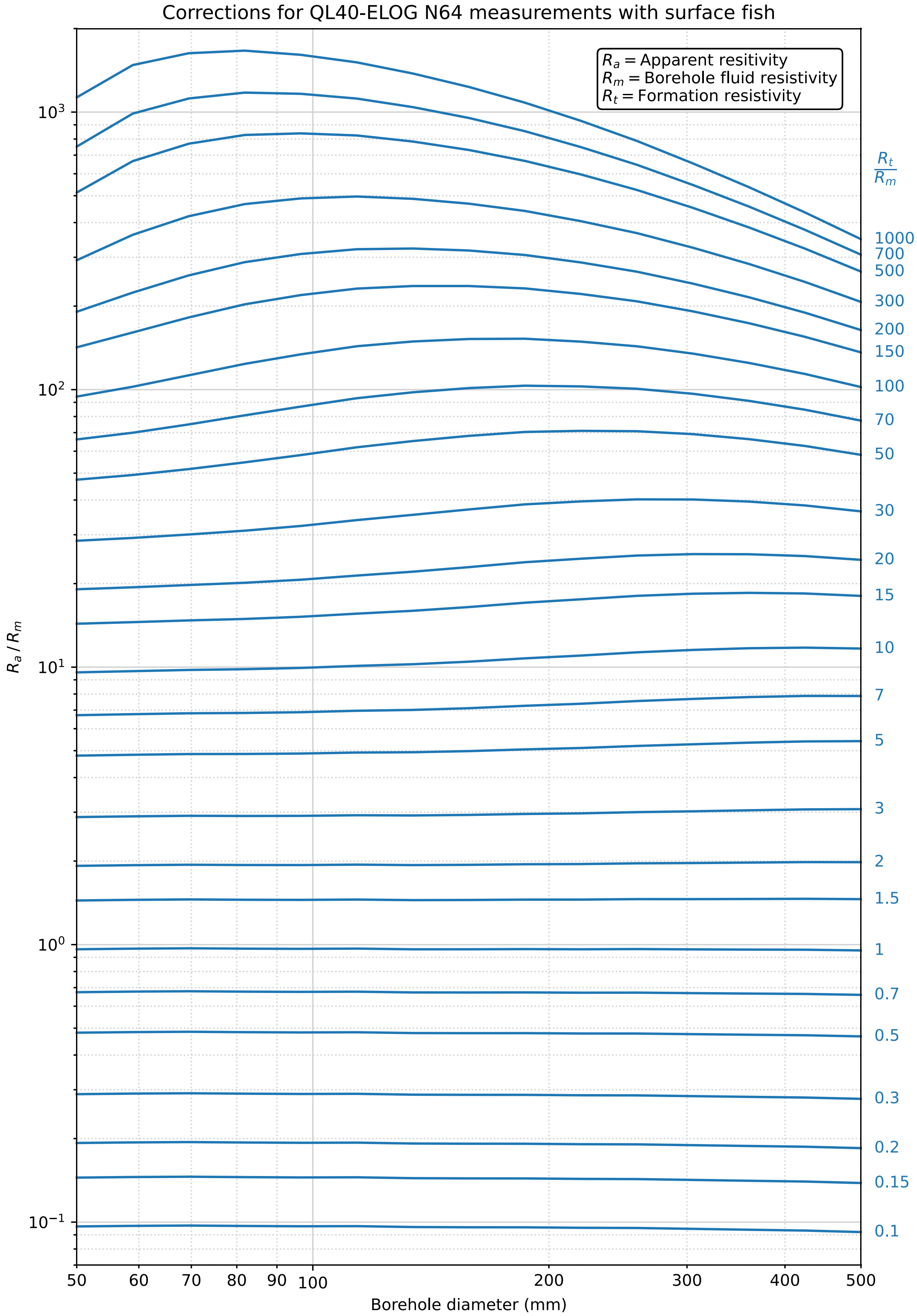

Corrections for QL40-ELOG N64 measurements with bridle
R_a = Apparent resitivity
R_m = Borehole fluid resistivity
R_t = Formation resistivity
$\frac{R_t}{R_m}$
1000
700
500
300
200
150
100
70
50
30
20
15
10
7
5
3
2
1.5
1
0.7
0.5
0.3
0.2
0.15
0.1
R_a / R_m
10^3
10^2
10^1
10^0
10^{-1}
50
60
70
80
90
100
200
300
400
500
Borehole diameter (mm)

8.2.2 Correction charts – Surface fish configuration




Corrections for QL40-ELOG N16 measurements with surface fish
R_a = Apparent resitivity
R_m = Borehole fluid resistivity
R_t = Formation resistivity
R_a / R_m
10^3
10^2
10^1
10^0
10^{-1}
50 60 70 80 90 100 200 300 400 500
Borehole diameter (mm)
$\frac{R_t}{R_m}$
1000 700 500 300 200 150 100 70 50 30 20 15 10 7 5 3 2 1.5 1 0.7 0.5 0.3 0.2 0.15 0.1


Corrections for QL40-ELOG N32 measurements with surface fish
R_a = Apparent resitivity
R_m = Borehole fluid resistivity
R_t = Formation resistivity
R_a / R_m
10^3
10^2
10^1
10^0
10^{-1}
$\frac{R_t}{R_m}$
1000
700
500
300
200
150
100
70
50
30
20
15
10
7
5
3
2
1.5
1
0.7
0.5
0.3
0.2
0.15
0.1
50
60
70
80
90
100
200
300
400
500
Borehole diameter (mm)


Corrections for QL40-ELOG N64 measurements with surface fish
R_a = Apparent resitivity
R_m = Borehole fluid resistivity
R_t = Formation resistivity
$\frac{R_t}{R_m}$
1000
700
500
300
200
150
100
70
50
30
20
15
10
7
5
3
2
1.5
1
0.7
0.5
0.3
0.2
0.15
0.1
10^3
10^2
10^1
10^0
10^{-1}
R_a / R_m
50
60
70
80
90
100
200
300
400
500
Borehole diameter (mm)

8.3 Parts list

Item No.	Qty	Part No.	Description
1	1	1673840	Silicone grease Molykote111
2	2	55459	DIN 1810B 40-42 Hook wrench w.pin
3	6	AS215-V-75°	Oring Viton shore 75° - 26.57 x 3.53
4	1	L0034-086	Grease Lubriplate

8.4 Bridle wiring configurations

8.4.1 QL40-IS4 bridle configuration for 4 conductor wireline

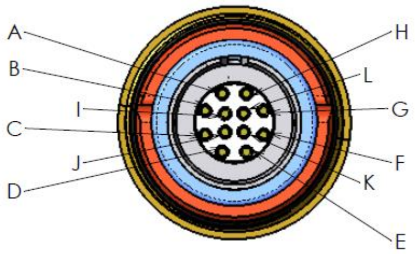


Figure 8-1 *Bridle bottom connection to tool*

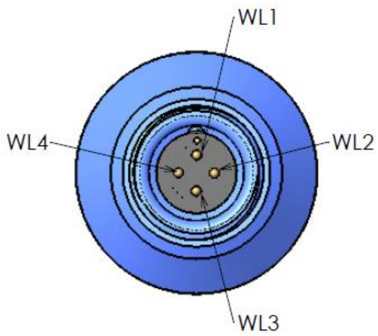
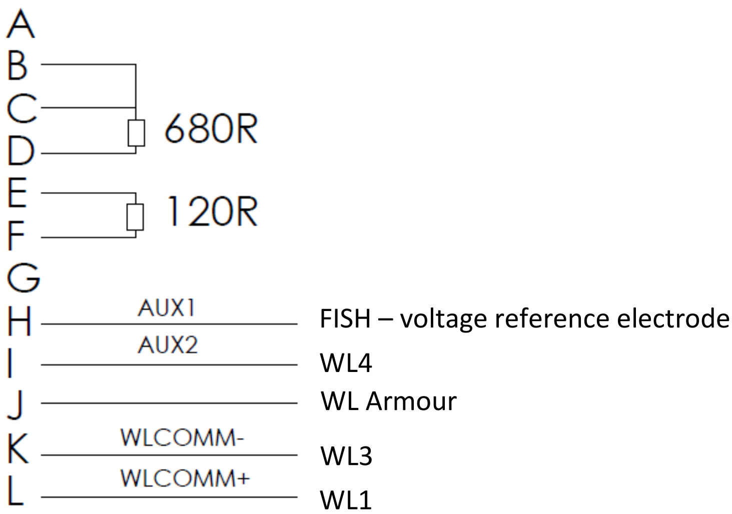


Figure 8-2 *Bridle top connection to cable head*



8.4.2 QL40-IS1 (MSI) and QL40-IS2 (GO1) bridle configurations for single conductor wireline

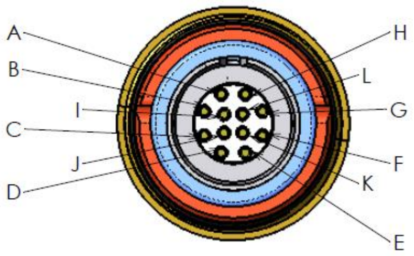


Figure 8-3 *QL40-IS1 and IS2 bridle bottom connection to tool*

Figure 8-4 *QL40-IS1 bridle top connection to cable head*

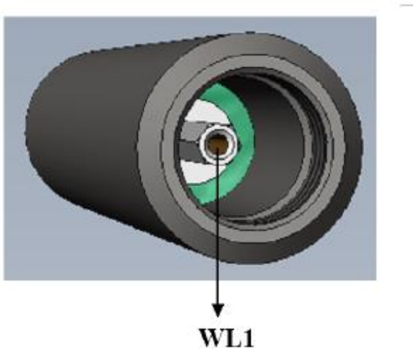


Figure 8-5 *QL40-IS2 bridle top connection to cable head*