

# User Guide

## QL40 ABI – Acoustic Borehole Imager





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# 1 General Information

The QL40 ABI is the latest generation of acoustic televiewer. Based on more than 10 years of experience and market leadership with BHTV technology, the new system consists of a completely redesigned acoustic sensor and new electronics. The electronic architecture uses a 14 Bit A/D converter directly coupled to a superfast 75 Mops DSP digital signal processor. The DSP is performing complex data processing operations in real time on each individual ultrasonic wave train and that allows a wider dynamic range of signal detection and easy field operation in a wide variety of logging applications.

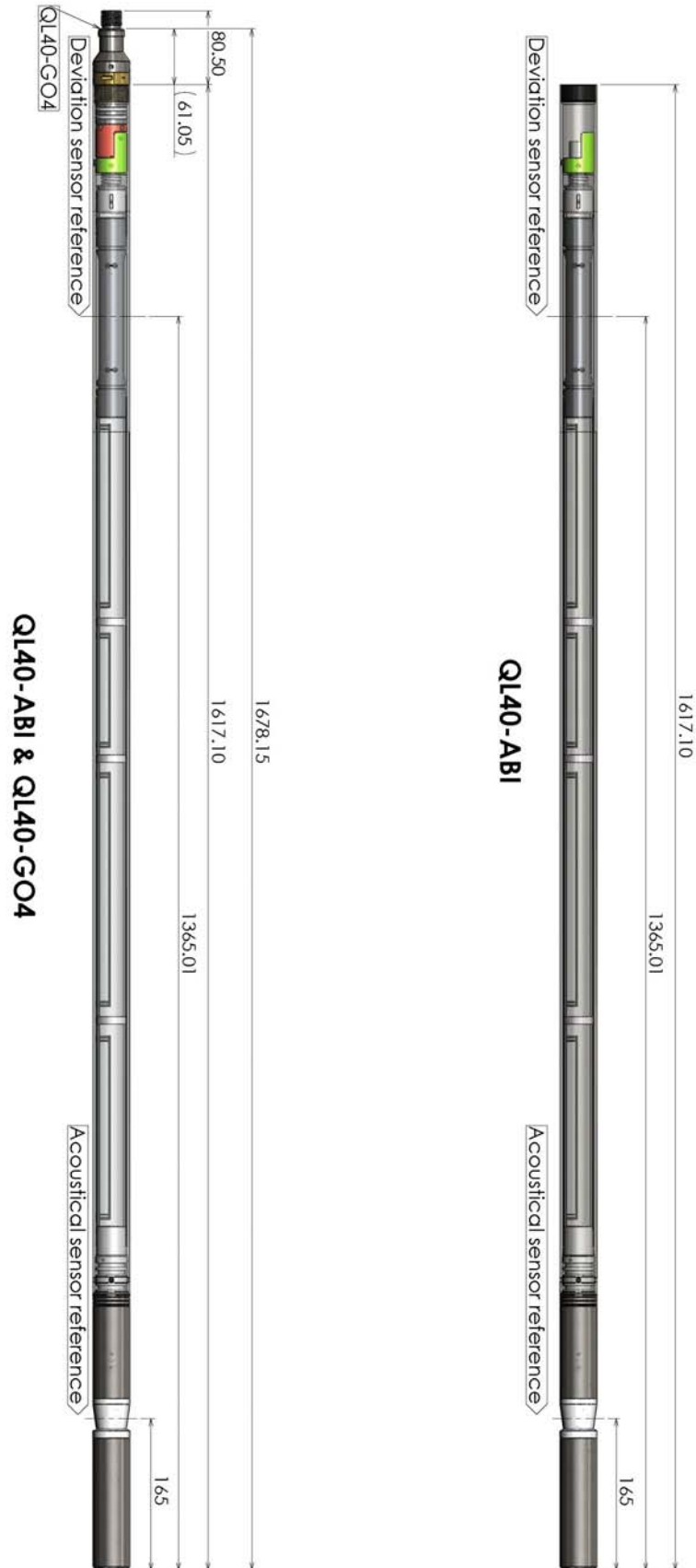
This QL40 ABI bottom sub has its own Telemetry board, Power supply element and A/D converter allowing the tool to be operated as a stand-alone probe (QL tool top needed) or in combination with other subs of the QL family.

## 1.1 Overview

Acoustic borehole scanner tools generate an image of the borehole wall by transmitting ultrasound pulses from a fixed transducer with rotating mirror and recording the amplitude - travel time of the signals reflected at the interface between borehole fluid and the formation (borehole wall). Compared to the older FAC40 model which measures a single echo, one amplitude and one travel time, the QL40 ABI has multi-echo capability. This is achieved by digitally recording the reflected acoustic wave train. On line analysis of the acoustic data is made by the DSP. Sophisticated algorithms allow the system to detect the reflection from the acoustic window and to separate and classify all subsequent echoes. Minimum input from the operator is needed to enable:

- Automatic or manual adaptation to variable borehole conditions.
  - Improved dynamic range of signal detection.
  - Very high travel time resolution.
  - The implementation of different operating modes. For example, when run inside PVC casing, the tool can record both the echo of the PVC casing and that of the borehole wall. With multi-echoes processing, application of the tool may be extended to steel casing thickness and corrosion evaluation.
- Tool upgrades and the implementation of customized operating modes can be done by simply downloading new firmware to the tool from the surface computer.

## 1.2 Dimensions



**Figure 1-1** QL40-ABI dimensions



### 1.3 Technical Specification

#### Tool

Diameter:	40mm
Length:	1.617m
Measurement point:	0.165m (from probe bottom)
Weight:	6.7 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:	ALTlogger – ABOX – Matrix

#### Acoustic sensor:



**Figure 1-2** Acoustic head

Acoustic sensor:	Fixed transducer and rotating focusing mirror
Measurement range <sup>1</sup> :	6" – 20" (150mm-500mm)
Focusing diameter <sup>2</sup> :	6" (152mm)
Frequency:	1.2 Mhz
Acoustic beam width:	3 mm
Rotation speed:	Up to 12 revolutions per second - automatic
Azimuthal resolution:	72, 144, 288 operator defined
Caliper resolution:	0.08mm

#### Orientation sensor:

Sensor:	APS544
Location:	Middle point of sensor located at 1.365 m from tool bottom
Orientation:	3 axis magnetometer, 3 accelerometers
Inclination accuracy:	0.5 degree
Azimuth accuracy:	1.2 degree

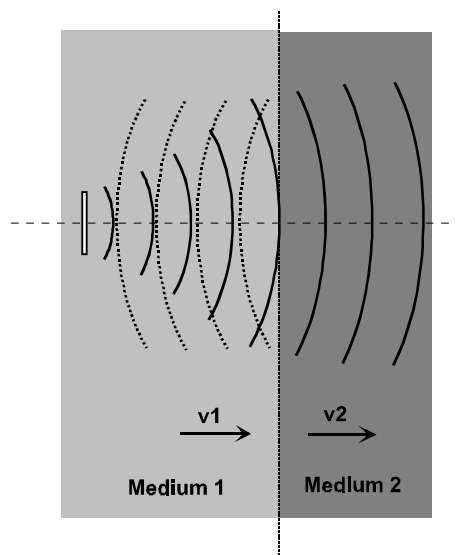
<sup>1</sup> Diameter range of the hole in which the measurement is possible.

<sup>2</sup> Diameter of the hole where the focusing of the acoustical beam is optimum.



## 2 Measurement Principle

An understanding of the basic principles of operation of the televiewer is essential for successful use of the tool. The QL40 ABI televiewer produces images of the borehole wall which are based on the amplitude and time of travel of an ultrasonic beam reflected from the formation wall. The ultrasonic energy wave is generated by a specially designed piezoelectric ceramic crystal and has a frequency of around 1.2MHz. On triggering, an acoustic energy wave is emitted by the transducer and travels through the acoustic head and borehole fluid until it reaches the interface between the borehole fluid and the borehole wall. Here a part of the beam energy is reflected back to the sensor, the remainder continuing on into the formation medium at a changed velocity (Figure 2-1). By careful time sequencing the piezoelectric transducer acts as both transmitter of the ultrasonic pulse and receiver of the reflected wave. The travel time for the energy wave is the period between transmission of the source energy pulse and the return of the reflected wave measured at the point of maximum wave amplitude. The magnitude of the wave energy is measured in dB, a unit less ratio of the detected echo wave amplitude divided by the amplitude of the transmitted wave.



**Figure 2-1** Wave propagation

## 2.1 Reflection coefficient

The strength of the reflected signal depends principally on the impedance contrast between the borehole fluid and the formation (Figure 2-1).

The reflection coefficient  $r$  is given by the following equation:

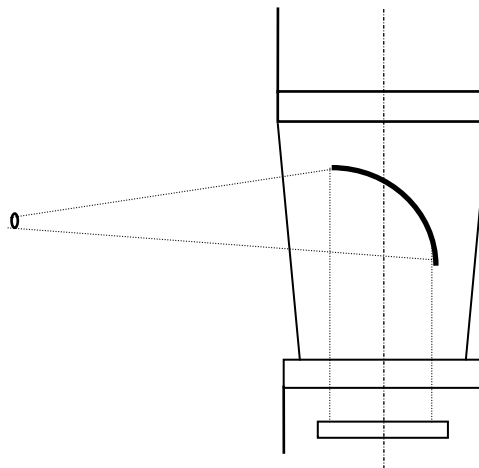
$$r = (\rho_b v_b - \rho_m v_m) / (\rho_b v_b + \rho_m v_m)$$

where  $\rho_b$  = density of formation  
 $\rho_m$  = density of borehole fluid  
 $v_b$  = velocity of sound of formation  
 $v_m$  = velocity of sound of borehole fluid

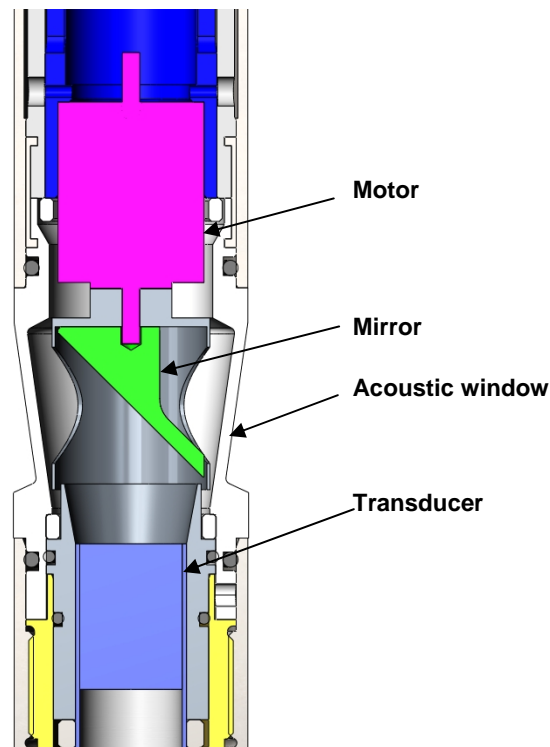
The larger the reflection coefficient is the greater is the signal reflection and thus the ability to detect the signal. From the equation above it may be seen that when the properties of the borehole fluid and borehole wall are similar, i.e.  $\rho_b v_b \approx \rho_m v_m$ , the reflection coefficient  $r$  approaches zero and there is negligible reflection. In this situation determination of the true reflected wave is made more difficult.

## 2.2 Acoustic head operation

The acoustic wave is generated by applying a high voltage pulse across the two faces of a piezo ceramic disc. The applied voltage causes deformation within the crystal structure, either an expansion or contraction depending on the polarity of the applied voltage, with a resultant energy wave emitted normal to the free surface. It has been shown that the beam generated by this process has a maximum energy at a distance of twice the diameter of the disc and that after this point the beam tends to diverge. In order to optimize the beam energy at the point of investigation the ALT televiewer head has been designed as illustrated below (Figure 2-2).



**Figure 2-2** Focussing arrangement



**Figure 2-3** Abi40 acoustic head architecture

The acoustic wave propagates along the axis of the tool body and is then reflected perpendicular to this axis by a special reflector that focuses the beam to a high-energy point of  $\pm 3$  mm diameter. The radial distance of the focal point from the axis of the tool is determined by the focal length of the mirror,  $\pm 75$  mm (for an acoustic head with a 6" focusing mirror).

The frequency of the transmitted wave is determined amongst other factors such as ceramic composition by the diameter of the piezo transducer, a smaller diameter giving a higher frequency. The ALT televiewer operates around 1.2 MHz.

The reflector is mounted on the drive shaft of a stepper motor. This enables the position of measurement to be rotated through 360°. Sampling rates of 72, 144 and 288 measured points per revolution are available, thus at maximum resolution a near continuous image of the borehole wall is made. The higher sampling rate can be used for better resolution in larger diameter boreholes but is less useful in small diameters due to overlap of the sampling points.



## 3 Notes on QL tool assembly

**QL** stands for **Quick Link** 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.

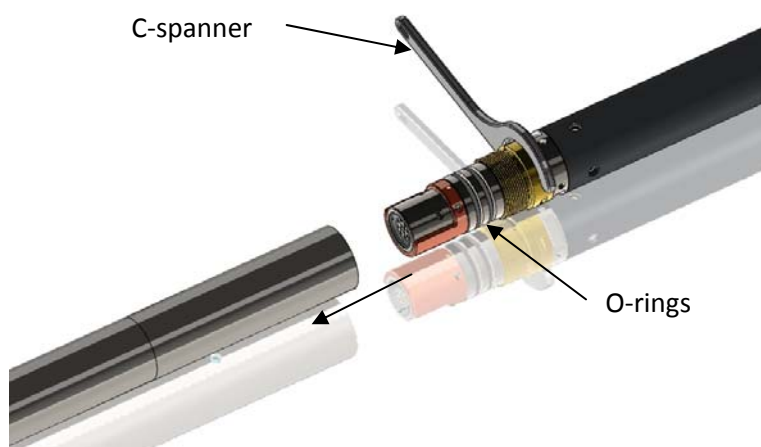
### Mid Sub

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

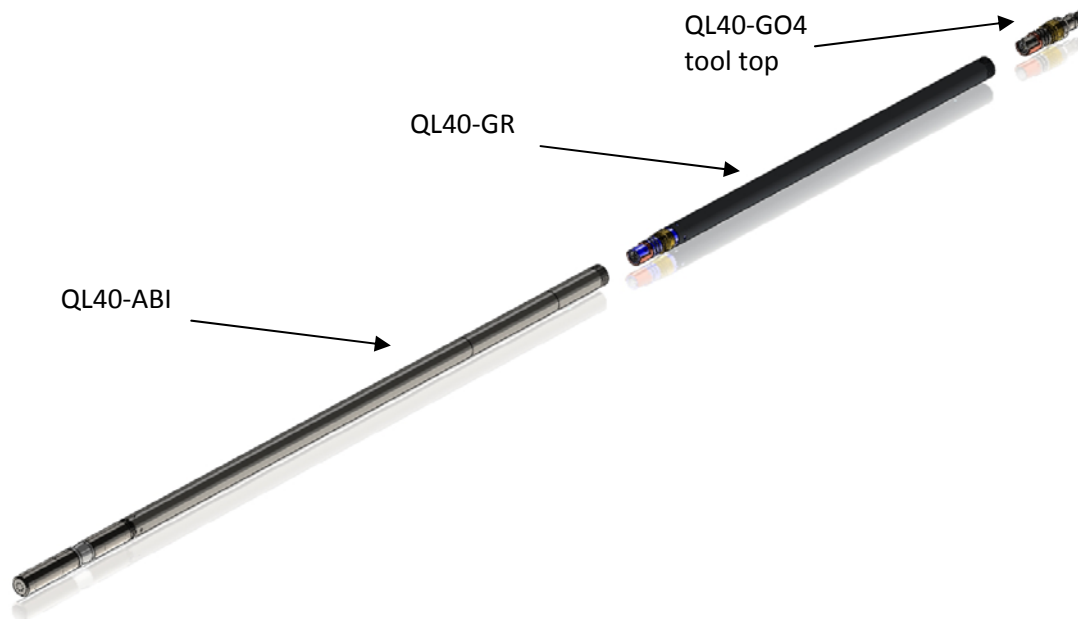
QL40 tool stacks are terminated by either a QL40 bottom sub or a QL40 bottom plug. At the top of the stack a QL40 tool top is required to connect the tool string to the cable head. Several tool tops are already available, special ones can be made on request.

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.



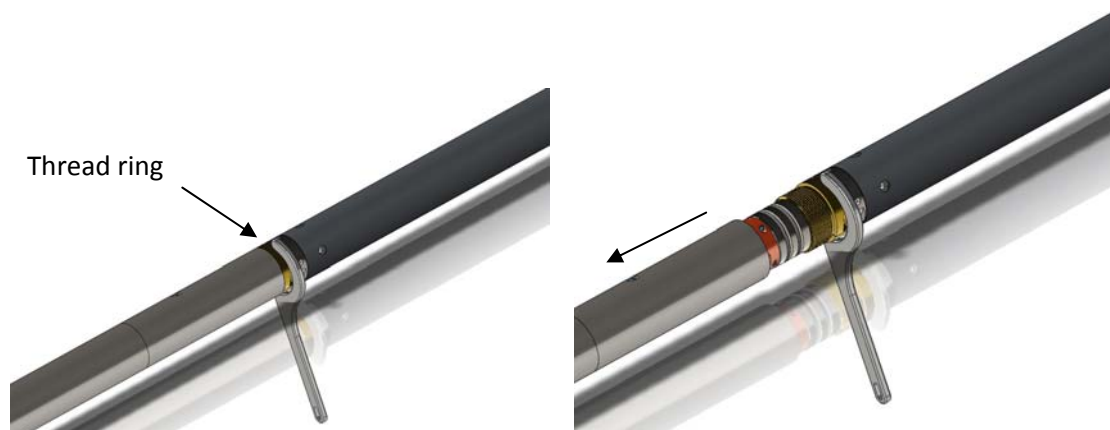
**Figure 3-1** C-spanner and O-rings of QL connection

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

### 4.1 Preliminary note

Acoustic televiewer image quality is highly dependent upon tool centralisation.

One set of centralisers is supplied with the QL40 ABI and is suitable for all tools with an external diameter of 40mm. The standard assembly comprises upper and lower mounting rings with sets of 3", 5" and 6" bowsprings. Two C spanners are provided for tightening the locking ring. Bowsprings for other borehole diameters are available on request.

The following points relating to the use of centralisers should be considered:

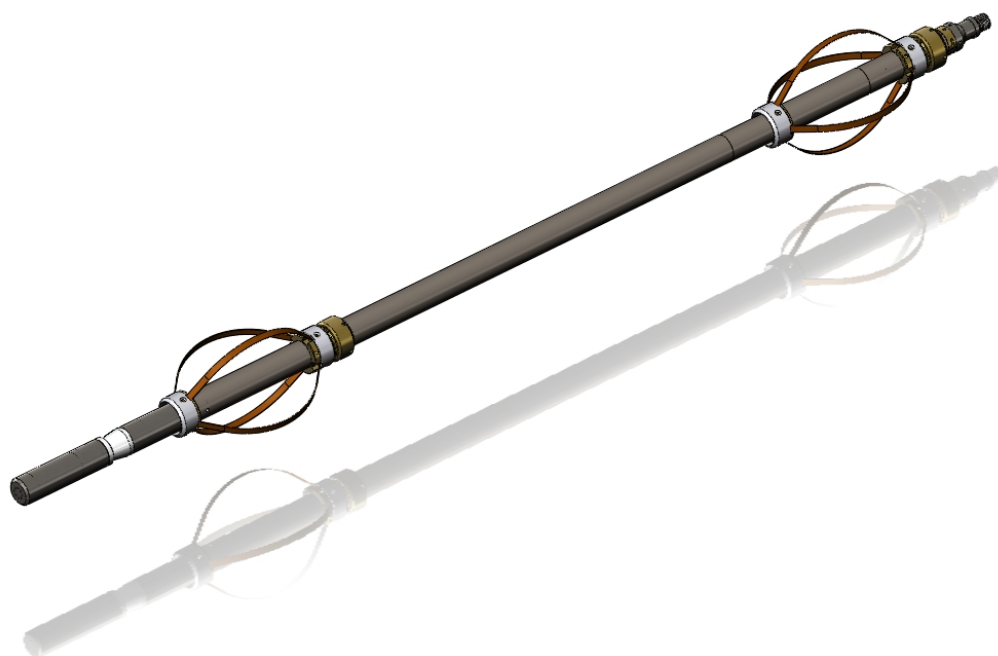
The centralisers should be fitted before mating the tool with the wireline cable head and should always be fitted from the cable head end to avoid damaging the acoustic window.

The compression ring of the centraliser, i.e. the one that is screwed tight, should always be fixed toward the **top** end of the sonde. This is to avoid catching on a downhole obstruction when winching up.

Use the C spanner to fasten the fixing rings but take care not to cross thread or over tighten them as this could damage the pressure housing

(The weak point of the bowsprings is the welded bearing pin. Take care during assembly as the weld can be broken by reverse bending.)

The QL40 ABI enables inspection behind PVC casing. In this situation, the PVC casing must be properly centred in the borehole and the tool correctly centralised in the casing to obtain satisfactory results.

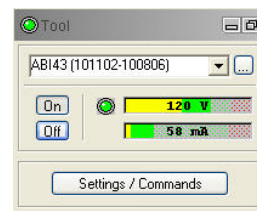


**Figure 4-1** QL40 ABI with mounted centralizers.

## 4.2 Quick Start

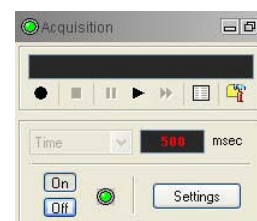
**Note:** Parts of the topics discussed in these sections below assume that the user is familiar with the data acquisition software. Refer to the corresponding operator manuals for more details. Information about assembly and configuration of tool stacks can be found in the same manuals.

1. Connect the QL40 ABI to your wireline and start the data acquisition software.
2. Select the relevant QL40 ABI tool from the drop down list (Figure 4-2) in the software's **Tool** panel (if your tool is not listed check that your tool configurations file is stored in the designated folder on your computer).
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.)



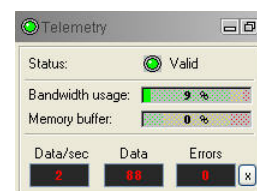
**Figure 4-2** Tool panel

4. On the **Tool** panel (Figure 4-2) click the **Settings / Commands** button to configure your tool for open hole/cased hole logging (see chapter 4.3 and 4.4 for details).
5. In the **Acquisition** panel (Figure 4-3) 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 4-3** Acquisition panel

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.
  - Verify motor status (synchronization) in MChNum browser is valid.



**Figure 4-4** 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.

### 4.3 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 4-5). 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.

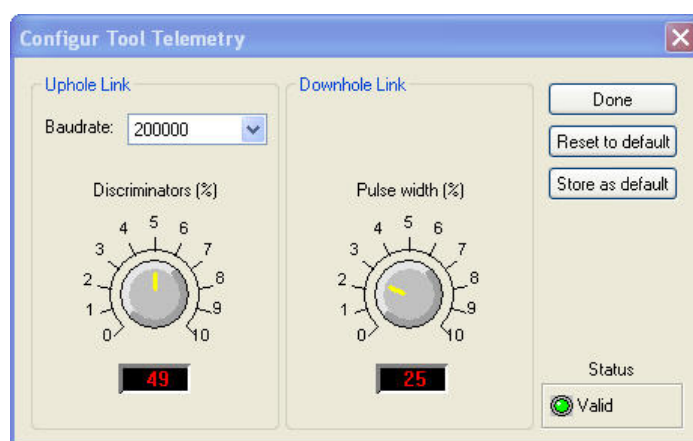


Figure 4-5 Tool communication settings

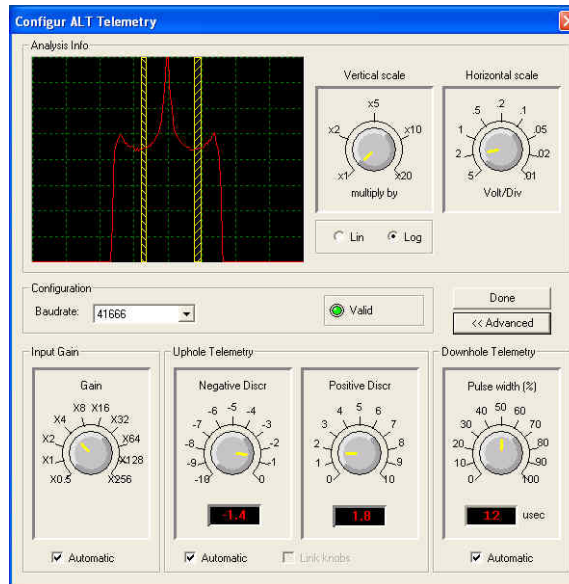
### 4.4 Tool Communication with MATRIX

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 4-6) 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 **linear / logarithmic** 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 4-6) 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 4-6** 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.

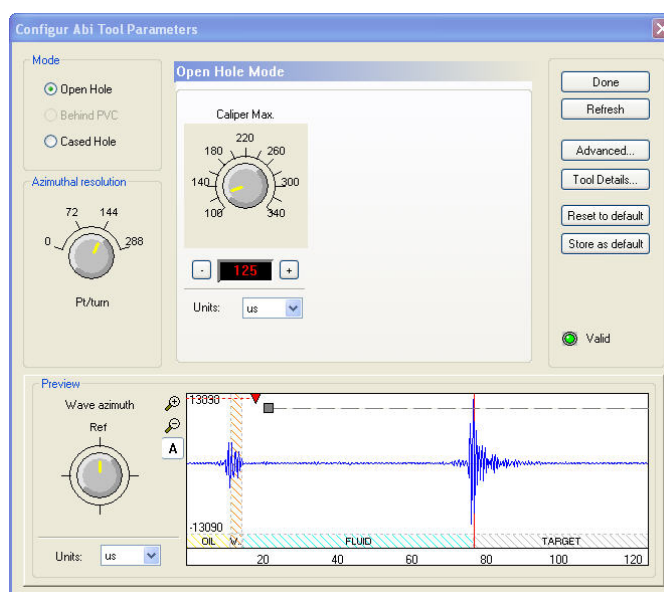
## 4.5 Configuring Tool Parameters

The **Configure ABI Tool Parameters** dialog box (Figure 4-7) can be accessed by clicking on the **Settings / Command** button on the dashboard’s **Tool** panel.

### 4.5.1 Azimuthal Resolution

The azimuthal resolution allows the operator to choose the number of points sampled per revolution of the tool sensor. Sampling rates of 72, 144 and 288 measured points per revolution are available.

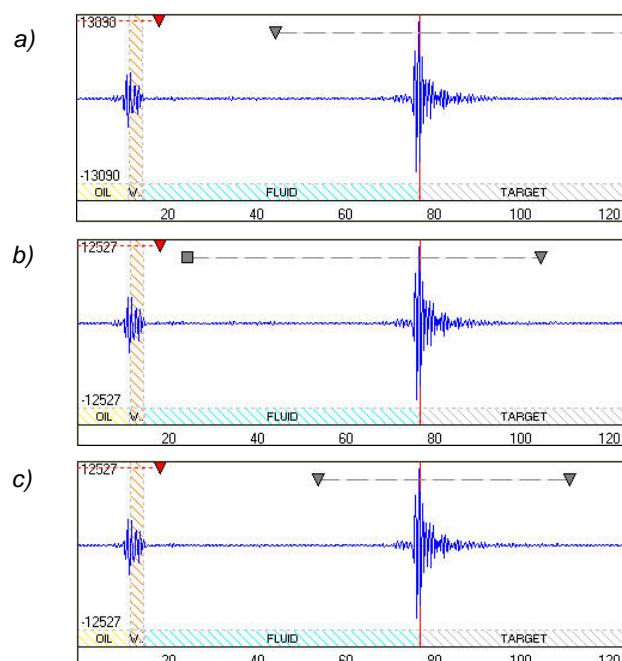
The higher sampling rate can be used for better resolution in larger diameter boreholes but it might be less useful in small diameter hole as it would cause an overlap of sample points. The speed of rotation of the focusing mirror is directly linked to the azimuthal resolution and echo mode chosen.



**Figure 4-7** Tool settings – Open Hole Mode (caliper scale here in  $\mu\text{s}$ )

### 4.5.2 Open Hole Mode Settings

This record mode is used in open-hole conditions or to record the inner face of a casing. Using the **Caliper Max** controls (Figure 4-7) the extension of the real time preview of the ultrasonic full waveform can be determined. Adjust the max. caliper settings to allow detection and recording of the main echo in all cases. The caliper limit and full waveform scale can be expressed in  $\mu\text{sec}$ , mm or inches.



**Figure 4-8 (a-c)** Acoustic full waveform preview

The waveform preview allows the user to adjust the limits of two gates – the Acoustic Window gate and the Echo Gate. The Acoustic Window is represented by a red dashed line while the Echo Gate is shown as gray dashed line (Figure 4-8 (a-c)). The tool firmware will record the strongest amplitude in the signal train within the Echo Gate and records

amplitude and taveltime. The Acoustic Gate allows determination of the tool's acoustic window reflection time.

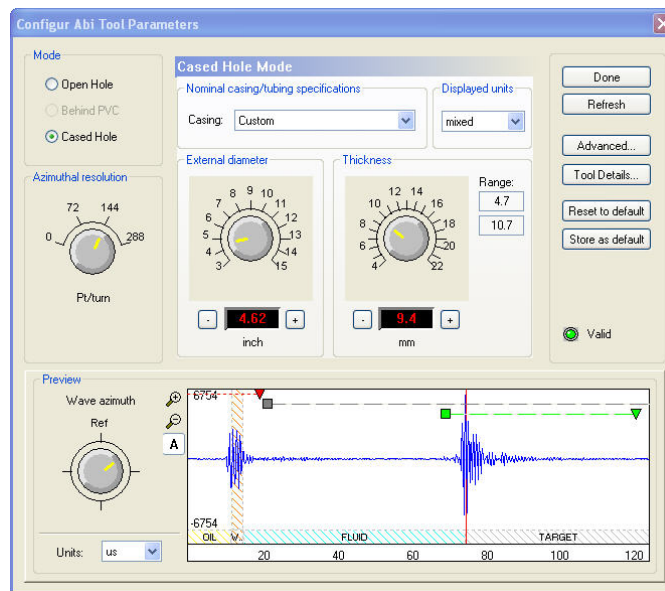
Echo limits can be determined automatically or adjusted interactively in the preview. Square and triangle symbols indicate whether the limits of the gates are automatically set (square or no symbol) or if the user can adjust the limit with the mouse cursor (triangle).

To toggle from automatic to manual mode click the **Advanced** button (see section 4.5.4 Advanced Settings).

The **Wave Azimuth** knob in the full waveform preview box (Figure 4-7) gives the possibility to display the ultrasonic wave train in a preferential direction other than the reference position of the mirror.

### 4.5.3 Cased Hole Mode Settings

This acquisition mode is used to perform casing thickness measurements and corrosion evaluation in steel casings.



**Figure 4-9** Tool settings dialog box – Cased Hole Mode

The operator will need to select from the dropdown casing list the nominal specifications of the casing under investigation (Figure 4-9). Casing external diameter and weight can be displayed in metric or imperial units. A mix of units is possible.

The position of the **External diameter** and **Thickness** knobs will be adjusted automatically according to the casing selected from the drop down list. When selecting **Custom** from the casing list, the operator has the option to enter external diameter and thickness settings manually.

The two **Range** values displayed next to the thickness knob are the measurement limits within which the system will compute the casing thickness.

In addition to the Echo and Acoustic Window Gates a third gate, the Thickness Echo Gate (green dashed line), is available for which only the end limit is user adjustable. Reduction of the gate length may be necessary if the ringing signal from the casing is superimposed by noise (e.g. multiples of the inner reflection) towards the end of the gate period.



#### 4.5.4 Advanced Settings

By clicking on **Advanced** in the Tool Parameters dialog box (Figure 4-7 or Figure 4-9) the operator has access to additional settings listed below:

##### Caliper settings (Figure 4-10)

The parameters shown in this dialog box are used to compute caliper values from recorded traveltime.

*Tool diameter (mm):* Default tool acoustic window diameter (read only).

*Blanking zone ( $\mu$ s):* Default blanked zone set before starting the detection of the acoustic window reflection (read only).

*Nominal window time ( $\mu$ s):* Default blanked zone set after the detection of the max amplitude and travel time of the acoustic window reflection. The system will look for the next useful echo (i.e. borehole wall, casing inner surface) after this nominal window (read only).

*Fluid velocity (m/s):* Fluid velocity constant used to convert the acoustic travel time from  $\mu$ sec to metric or imperial units. This value can be edited.

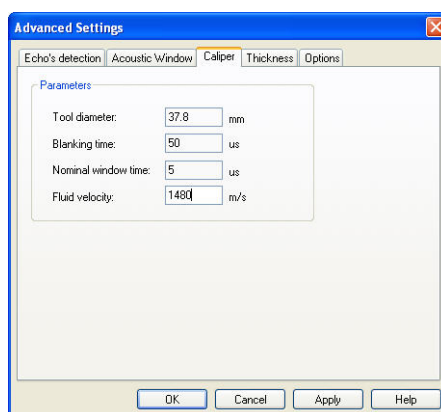


Figure 4-10 Advanced settings – Caliper

##### Echo Gate settings (Figure 4-11)

Select from the **Start Mode** and **Length Mode** drop down lists, to choose whether the Echo Gate limits (Figure 4-8 (a-c)) are controlled by the user or set automatically. If **Manual** has been selected triangular handles are displayed in the preview window which can be dragged with the mouse. It is also possible to edit the gate limits by turning the controls in this dialog box.

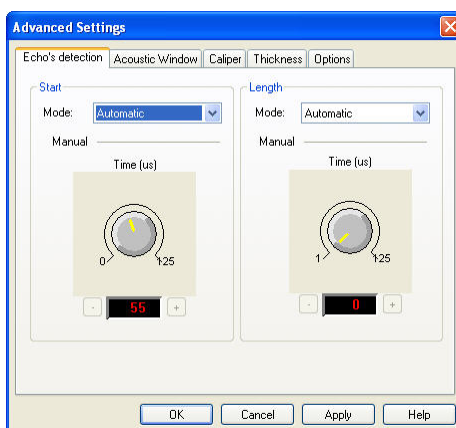


Figure 4-11 Advanced settings – Echo Gate

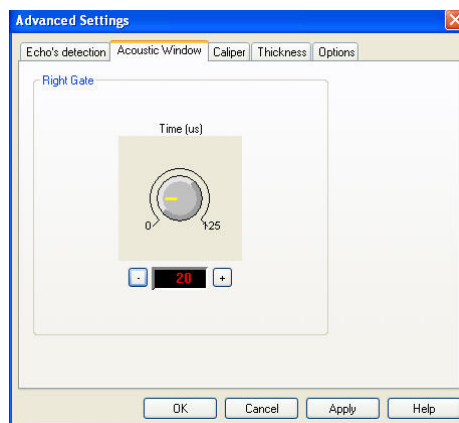
Three modes are supported to set the **Start** time of the Echo Gate:

- *Automatic*: The system will automatically detect and record the highest amplitude occurring after the Acoustic Window Gate and the upper limit of the Echo Gate (Figure 4-8 b). Automatic is the recommended setting.
- *Automatic Multiple*: The system will automatically adjust the start time of the Echo Gate so that the first multiple of the Acoustic Window reflection is skipped. This setting is useful for large diameter boreholes when the amplitude of the first multiple of the Acoustic Window reflection is higher and arrives earlier than the echo from the borehole wall.
- *Manual*: Manual adjustment of the Echo Gate start time is useful to exclude noise with amplitudes higher than the formation signal (e.g. exclude the reflection from the inside of a PVC casing).

Manual adjustment of the Echo Gate **Length** could be useful when noise with large amplitudes arrives towards the end of the gate period (e.g. exclude Acoustic Window reflection multiples when logging in soft formations).

#### Acoustic Window Gate settings (Figure 4-12)

The length of the acoustic window can be adjusted by the user dragging the triangular handle in the preview or turning the knob in this dialog box



**Figure 4-12** Advanced settings – Acoustic Window (Automatic mode)

The system will automatically pick the arrival time of the most dominant amplitude within the Acoustic Window Gate and will store the values in the WinTime channel.

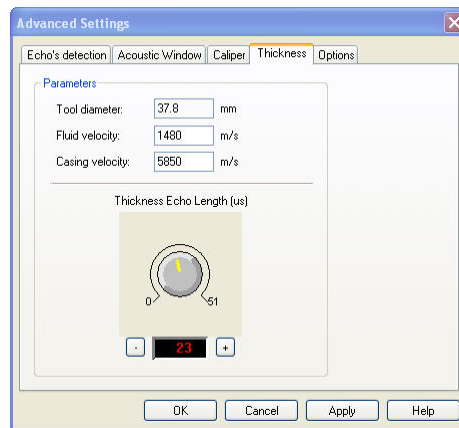
#### Thickness settings (Figure 4-13)

The parameters shown in this dialog box are used to compute thickness values from recorded traveltime.

*Tool diameter (mm)*: Default tool acoustic window diameter (read only).

*Fluid velocity (m/s)*: Fluid velocity constant used to convert the acoustic travel time from  $\mu\text{sec}$  to metric or imperial units. This value can be edited.

*Casing velocity (m/s)*: Steel velocity constant used to convert the acoustic travel time from  $\mu\text{sec}$  to metric or imperial units. This value can be edited.

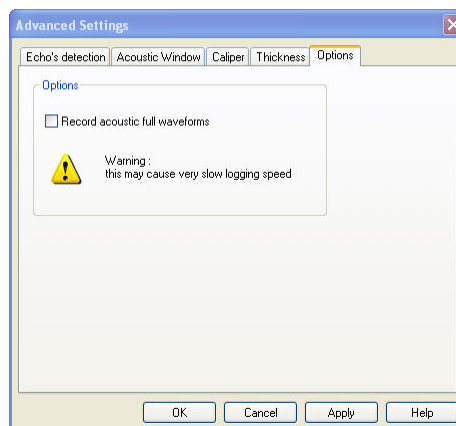


**Figure 4-13** Advanced settings – Acoustic Window (Thickness)

The length of the Thickness Echo Gate can be adjusted by dragging the triangular control in the preview or by turning the knob in this dialog box.

### Options settings

For diagnostic purposes the full waveform signal shown in the preview window can be recorded. As this will affect the performance of the system we do not recommend turning the recording option on during normal logging operation.

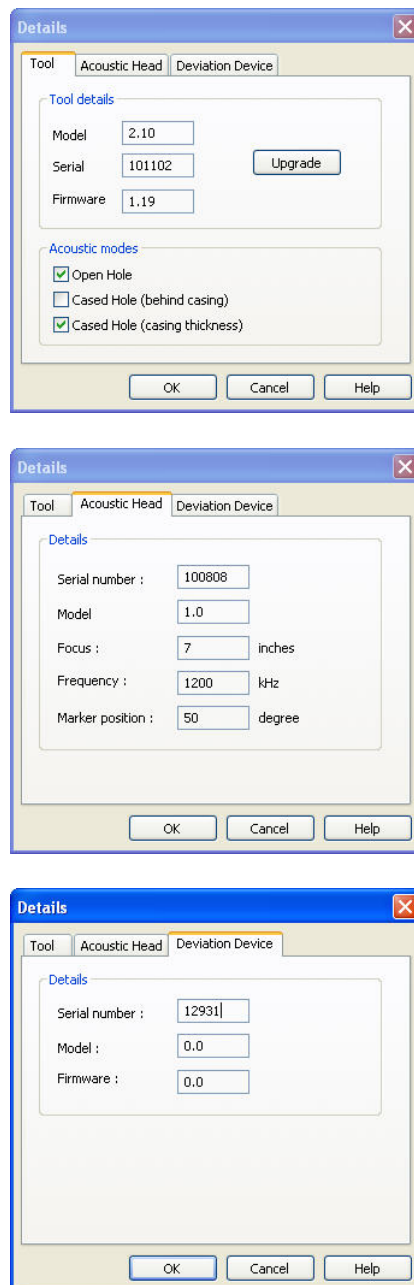


**Figure 4-14** Advanced settings – Options

### 4.5.5 Tool Details

**Note:** All information displayed in the following dialog box is read only and not editable.

By clicking on the **Tool Details** button in the **Configure ABI Tool Parameters** dialog box three tabs (Figure 4-15) become available summarizing serial numbers, acoustic details and firmware version of the tool. If necessary, newer tool firmware versions can be uploaded. The upgrade procedure will be explained in a later chapter.



**Figure 4-15** Tool details dialog box

## 4.6 Recorded Parameters and Browsers

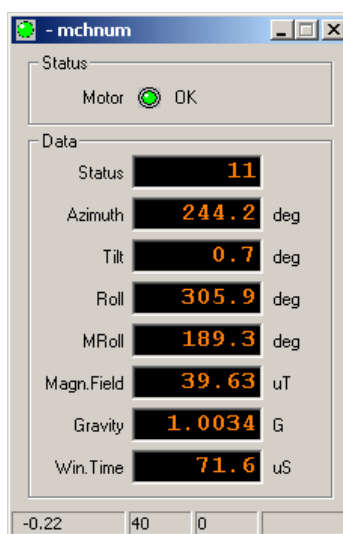
### 4.6.1 Recorded parameters

The following data channels will be recorded by the tool:

TravelTime (1 <sup>st</sup> echo):	Two Way Traveltime 1 <sup>st</sup> echo - $\mu$ sec
Amplitude (1 <sup>st</sup> echo):	Amplitude 1 <sup>st</sup> echo (NM = North Magnetic, HS = High Side)
TravelTime (2 <sup>nd</sup> echo):	Two Way Traveltime 2 <sup>nd</sup> echo - $\mu$ sec
Amplitude (2 <sup>nd</sup> echo):	Amplitude 2 <sup>nd</sup> echo (NM = North Magnetic, HS = High Side)
ThicknessTTime:	Two Way Traveltime within casing - $\mu$ sec
Score:	Quality Index for thickness signal detection
Azimuth:	Azimuth from Magnetic North – deg
Tilt:	Inclination from verticality – deg
RBR:	Orientation angle to High Side – deg
Roll:	Tool relative bearing calculated from accelerometers - deg
Mroll:	Tool relative bearing calculated from magnetometers - deg
Magn.Field:	Magnetic field surrounding the borehole - $\mu$ T
Gravity:	Absolute value of the Earth gravity – g
WndTime:	Two way traveltime of acoustic window reflection – $\mu$ sec
WndAmpl:	Amplitude of acoustic window reflection
VT CPU:	Sensor reading for CPU board temp. - volt
T CPU:	Temperature recorded on CPU board - °C
T APS:	Temperature inside the deviation sensor - °C
MotSpeed:	Motor - Speed of rotation – rps
Motor Status:	Diagnostic code
Motor Period:	Time for a single revolution – sec

### 4.6.2 MChNum Browser Window

Figure 4-16 shows a typical example of the numerical values displayed in the MChNum browser window during logging.



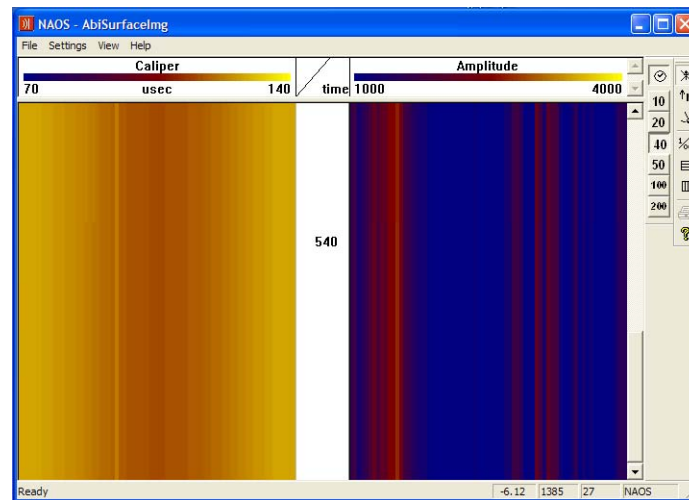
**Figure 4-16** Multi Channel Browser for Numerical Data (MChNum)

Motor:	Motor synchronisation status
Status	Tool record status
Azimuth:	Azimuth from Magnetic North - deg
Tilt:	Inclination from verticality - deg
Roll:	Tool relative bearing calculated from accelerometers - deg
Mroll:	Tool relative bearing calculated from magnetometers - deg
Magn.Field:	Magnetic field surrounding the borehole - $\mu$ T
Gravity:	Absolute value of the earth gravity - G
Win.Time:	Travel time of the acoustical window - $\mu$ s

### 4.6.3 Surface Image Browser Window (AbiSurfacelmg)

The system returns an unwrapped image of the borehole wall based on the caliper and amplitude of the recorded acoustic signal (Figure 4-17). The left column shows the caliper image and the right column the amplitude image.




These images consist of a succession of variable density colors. By double clicking on the log titles Minimum and Maximum scale values may be adjusted to enhance areas of interest.



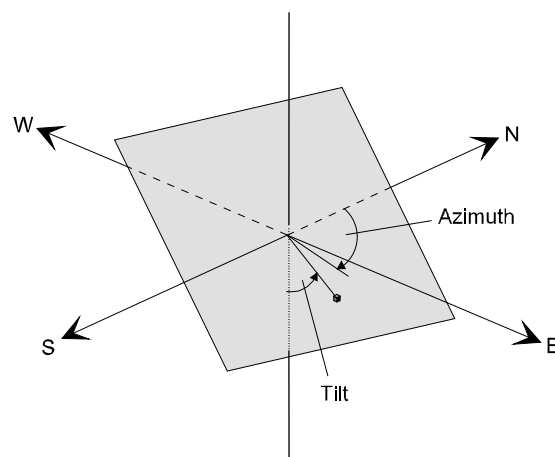
**Figure 4-17** QL40 ABI Surface Image browser window

Note that the displayed units for the caliper log can be converted to either metric or imperial units via the menu bar's **Settings** option or by double clicking on the log title.

#### Image orientation:






-  Image is non-oriented
-  Orient image to magnetic North
-  Orient image to High Side of the tool

There are two modes of tool data orientation: orientation to High Side and orientation to North. Orientation to High Side is used in inclined boreholes when magnetic data is unavailable (for example in a cased hole).



**Figure 4-18** Orientation to Magnetic North

### 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

#### 4.6.4 Thickness Image Browser Window (AbiThicknessImg)

In Cased Hole Mode, the ABI Thickness browser displays on the left column an unwrapped color coded image of the casing *thickness* processed by the system (Figure 4-19). The right column is a color-coded image of the *score*. The score is a *quality index* on the thickness measurement. In a general way, high score values mean high reliability of the thickness measurement and the reverse.

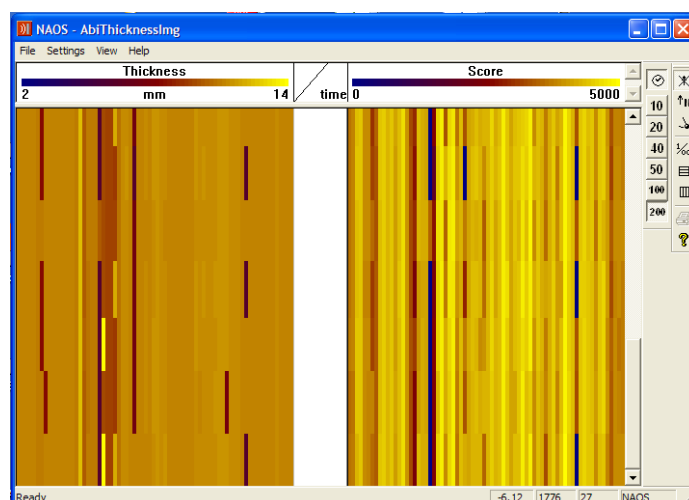


Figure 4-19 QL40 ABI Thickness Image

As for the Surface image browser, scales and units of the displayed parameters can be adjusted by double clicking on the log title or from the **Settings** option of the menu bar.

#### 4.6.5 Caliper Browser Window (AbiCaliper)

##### Caliper browser - Open Hole Mode

The open hole caliper view (Figure 4-20) shows in real-time a cross-section of the acoustic caliper. Scaling, concentric gridding and displayed units are adjustable from the tool bar "Settings" option.




The black circle shows the external limit of the acoustic window.

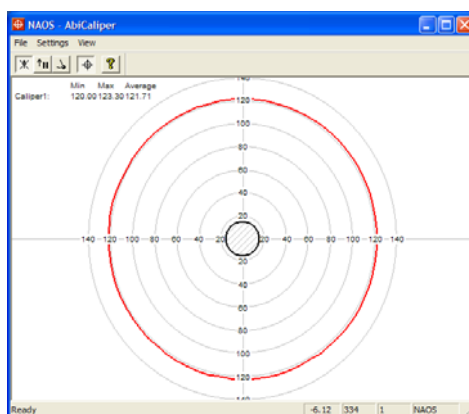
The red circle is the cross section of the acoustic caliper corresponding to the main reflector detected by the system (borehole wall or inner surface of a casing)

As for the image browsers, the caliper view can be oriented to Magnetic North, High side or displayed without orientation.

During the acquisition, it is possible to centralize the caliper cross section to remove the effect of decentralization of the tool in the borehole.

Clicking the symbol  can do this.

Statistical caliper figures (Min, Max, Average) are displayed on the left side of the dialog box.

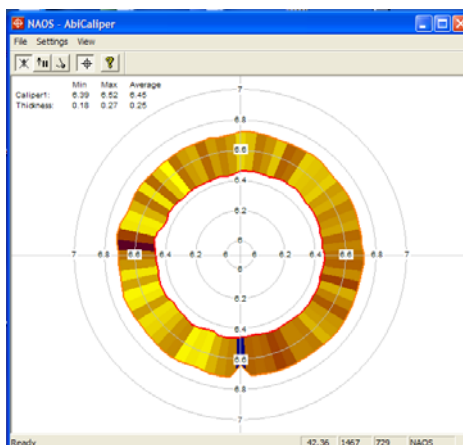


**Figure 4-20** QL40 ABI Caliper – Open Hole Mode

### Caliper browser - Cased Hole Mode

Cross sections of both of the inner (red circle) and outer (orange circle) surface of the casing are shown in this browser (Figure 4-21), giving a good visualization of the casing thickness in real-time. The space between the 2 circles is filled with the corresponding color coded score values.

Orientation, scaling, concentric gridding and displayed units are adjustable from the menu bar's **Settings** option.



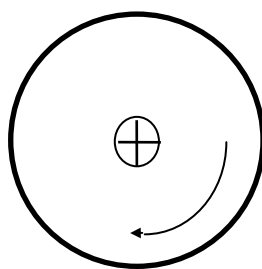
**Figure 4-21** QL40 ABI Caliper – Cased Hole Mode

## 5 Performance Check & Calibration

### 5.1 Mirror rotation

Direction of motor rotation is **clockwise viewed from top of tool** (Figure 5-1):

Placing 2 fingers<sup>3</sup> on the acoustic window may check mirror rotation. In time mode, record the 2 finger traces shown<sup>4</sup> on the Abi surface browser. Remove your right finger from the acoustic window; the corresponding right finger trace on the Abi surface image should disappear.



*Figure 5-1 Direction of mirror rotation*

### 5.2 Functionality test of the deviation system

#### 5.2.1 Functionality test

The QL40 ABI's deviation system is factory calibrated and does not require further calibration.

The functionality tests subsequently described have to be done to check that the tool is giving the correct deviation outputs:

To verify inclination at 0° and 90°, position the probe vertical (acoustic head pointing down) for 0° inclination and horizontal for 90° inclination. Note that uphole measurement is possible with the APS544 deviation system as it includes 3 accelerometers. In uphole, the inclination will be between 90° and 180° (probe vertical, acoustic head pointing up).

To verify azimuth accuracy, a good compass and an area free of magnetic materials must be used. Use a compass to orient North with the probe horizontal and verify that the azimuth reading is  $0^\circ \pm 1^\circ$ . Repeat the procedure for East, South and West directions.

#### 5.2.2 Rolling test – azimuth and tilt check

Azimuth and tilt could 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  $\pm 2.5^\circ$  and a deviation of the tilt less than the limit  $\pm 0.5^\circ$ .

<sup>3</sup> Wet your fingers first for a better coupling

<sup>4</sup> Adjust the amplitude scale to enhance the finger traces

### 5.3 Marker Position

The marker position is the angular value between the reference Y deviation axis, and the first trace recorded by the tool.

The acoustic head contains a coil sensor that detects a passing magnet for each rotation of the mirror drive. The synchronization pulse generated by this allows the tool micro-controller to monitor rotation speed against number of samples and determine whether or not the acquired data is valid. The sensor is physically positioned during assembly to be close to either 0° or 180° from the measuring zero point, the +Y axis. However, it is necessary to verify exactly this position and record it in the \*.sub file of the acoustic head to obtain the correct orientation of data. This procedure must be redone if maintenance operations have been made on the acoustic head.

A reference mark is engraved on both ends of the tool pressure housing to indicate the direction of the +Y axis (Figure 5-2).



**Figure 5-2** Pressure housing – reference mark

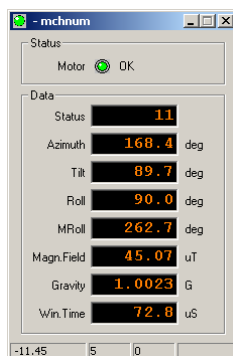


**Figure 5-3** Marker jigs

To check the marker position two support jigs are needed, one square and one a half square in section as shown in Figure 5-3. Each of the jigs must have a 40mm diameter hole centered on the intersection of the vertical and horizontal centre axis. The square section jig must have a square pin mounted on it with one edge of the pin at a radius of 28mm from the hole centre, and on the vertical axis of the hole when the jig is placed on edge. This jig also needs a locking screw to clamp the jig to the tool body. Slide this jig over the bellows cover of the

acoustic head until the pin is positioned above the plastic window. The second jig is used to support the other end of the tool.

With the tool on a flat, exactly horizontal surface held in the two support jigs and the logging software with the Mchnum browser running, rotate the tool until the Roll display shows 90°. (Figure 5-4).



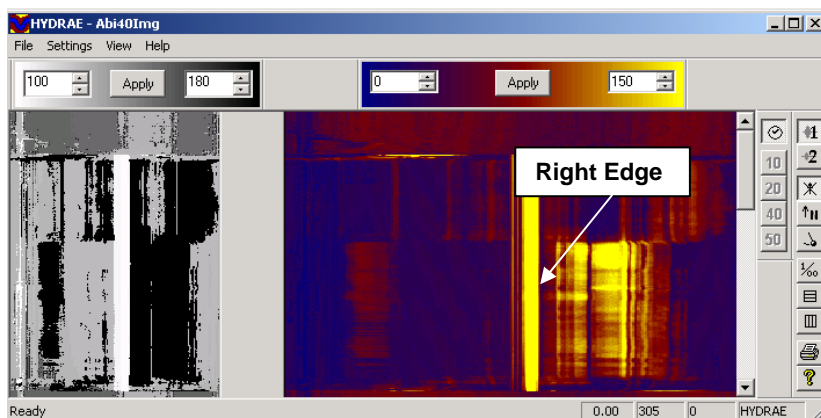
**Figure 5-4 Mchnum browser – Roll 90°**

The jig holding the pin must then be locked in position with the screw – without damaging the head! Remove or lock the second support jig and suspend the tool vertically in a bucket of water (Figure 5-5).



**Figure 5-5 Tool vertically suspended**

Adjust the window settings so that the pin is visible, normally default values will do but be careful that your image is not a window reflection.



**Figure 5-6 Travel time and amplitude images**

Record a file in time mode. Leave the tool suspended for a later verification. Import the data file into WellCAD selecting no orientation when prompted in the Import options dialog box.

Use the Tabular Editor and look for the angular position of the edge of the pin's reflection (alternatively select the log title and move your cursor over the data observing the amplitude and azimuth values displayed in the lower left edge of the WellCAD window). Be sure that it is the right side of the pin in relation to mirror rotation! Both the Travel Time and the Amplitude images can be used to determine the correct angle. Use the new value and update the MarkerPos parameter in the \*.sub file of the acoustic head.

Having completed the calibration, verify the new settings by orienting the tool using a compass such that the marker jig pin is approximately aligned to North. With orientation to North selected in the ABI40Img browser, i.e. North at the left of the plot, you should find that the edge of the pin is now close to the extreme left hand edge of the plot with the bulk of the pin showing on the extreme right. If so you have correctly set the value. If the pin is in the middle of the plot you are 180° out.

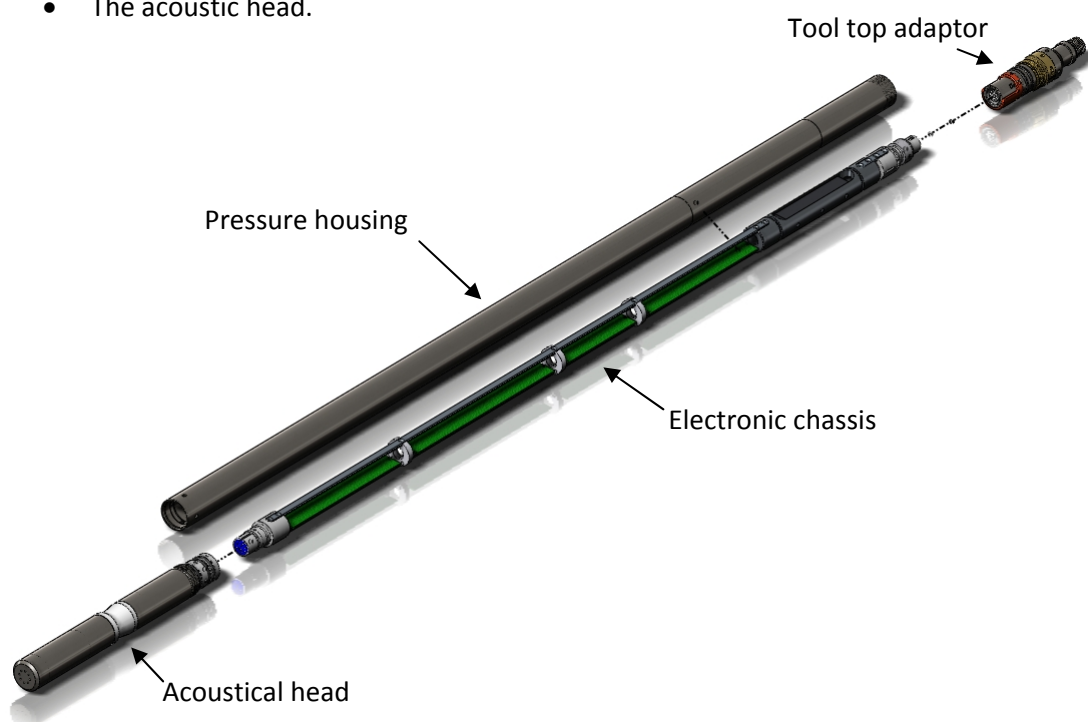
## 6 Maintenance

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

The QL40 ABI televiewer is a delicate instrument and should be treated with care at all times. Excessive shock or extreme temperatures should be avoided and the tool should always be transported in its transport case or a similarly cushioned enclosure. Never support the tool on the acoustic head. Experience shows that with attention to these points the QL40 ABI will give several years fault free operation.

The QL40 ABI televiewer separates into four basic parts

- The tool top adaptor
- The pressure housing
- The electronic chassis
- The acoustic head.



**Figure 6-1** QL40-ABI and QL40-GO4, exploded view

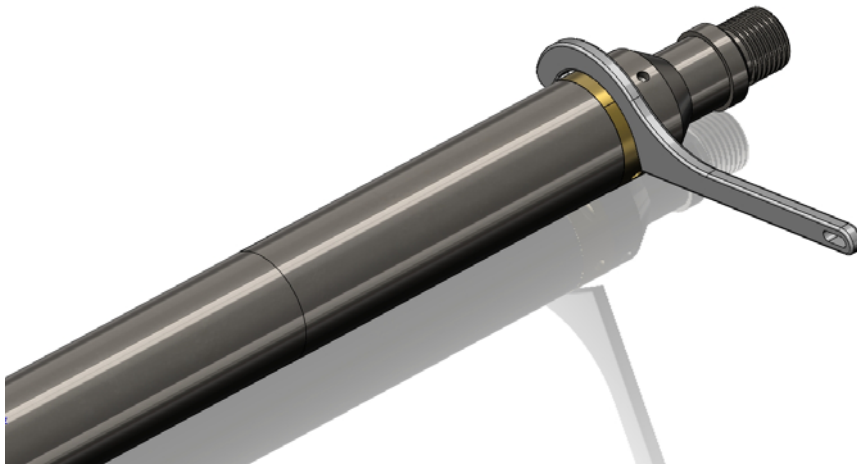
Should it become necessary to open the tool, the tool parts must be separated in the following sequence:

1. Remove the tool top adaptor
2. Remove the acoustic head
3. Remove the pressure housing

Disassembly of the electronic chassis from the pressure housing should never be attempted in the field.

## 6.1 Tool Top Adapter

The tool top adapter provides the connection between wireline cable head and chassis electronics and can be provided to suit 7 conductors, 4 conductors, mono or special wireline configurations. The adapter is fixed by the means of a threaded ring screwed in the pressure housing. To remove the tool top adapter, use the correct C spanners provided with the tool - see picture below (Figure 6-2).



**Figure 6-2** Removing the tool top

The wireline cable head socket and tool top adapter connector pins should be checked for cleanliness before each use of the tool. The pin inserts, whether 4 or 7 pin, have a locating mark indicating WL1 or A that should line up with the slot mating with the cable head.

Check O-Ring seals and apply silicon grease before re-assembly. Silicon grease of a similar type to RS Components Ref 494-124 is suitable for this and other O-Ring seals.

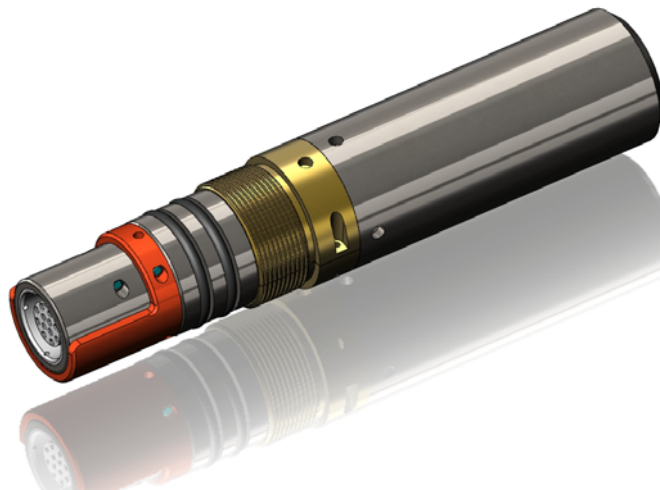
*(Rem: O-Ring reference for tool top and for the quick link 40 is AS215 26,57 x 3,53 Viton Shore 75)*



**Figure 6-3** QL40-GO4 Tool top adaptor



**Figure 6-4** QL40-G07 tool top adaptor



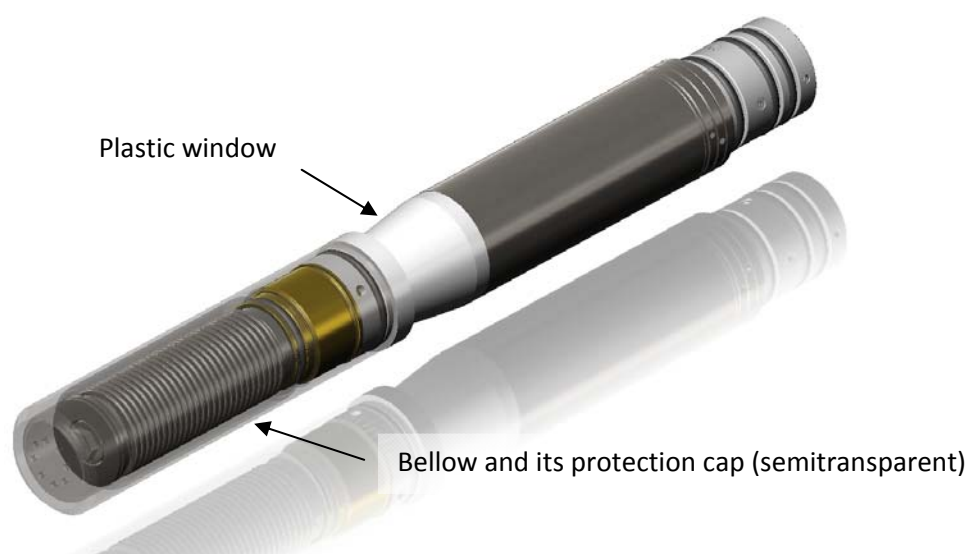
**Figure 6-5** QL40-G01 tool top adaptor



## 6.2 Acoustic head

**Warning: The televiewer acoustic head is extremely delicate and must be treated gently at all times. Any laterally applied force on the end of the head is liable to cause damage!**

The acoustic head is attached to the electronic chassis of the sonde by three 2.5mm hex set screws. To remove the entire televiewer head the tool top and pressure housing must first be removed as described below. Slacken off the fixing screws and slide the televiewer head off the connector. The connector has a keyway to locate the head with the correct orientation.



**Figure 6-6** Acoustical head

Re-assembly is the same procedure in reverse order, but taking care not to force the head on to the connector. This will result in bent or broken connector pins! Check all “O” ring seals (Orings AS215, 26.57x3.53, viton, shore 75) and apply silicon grease to them.

The acoustic head needs to be properly maintained to give the best image results.

Note the following points:

- Check that there are no air bubbles visible in the acoustic window. Air can separate out of the oil filling the head, notably after airfreight at low pressure, and can also work its way out of the inner parts of the motor. The presence of air in the head is indicated by a spotty image or streaking. These effects may come and go as the orientation of the tool is changed.
- Check that there is not excessive lateral movement on the end of the head. The bellows cap must be screwed up against the acoustic window but not excessively tight.
- If the acoustic signal is lost, check for isolation between pins A&B in the acoustic head. The most common reason for loss of signal is the cutting of the signal coax to the transducer in the head. This happens when the window is rotated relative to the head body. Check with a gentle twisting motion that the window does not rotate more than a degree or two relative to the tool body.

- At very low temperatures the oil in the acoustic head becomes viscous and this may prevent the mirror from rotating. In this case keep the tool and head warm before use.

### 6.2.1 Cleaning the acoustic head bottom section

The bottom section of the televiewer assembly houses a pressure compensating bellows that must be free to move. For this reason the bellows cover is removable to allow cleaning of the exterior of the bellows. The interior of the bellows and main body of the televiewer head is oil filled. Both, the end of the bellows cover and its side wall, have holes to allow pressure equalization, and these holes must be kept clear. The bellows cover is threaded at the top end and held by a screw thread on the main body below the nylon window. The cover should only be **hand tightened**.

Keep the bellows section clean. This will prevent the deterioration of glue seals and the bellows itself. Grit lodged in the folds of the bellows can cause perforation if left over a period of time.

When removing the cover, it is important to **hold the nylon mirror section only**, which is locked integrally with the main tool, while unscrewing the cover. Wrenches must **NOT** be used (Figure 6-7 and Figure 6-8).

---

**Warning: Any Rotation of the nylon section relative to the main tool pressure housing will result in damage to the head and probable tool failure. (The outer casing to the motor section of the televiewer head, i.e. between the nylon and main pressure housing, is free to rotate on "O" ring seals and is not locked with the nylon mirror window section.)**

---

The necessity for cleaning will depend on the borehole fluid and borehole conditions. The bellows should only be cleaned when the sonde was used in heavily contaminated fluids, i.e. heavy muds or sediments, or when the fluid is known to be corrosive. In this case it is important to clean deposits off the bellows where it is glued to the flanges at either end. The bellows wall is thin and can become perforated if allowed to corrode.



*Figure 6-7 Unscrewing the bellows cover*



**Figure 6-8** Bellows cover removed

### 6.3 Pressure Housing

The main pressure housing is locked on to the televiewer head by four 2.5mm hex cap screws. After removal of the tool top, the pressure housing can be removed after undoing these screws. When separating the two parts, place the tool on suitable stands, grip the pressure housing with one hand and the acoustic head close to the joint with the other and apply a straight pull. During re-assembly extreme care should be taken not to over tighten the fixing screws which may shear off if overloaded!

The outside of the pressure housing is marked with a Y symbol to indicate the position of the Y axis vertical and upward. The purpose of this is to simplify tool checking.

When re-assembling the pressure housing make sure that the reference mark is correctly aligned with the upper side of the deviation sensor.

### 6.4 Upgrading QL40 ABI firmware

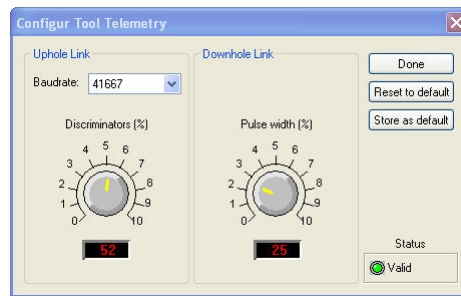
In accordance with the ALT policy of continuous development the QL40 ABI has been designed to allow firmware upgrades. The current version of firmware installed in a tool may be verified in the Tool Details window opened from the Tool Settings dialogue box.

Firmware upgrade procedure is as follows:

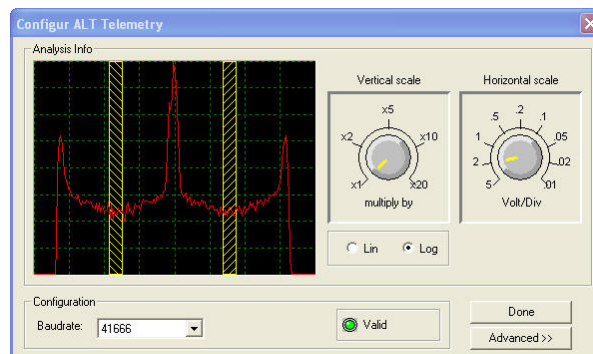
1. Checking the communication is valid.
2. Upgrading firmware

#### 6.4.1 Checking the communication

1. Connect the QL40 ABI 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 6-9 or Figure 6-10).



**Figure 6-9** Tool communication settings - ALTLog

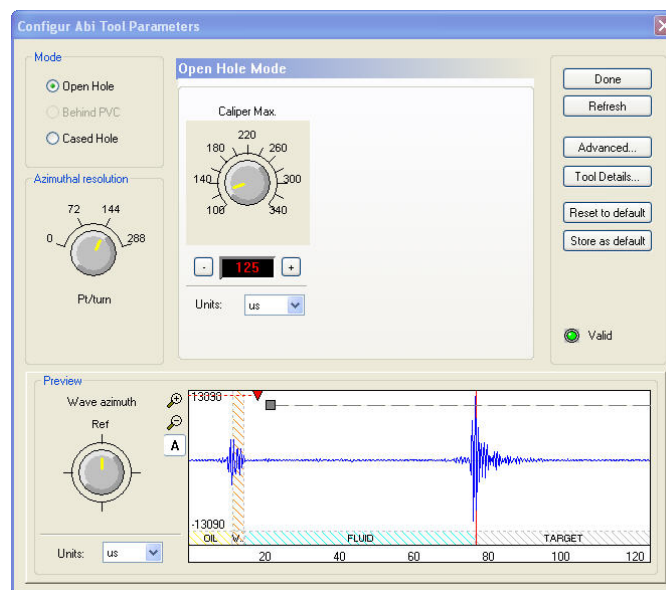


**Figure 6-10** Tool communication settings - Matrix

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

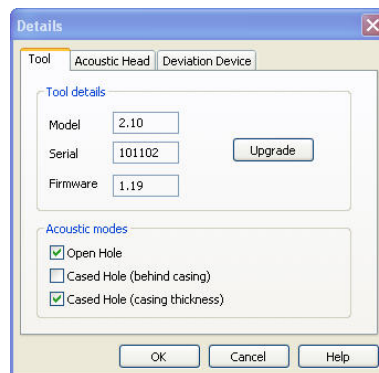
### 6.4.2 Upgrading the firmware

In the **Tool** panel, select **Tool settings/commands**. Check that the communication status is valid (Figure 6-11).



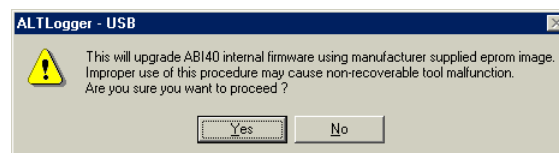
**Figure 6-11** Tool settings dialog box

1. Click on **Tool Details**. Note that the firmware version currently in use is displayed in the firmware box. Click on the **Upgrade** button (Figure 6-12).



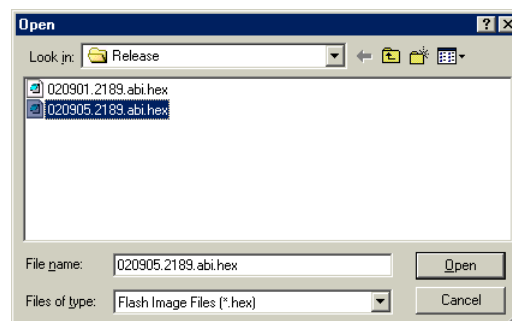
**Figure 6-12** Tool Details dialog box

2. The following message will appear (Figure 6-13). Click **Yes** to validate your choice.



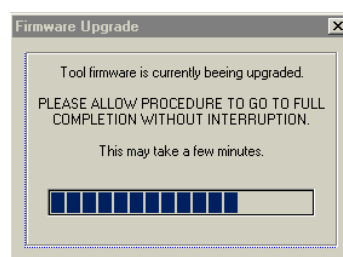
**Figure 6-13** Warning Message during firmware upload

3. Select and open the appropriate **.hex** file provided (Figure 6-14). The upgrade will start.



**Figure 6-14** Select firmware upgrade

4. During the upgrade procedure, the following message is displayed:



**Figure 6-15** Firmware upgrade progress window

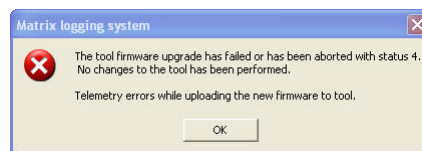
5. Once the upgrade has been successfully completed (Figure 6-16), click on **OK** to turn off the tool.



**Figure 6-16** Successful upgrade

6. Power on the tool to start the upgraded firmware. Check in **Tool settings/commands** and **Tool details** that the firmware version has been changed with the new one.

Note that this error message (Figure 6-17) will appear at end of the procedure when the tool firmware upgrade has failed or has been aborted. Check tool communication settings.



**Figure 6-17** Error message

## 7 Troubleshooting

Observation	To Do
<i>Tool not listed in Tool panel drop down list.</i>	<ul style="list-style-type: none"> <li>- Do you have a configuration file?</li> <li>- Has the configuration file been copied into the .../Tools folder (refer to MATRIX or ALTLog manual about details of the directory structure)?</li> </ul>
<i>Tool configuration error message when powering on the tool.</i>	<ul style="list-style-type: none"> <li>- Check all connections.</li> <li>- Adjust the telemetry settings for your wireline configuration (see chapter 4.3 or 4.4) and store the new settings as default. Apply the appropriate tool settings for your logging run (see chapter 4.5).</li> </ul>
<i>Tool panel - No current.</i>	<ul style="list-style-type: none"> <li>- Verify that the wireline armour is connected to the logging system. Test your interface cable between winch and data acquisition system.</li> <li>- Verify cable head integrity.</li> <li>- Verify voltage output at the cable head (it should be 120V).</li> </ul>
<i>Tool panel - Too much current (red area).</i>	<p><b>! Immediately switch off the tool !</b></p> <ul style="list-style-type: none"> <li>-Possible shortcut (voltage down, current up): Check for water ingress and cable head integrity - wireline continuity.</li> <li>- 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.</li> <li>- If the above shows no issues, use test cable provided by ALT to verify tool functionality.</li> <li>- If the problem still occurs, please contact service centre.</li> </ul>
<i>Telemetry panel - status shows red.</i>	<ul style="list-style-type: none"> <li>- Verify the telemetry settings for your wireline configuration (see chapter 4.3 or 4.4).</li> <li>- If problem cannot be resolved contact support@alt.lu .</li> </ul>
<i>Telemetry panel - memory buffer shows 100%.</i>	<ul style="list-style-type: none"> <li>- 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.</li> </ul>
<i>Telemetry panel – bandwidth usage shows 100%. (Overrun error message.)</i>	<ul style="list-style-type: none"> <li>- Set the baudrate to highest value allowed by your wireline configuration.</li> <li>- Reduce logging speed, decrease azimuthal resolution and/or increase vertical sample step.</li> </ul>
<i>Telemetry panel - large number of errors.</i>	<ul style="list-style-type: none"> <li>- Verify the telemetry settings for your wireline configuration (see chapter 4.3 or 4.4).</li> <li>- Check bandwidth usage and telemetry error status.</li> </ul>

Observation	To Do
<i>Permanent No Sync message and red led status in MChNum browser.</i> <i>Motor stalled and increase of current drawn by the tool.</i>	<b>! Immediately switch off the tool !</b>  - Stepper motor and mirror synchronization issue. Contact ALT for Acoustic Head service.



## 8 Appendix

### 8.1 Parts list

#### 8.1.1 Tool delivery kit QL40-ABI

Item No.	Qty	Part No.	Description
1	2	211-004	C-spanner 40-42 (QL43)
2	2	211-005	C-spanner 58-62 (centralizer)
3	1	ALT11235	ABI40 Marker position jig
4	1	ALT11232	ABI40 tool support
5	1	ALT11234	Marker jig pin
6	2	Din934-M3	Nut M3
7	1	210-002	Silicon grease
8	1	211-001	Allen key set
9	1	2090001001	QL40-ABI - spares kit

#### 8.1.2 Spare kit QL40-ABI (ref. 2090001001)

Item No.	Qty	Part No.	Description
1	5	25340642	O Ring Viton shore 75°, 26,57x3,53 ref . : 10023313
2	2	25340668	O Ring Viton shore 75°, 31,42x2,62 ref . : 10023279
3	2	25340667	O Ring Viton shore 75°, 26,65x2,62 ref . : 10023276
4	4	25332006	M4x6mm Hex cap screw A2 DIN7854
5	4	25332757	M2,5x3mm Hex cap screw A2 DIN912
6	3	25331781	M3x6mm Hex set screw A2 DIN913

### 8.2 Technical drawings

The following technical drawings are available on request:

- 19" Rack connection diagram.
- ABI40 Wiring Diagram.

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