QL40-IND
Dual Induction Probe
Operator Manual

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Denver, CO U. S. A.
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General Information

Induction Tool Overview

The QL40-IND Dual Induction probe uses a 3-coil induction measurement array, with 80 cm spacing between the transmitter and deep receiver coil, and 50 cm spacing between the transmitter coil and medium receiver coil. It is designed for measurement of the electrical conductivity of formations in both liquid filled and dry boreholes. It is also capable of logging inside PVC or other non-metallic casings. This instrument is characterized by high stability and exceptionally wide dynamic range.

QL40 Stackable Logging Tool Overview

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 ï a sophisticated extension of the acquisition software ï 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 GenCPU card in each measurement handles Analog to Digital conversion and/or counting of the measurement signal and formatting of the data for transmission up hole.

When used as a standalone or stack of active subs the tool is completed by adding a Tool Top sub and where applicable a Tool Bottom sub. At present there are varied tool top subs available. These top subs include an MSI single conductor, GOI 4 conductor, GOI Single conductor and GOI 7 conductor. Consult the factory for additional options. The number 40 indicates a nominal OD of 40mm. Over coating and special measurements may make some subs larger in diameter than this. See their particular specifications.

Minimum requirements

Matrix Logger with appropriate Matrix logging software 10.X and above.
See the installation instructions for Matrix software for more information.

Controls, Connectors, and Layout

Connectors for the tool are as follows. The probe top described below is a Mount Sopris standard single conductor probe top. Other variations of probe tops and wiring can be accommodated at the factory such as the GO-4 probe top listed below.

Probe Top sub connections:

MSI-1 Conductor

Pin	Signal	Origin
Probe Top Housing	Tool Power Ground	Armor
Center pin in Probe Top	Tool Power Positive	Center Conductor

GOI-4 Conductor

Pin	Signal	Origin
Probe Top Housing	Tool Power Ground	Armor
1	Tool Power Positive	Com A&B
2,4	No Connection	No Connection
3	Tool Power Positive	Com C&D

Theory of Operation

Inductions tools, in a very simplified approach, following Doll's theories, assume that magnetic permeability, μ, is constant (true for most sedimentary, iron-free rocks). By imposing an electromagnetic field between a transmitter and receiver located in a fixed axial symmetry on a logging probe, electric currents are induced in the formation surrounding the probe. The strength of the induced currents is proportional to the conductivity of the formation. These induced current loops produce a secondary electromagnetic field called the R signal, phase shifted from the original survey frequency, which is picked up by the receiver coil. The strength of the received R signal is related to the conductivity of the formation. Thus, induction tools respond to both the resistive and capacitive components of the complex impedance.

Some induction tools in the field today record the two components. These are sometimes called the in-phase or X signal, and the quadrature or R signal. The R signal (quadrature) is resistivity dependent. The X signal is capacitance dependent.

If the formation is purely resistive (typical sedimentary rocks), then the resistivity measured by galvanic and induction tools is the same.

The QL40-IND Dual Induction probe measures formation conductivity at two different radial distances from the borehole, which provides additional information on the possible invasion of drilling fluid into the formation.

Specifications

Power Requirements

DC. Tool Top Voltage 120 (160 Maximum) with Nominal current draw of 40 mA

Conductivity Measurement

Range	1 mS/m ï 3,000 mS/m	
Accuracy	< 100 mS/m	3% Full Scale
	0.1 ï 1 S/m	2%
	1 ï 3 S/m	5%

Operating Frequency ~100 kHz
Zero Temperature Stability < 0.5 mS/m/10 ºC.

Operating temperature range

0 to 75 ºC 32 to 167 ºF

Pressure rating

20 MPa 3000 PSI

Dimensions

Length	192.5 cm	6.32 feet
Diameter	45 mm	1.77 inches
Weight	15.4 lbs	7 kg

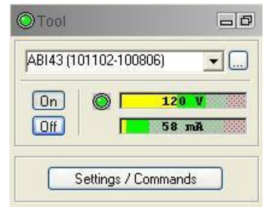
Operating Procedure

Quickstart

For more detailed instructions, see following sections.

1. Connect the QL40 IND to your wireline and start the data acquisition software.

2. Select the relevant QL40 IND tool from the drop down list in the software's **Tool** panel.

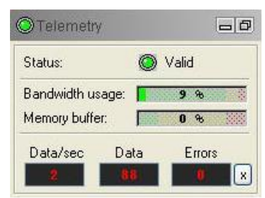


3. In the **Tool** panel switch on the tool (click **On** button) and verify that the power indicator shows a valid (green) level. The system goes through a short initialization sequence which sets the default parameters and communication settings held in the tool configuration file. The configuration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

4. On the **Tool** panel click the **Settings / Commands** button to configure your tool.

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

6. Press the **Record** button in the **Acquisition** panel, 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 **Error**s negligible.

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.

Installing the QL40-IND and Support Equipment

Before operating the QL40-IND, Dual Induction sub, determine if the sub will be used in a stand-alone configuration, or if it will be used in conjunction with another QL Series sub. The subs are connected by threading the male end of the top sub into the next lower one. The following shows this connection process.

Remove the bottom protector from the Top sub. The GOI-4 Top sub is shown below:

Locate the spanner wrenches as shown below:

Align the top sub with the key way inside the female housing of the next section. Inspect all O-rings for defects and make sure threads are clean. Threads and O-rings should be lightly greased. **Do not use silicone grease intended for O-rings on threads.** When connecting subs, it is best to balance each sub section on a tool stand so that the ends join with no load. See photo below.

Slide the top sub in until the threads meet the mating ones inside the housing. Start turning the brass nut by hand until the threads engage. Slightly raise or lower the joint so the pieces mate evenly and the threads turn easily.

Warning: Do not force the threads! When properly aligned they should turn smoothly.

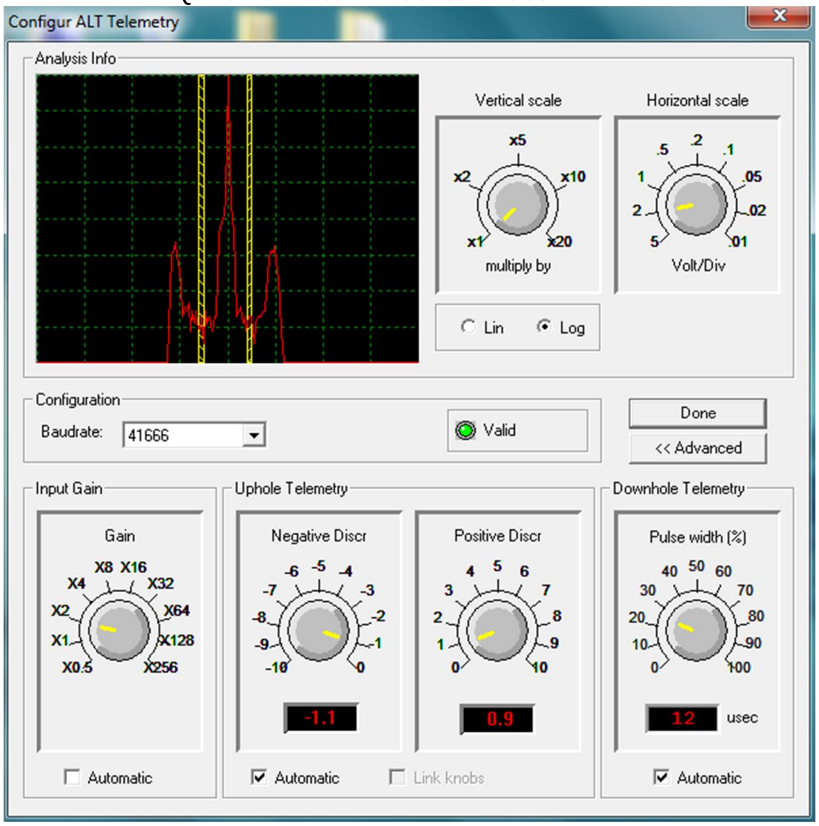
Use the spanner wrenches to tighten the threads until the brass nut is fully engaged. **Do not use cheater bars on the spanner wrenches.**
The threads should go on smoothly. If they are binding adjust the supported location top or bottom section so they are level and evenly aligned.

File Installation and Set-Up

To use the QL40-IND, Dual Induction sub with the MATRIX logging system, make sure the correct sub files are installed in the C:\Logger\Tools\QL40-12 directory. The files are most easily installed using **LoggerSettings.exe** utility program supplied with the software installation. QL40 sub files may be found on the installation or separate CD.

In the case of the Matrix logger, the power settings are set to default values used for all probes equipped with the QL TelePSU down-hole power supply. Different wirelines may require some adjustment to the telemetry. These settings are accessed by pressing the **Settings** button in the **Telemetry** section of the Matrix dashboard. The user may also view the pulse stream on the cable line by pressing on the **Scope** button. To change telemetry settings, press the **Properties** button after the Modem Settings window appears.

The user can observe the discriminators (vertical yellow lines) on the histogram of the up-hole data signal (see figure below). Within the histogram, the vertical axis is frequency and the horizontal axis is voltage. The discriminators are generally set to automatic. Make changes as necessary using the ñ**<<Advanced**ò button in the Telemetry window on the dashboard. The two discriminator bars should be placed in the middle of the displayed troughs, as shown in the following figure. When correct discriminator settings are made, SAVE the configuration, naming it as to describe the wireline configuration and the settings will be recorded for future use. In general the ñfactoryò settings will not need adjustment.



The **Baudrate** can also be adjusted. Most QL tools will use a Baudrate of **41666**. Only the Optical Televiewer, Acoustic Televiewer, and other tools that require larger data streams will need increased baud rates. The input **Gain** should not be set too high (unless needed for longer wirelines) and should **NEVER be set to Automatic**.

Before logging, the probe should be allowed to warm-up for at least 15 minutes in the borehole fluid before calibrating to make sure that the tool is mechanically and electronically stable. Calibrate quickly in air as on the stands below so the tool doesn't warm up from the borehole environment.

Performance Checks and Calibrations

The probe should be suspended in air, approximately 5 feet above the ground and at least 10 feet from any metallic or conductive objects. This represents a zero conductivity reference.

An example of a calibration /zero fixture is shown below.

Using the MCHNum calibration function, turn off calibrations and observe the zero signal values. They should be approximately 100 - 300 cps for both the medium and deep induction. This will vary somewhat by probe. Factory calibration numbers for individual probes are provided.

Either two individual calibration rings or one combination ring can be provided for the probe. Each ring has values written on it. The white values refer to the medium induction channel, and the red values refer to the deep induction channel. Note: Other colors may be used to indicate the differing values.

The table below describes the calibration ring functions:

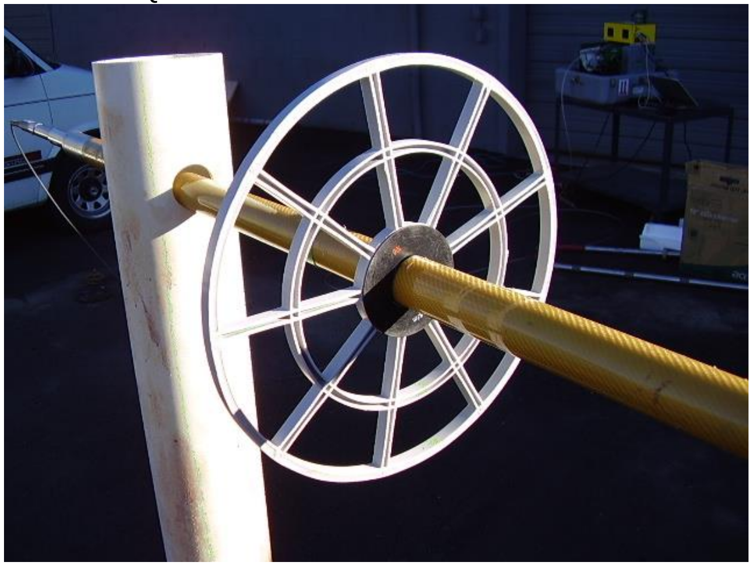
Low Conductivity Ring:

- 200 mS/m (White) for Medium Induction (center ring on the green tape or white dot 73 cm from probe bottom)
- 40 mS/m (Red) for Deep Induction (center ring on the black tape or red dot, approximately 60 cm from the probe bottom)

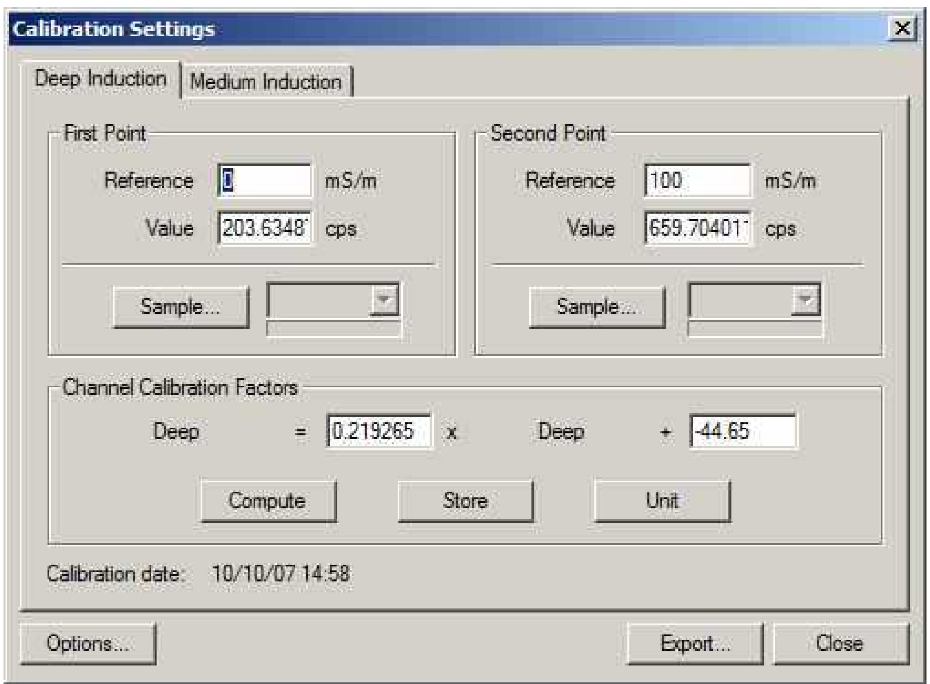
High Conductivity Ring:

- 500 mS/m (White) for Medium Induction (center ring on the green tape or white dot, about 73 cm from probe bottom)
- 100 mS/m (Red) for Deep Induction (center ring on the black tape or red dot, about 60 cm from the probe bottom)

To calibrate, place the low conductivity ring on the probe, center it on each ring, and save the calibration numbers using the controls in the MCHNum calibration browser. Do this for both spacings. The figure below shows the position of the ring for the low conductivity deep induction calibration:



The screenshot below shows the MCHNum calibration screen showing the input values for a sample deep induction calibration:



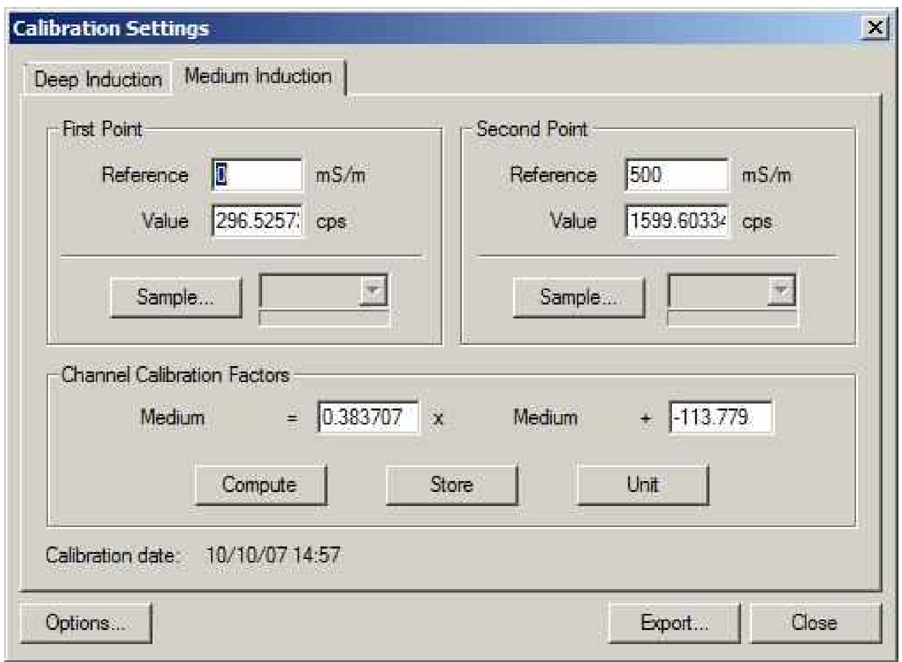
Make sure that both the high and the low values are calibrated for both spacings. This involves putting one ring on, sliding it between spacings and changing between the deep and medium calibration channels. It can be easy to make a mistake when doing this, so please check your values before exiting the calibration phase. Don't forget to store the calibrations and turn the calibrations back on when finished.

When calibrating in Matrix Logger software be sure to press the *Compute* and *Store* buttons before leaving the MCHNum Channel Tab.

An example of the low conductivity coil on the medium position follows on the next page:

QL40-IND Dual Induction Probe

Low Conductivity Coil on Medium Induction position



Alternately, calibration can be done from factory calibration values of the zero and scale factor for the counts. Where, for example, a zero value of 305cps is the First Point Value with a Reference of 0 and the Second Point Value is determined with the factory scale value of 260 cps/100mS/m so using 500 ms as the Reference, the Value would be 260 x 5 = 1300

> Note: the previous values are examples from a sample tool calibration for the medium induction but will be different for each tool. Consult the manual that comes with the tool for the proper factory scale values.

Also for the First Point you can use a Reference of 0 and the Sample button to capture the zero value for the tool. The Second Point then uses one ring value as in the graphic above the 500 mS/m Reference ring is captured with Sample. This is the way Mount Sopris usually calibrates Induction tools. The other ring values can then be used as checks between the zero and 500mS/m values.

When calibrating in Matrix or Logger software be sure to press the *Compute* and *Store* buttons before leaving the MCHNum Channel Tab.

Preventative Maintenance

The QL40 series tools require some maintenance. Make sure the threads on the brass nut on the tool joints 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 Lemo electrical connector inside.

Before probe is removed from cable head it is good to wash the probe off after each use if at all possible. Wash the probe with clean tap water and remove any sediments or grime that may have attached to the housing. You may scrub the surface of the housing with a brush or something similar to remove any surface contaminants. Take great care while handling or packing the probe and during transportation, the housing is fiberglass and is somewhat fragile.

Inspect O-rings occasionally when breaking tool joint apart and keep the threads on both ends of the probe clean, to minimize problems in the future.

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.

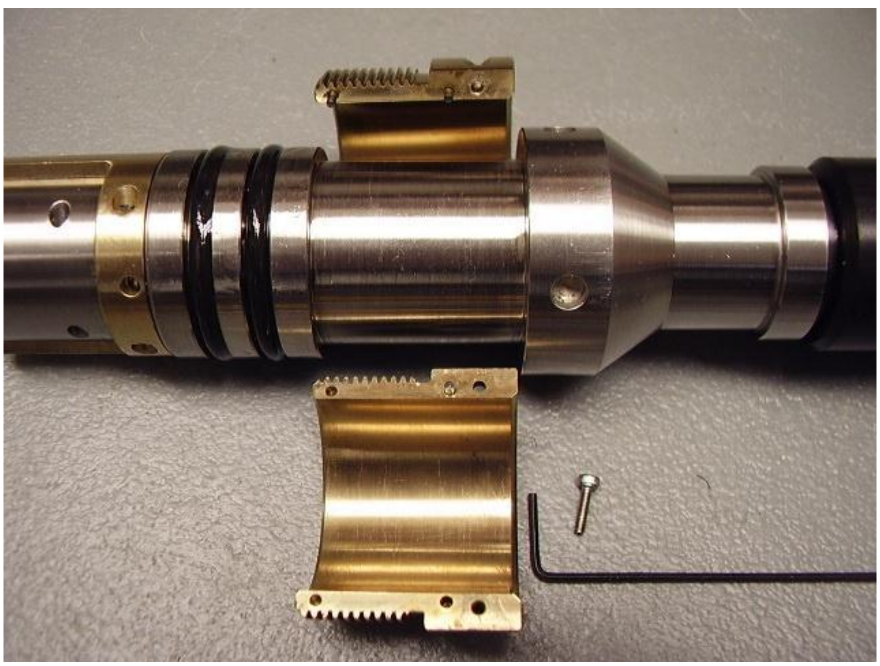
Locking Ring assembly Maintenance

Tools required:
1.5mm Allen wrench
2 ea 40-42mm spanner wrench
Paper towels or clean rags

Replacement Parts:
ALT26005, Large Threaded Ring, Qty 2
28-174-995 M2x8 SHCS, Qty 2

Disassembly:
Unscrew and remove the two M2x8 socket head cap screws and separate the two halves.
Four guide pins align the two ring halves and tend to hold them together after the screws are removed.
To pry the halves apart you can use a pair of spanner wrenches inserted into the wrench holes on opposite sides of the ring mating surfaces to pull them apart slightly.
Do this carefully to prevent bending the guide pins.

Place something small in the opening and move the spanners to the other side and pry it open slightly. This should be enough to release the two rings as below.



Clean inside surfaces thoroughly and reassemble, coating the inside with a very light film of anti-seize compound. Nickel based compounds are best, to prevent any sticking between the brass and steel surfaces.

Troubleshooting

Problems with the Tool

In the event the tool develops a problem, follow the troubleshooting procedure listed below.

Observation	To Do
Tool not listed in Tool panel drop down list.	- Do you have a configuration file? - Has the configuration file been copied into the é /Tools folder (refer to acquisition software manual for details of the directory structure)?
Tool configuration error message when powering on the tool.	- Check all connections. - Adjust the telemetry settings for your wireline configuration (see **Adjust the Telemetry**) and store the new settings as default.
Tool panel - No current.	- Verify that the wireline armor 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 short in wireline (voltage down, current up). Check for water ingress and cable head integrity - wireline continuity. - Verify the interface cable between winch slip ring and data acquisition system is not loose at the connectors. Check for possible source of a short. - If the above shows no issues, use test cable provided by MSI to verify tool functionality. - If the problem still occurs, please contact MSI.
Telemetry panel - status shows red.	- Verify the telemetry settings for your wireline configuration (see **Adjust the Telemetry**). - If problem cannot be resolved contact tech.support@mountsopris.com.
Telemetry panel - memory buffer shows 100%.	- Indicates that the systems internal memory buffer is full. PC canôt receive incoming data streams fast enough. Ensure your PC has enough resources available.
Telemetry panel – bandwidth usage shows 100%. (Overrun error message.)	- Set the baudrate to highest value allowed by your wireline configuration. - Reduce logging speed, decrease azimuthal resolution and/or increase vertical sample rate.
Telemetry panel - large number of errors.	- Verify the telemetry settings for your wireline configuration (see **Adjust the Telemetry**). - Check bandwidth usage and telemetry error status.

WARNING: ***NEVER DIS-ASSEMBLE THE PROBE WITHOUT KNOWLEDGE OF PROCEDURE***

- No counts from the Induction probe.

1. Is the probe isolated from any metallic objects? Rebar in a concrete floor can kill the count rate.

2. Are discriminators set properly?
   a. In Matrix / Logger, Telemetry, Settings, Advanced, be sure you see the classic double fishhook signature indicating positive and negative pulses.

3. Did you install the probe correctly using the LoggerSettings program?

4. Is the logger supplying the correct voltage (~38V) at logger?

   a. In Matrix / Logger the tool will show approximately 90-100ma current draw

5. Check cable for conductive leakage between the center conductor and ARMOR. (20 Million Ohms MINIMUM.)

6. If no results from the above, consult Mount Sopris Instruments.

- Counts are too high compared to the factory calibration values.

  1. Are discriminators set properly?

     a. In Matrix/ Logger, Telemetry, Settings, Advanced, be sure you see the classic double fishhook signature indicating positive and negative pulses. The gain for this tool needs to be 0.5 for up to 500M 1/8ò single conductor cable. If the gain is set too high the system will count noise.

Suggested QA Procedure

General notes for Quality Assurance are presented here for users who need to utilize these techniques when collecting data. These users will need to periodically calibrate their equipment using equipment whose calibration is traceable to an approved standard. Details of these calibrations must be recorded.

When an instrument is calibrated, records need to be kept regarding the calibration standard(s) used and what was changed on the instrument to calibrate it. Typically, the corrections made to the instrument involve changing constants that are used to scale the raw instrument reading so that the proper value is reported. The constants must be recorded during a calibration procedure. The Mount Sopris acquisition software provides records of calibration constants. This aids the QA process, but does not replace the need for recording these constants at the time of calibration. The reason for this is that the length of time since the last calibration is unknown with only this information.

The device providing the standard must be traceable to an accepted standard. Examples of organizations providing standards for measuring instrumentation are: The U. S. National Bureau of Standards; The American Petroleum Institute; and the American Society for Testing Materials. For example, if the voltmeter or the density standard used for calibration is not traceable to an approved organization, such as those listed above, the calibration should not be considered valid. Records should be kept indicating the last time that standard being used for calibration was calibrated or checked against an approved standard. The QA procedure necessary for some programs mandate that the calibration standards be periodically checked against a standard approved by a proper agency.

A QA procedure may dictate that data taken from a given locale be associated with records indicating the exact time and location that the data was collected. The data itself may have to be collected in a certain format to meet requirements. Often, QA procedure specifies that surveys must be repeated and the data from the successive surveys compared. This technique is used to eliminate poor or invalid data.

Figures

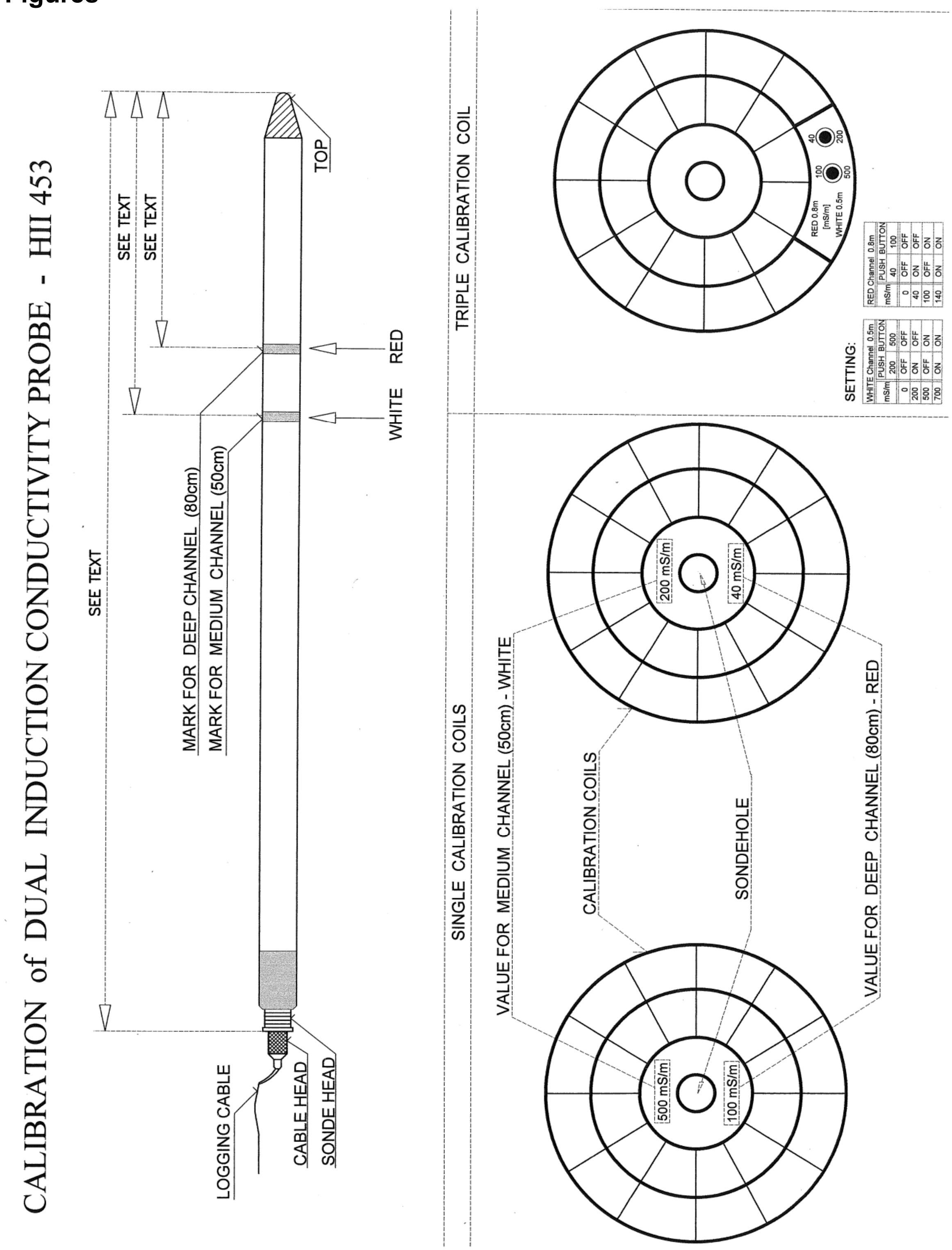


Figure 1 Calibration of Dual Induction HII 453

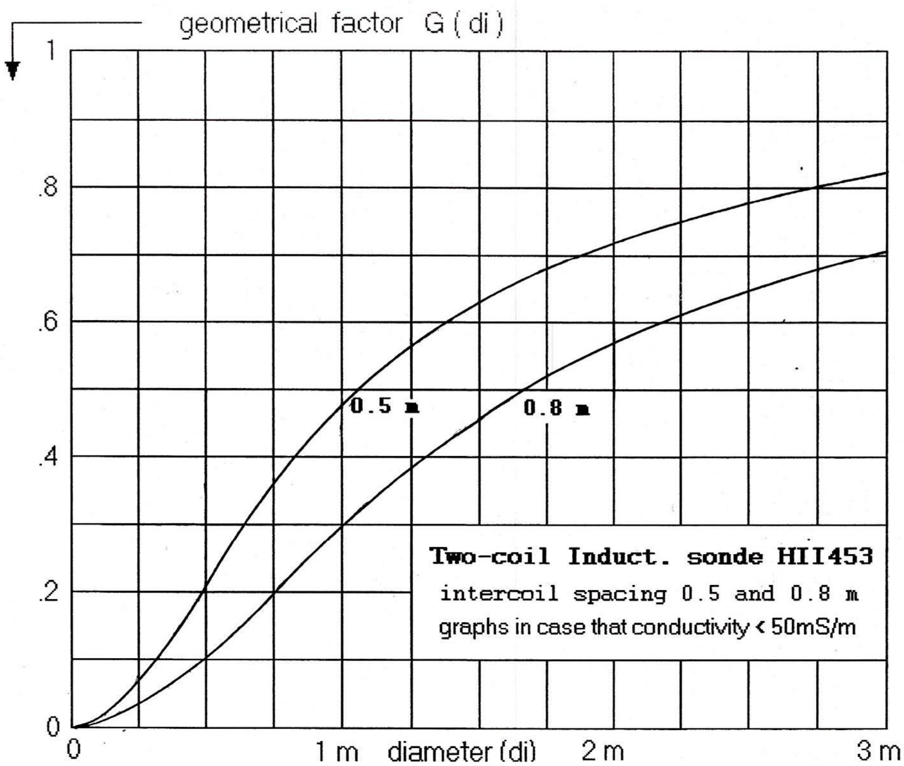


Figure 2 Geometrical Factor

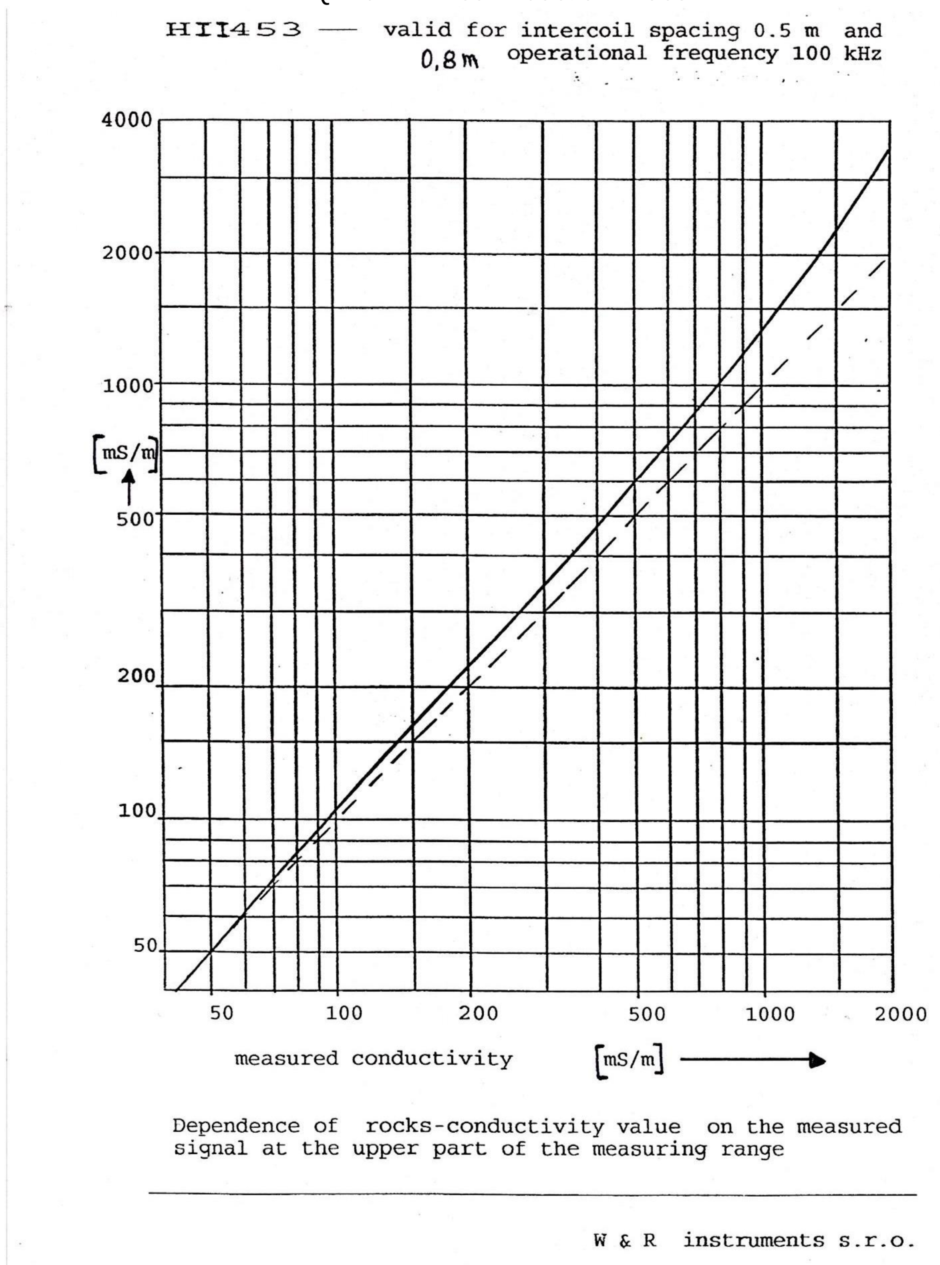


Figure 3 Upper range rock conductivity dependence