COMPASS COMBINATION MUD PULSE ELECTROMAGNETIC OPERATIONS MANUAL

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LEGAL NOTE

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PRELUDE:

The enclosed is a composite of materials designed for the users of MWD tools based on the Compass Platform or systems that are compatible; including Tensor MWD (now GE) the existing GE 3-bay system and other various compatible Tensor MWD platforms:

Mud Pulse MWD

- complete with pulsers types
  - solenoid
  - stepper
  - top mount
  - Hot Hole
  - Pressure Transmitting Tools

EM MWD

- High amp tools
- High voltage tools
- Pressure Transmitting Tools

Survey Monitoring MWD

MWD accessories

- **Resistivity Package**
- **Gamma**

Compass has incorporated material from various vendors as needed to ensure the ability to cover different and various tool configurations.

INTRODUCTION

This manual was designed for users of MWD systems

Presented on the

Compass Directional Guidance Platform

And

With other various compatible Tensor MWD too

CHAPTER 1
INTRODUCTION

A. COMPASS PLATFORM
B. OTHER ACCESSORIES

A. COMPASS PLATFORM

Compass has been working on the current platform since the first Tensor tools were being introduced back in 1996. During the earlier Tensor years the answer to problems was to make slight modifications ("tweek it). After being acquired by several other companies and finally by General Electric; all involved did not make any significant changes to the tool and became obvious that it became synonymous with "good enough."

In spite of obstacles compiled by the various companies; Compass has stayed with the basic platform and built on it as well as some of our key suppliers.

Today Compass can take the basic Compass platform or other compatible Tensor tools and customize it or make add-ons to give the customer the following capabilities:

Mud Pulse MWD package that can include the following:

- Directional Module
  - Standard electronics
  - Fully GE compatible
  - Fully digital
  -Hot Hole electronics
- Pulsers
  -Solenoid
  - Stepper
  - Hot Hole
  - Top mount
- Wellbore monitoring tools
- Gamma
  - Standard and Focused
- Resistivity
- Rotary bow spring interconnects for higher angle wells for additional flex or for use with EM to provide needed contacts
- Rotary connectors with integrated rubber fins are standard on monitor tools but with time will be standard on all tool configuration
- **EM MWD package that can include the following:**
  -Gap subs for all hole sizes
  -EM Transmitters and Receivers
  -High amp
  -High volt
  -PEM transmitters capable of both EM or Mud pulse

As can be seen the Compass platform as described above gives a customer one of the most versatile systems on the market. This results in the ability to optimize usage on the fleet which in turn will lead to higher margins and minimal repairs. When repairs are needed Compass or our key vendors will ensure quick turn around. As needed Compass can also provide fleet maintenance and audit programs to ensure product compatibility and reliability.

B. OTHER ACCESSORIES

B.1 GAMMA

Technical Data Sheet

Gamma ray tools record naturally occurring gamma rays in the formations adjacent to the wellbore. This nuclear measurement indicates the radioactive content of the formations. Effective in any environment, gamma ray tools are the standard device used for the correlation of logs in cased and open holes.

Gamma ray tools use a super sensitive hermetically sealed Sodium Iodide Scintillator crystal and a ruggedized high temperature Photomultiplier for maximum log quality.

	Standard Module	Focused Module
Application	Logging/MWD	Geosteer/MWD
Mechanical		
Diameter	1.875"	1.30"
Length (make up)	34.05"	13.6"
Weight	15.0 lb.	3.0 bl.
Operating Temp.	-77° to +350° F.	-77° to +350° F.
End Connectors	200°, 10 Pin GE	MDM-15 Pin
Material	BeCu	BeCu
Pressure	18,000 PSI	18,000 PSI
Performance		
Sensitivity	1.7 Counts per API	0.6 Counts per API
Accuracy	+/-5% to 300° F. +/-10% to 350° F.	+/-5% to 300° F. +/-10% to 350° F.
Resolution	6.8"	6.8"
Environmental		
Survival Temp.	400° F.	400° F.
Max Heat/Cool	5° F./Minute	5° F./Minute
Vibration (3 axis) 50-300 Hz Random	 30 G. 30 G.	 30 G. 30 G.
Shock (Z-axis)	500 G., 0.5 mS	500 G., 0.5 mS
Shock (Y-axis)	1000 G., 0.5 mS	1000 G., 0.5 mS
Power		
Input Voltage	22-30 Volts	22-30 Volts
Input Current	18-14 mA.	18-14 mA.
Maximum Voltage	31.5 Volts	31.5 Volts
Output Signal		
Pulse	+5V to 0V, 2(+/-0.5) microseconds	+5V to 0V, 2(+/-0.5) microseconds

Applications

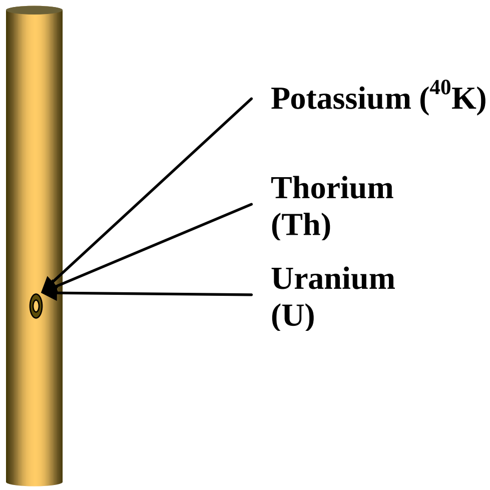
- ● Depth determination
- ● Depth correlation within the well and between wells
- ● Lithology identification
- ● Qualitative evaluation of shaliness
- ● Qualitative evaluation of radioactive mineral deposits

GAMMA RAY

- The Gamma Ray Tool measures the naturally occurring gamma radiation in the formations.
- Most naturally occurring radiation comes from potassium which is contained in clay minerals. Thus the gamma ray log is useful for distinguishing shales from non-shales.
- Some gamma radiation comes from uranium (which is most often found in formations through which water once flowed) or thorium (which is found in various clay minerals) and potassium.
- The spectral gamma ray device differentiates these three sources of gamma radiation based on the energy distribution of the gamma rays striking the detector.

USES

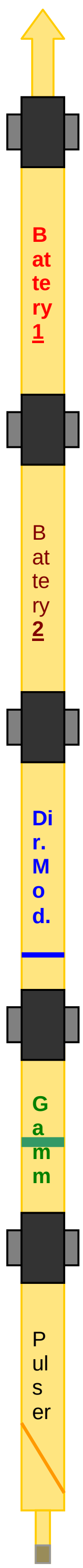
- Distinguish shales from non-shales
- Estimate clay content in sands and limestones
- Correlation of real-time data with offset logs to determine geologic location
- Picking casing and coring points



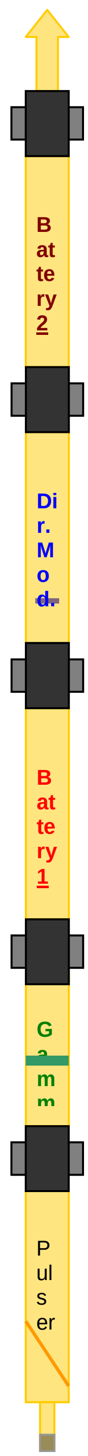
LIMITATIONS

- Count rates are time-dependent and are thus less accurate at high ROP's
- The drill collar absorbs gamma rays differently than the housing of a wireline gamma ray tool, making exact comparisons of wireline and MWD gamma ray logs difficult
- Drill cuttings and drilling fluids with high potassium (K) content can have effects on the MWD gamma probe.

MWD GAMMA TOOL LAYOUT



Option 1 Gamma Tool configuration should be run in the vertical hole sections and through the curves.

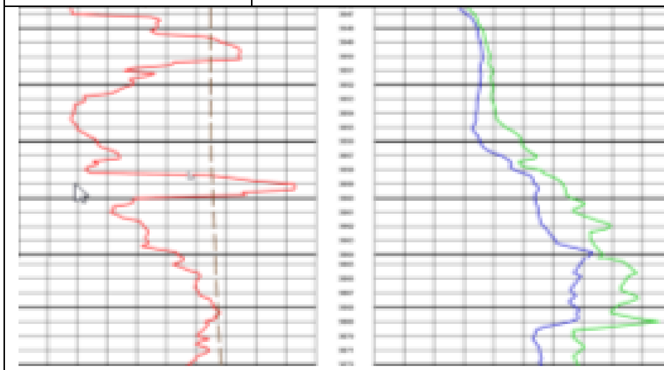


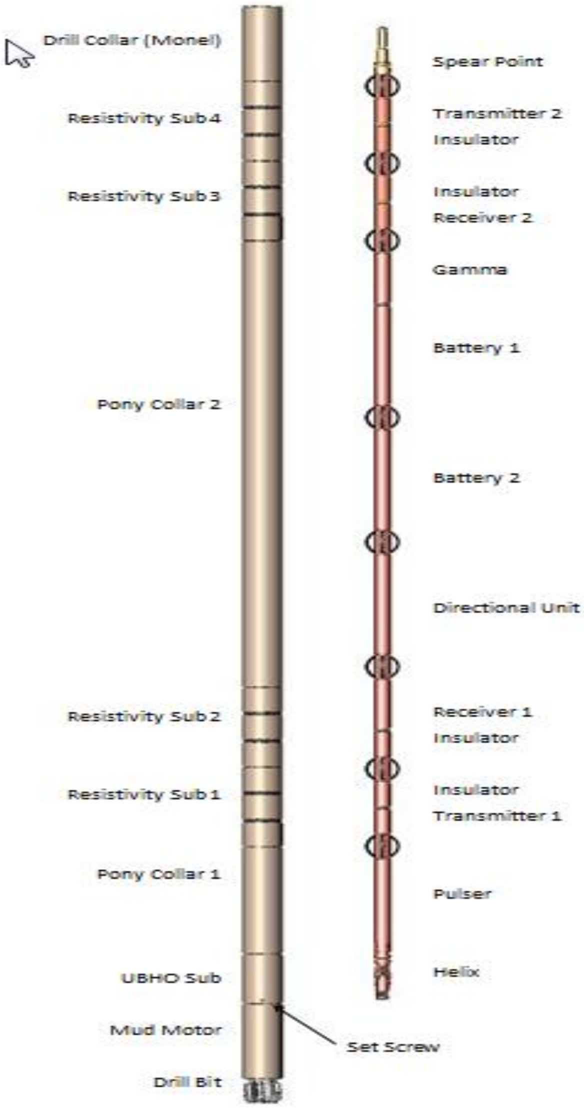
Option 2 Gamma Tool configuration should be run in the through the lower curved section and in the lateral sections.

Magnetic Spacing is an extremely important factor to consider when designing the gamma tool configuration. Check all magnetic spacing charts to insure the proper spacing from the motor and from the upper drill string.

B.2 RESISTIVITY
Technical Data Sheet

Platform	Compass Mud Pulse Platform
Collar Sizes	89mm or 3 ½” 121mm or 4 ¾” 165mm or 6 ½” 203mm or 8”
Data	Real time as well as memory
Curves	Resistivity curves with option of gamma, inclination and ROP as requested Resistivity curves are not bore hole compensated 1 – Frequency 2 – Depths of investigation Measurements up to 2000 ohms
Applications	The platform is the Compass Mud Pulse which is fully retrievable. This same retrievability is available in the Gen II resistivity package
Probe O.D.	1 7/8” Used in monels and resistivity collar from 3.5”- 9.5”. Fully retrievable sensor package
Maximum Temperature	150° C. (302° F.)
Tool Power Source	High performance lithium batteries
Collar	Field rebuildable collar. Ideal for remote locations including international operations


Typical Log c/w Gamma



RESISTIVITY

The ability of a material to resist electrical conduction. It is the inverse of conductivity and is measured in ohm-m. The resistivity is a property of the material, whereas the resistance also depends on the volume measured. The two are related by a system constant, which in simple cases is the length between the measurement electrodes divided by the area. In the general case, the resistivity is the electric field divided by the current density and depends on the frequency of the applied signal

A log of the resistivity of the formation, expressed in ohm-m. The resistivity can take a wide range of values, and, therefore, for convenience is usually presented on a logarithmic scale from, for example, 0.2 to 2000 ohm-m. The resistivity log is fundamental in formation evaluation because hydrocarbons do not conduct electricity while all formation waters do. Therefore a large difference exists between the resistivity of rocks filled with hydrocarbons and those filled with formation water. Clay minerals and a few other minerals, such as pyrite, also conduct electricity, and reduce the difference. Some measurement devices, such as induction and propagation resistivity logs, may respond more directly to conductivity, but are presented in resistivity.

B.3 PRESSURE WHILE DRILLING

ANNULAR PRESSURE

Annular pressure requires the Pressure Stinger and pressure Muleshoe sleeve. The Muleshoe sleeve is seated into the UBHO Sub and is oriented to the high side of the mud motor. Modified set screws with a ported hole in the middle are used to tighten up the Muleshoe sleeve to the UBHO Sub. An alternate method is to use a UBHO Sub that is ported.

When setting the Muleshoe sleeve to the high side, use solid set screws to lock the sleeve in place first. Pick up tool string and seat the tool string in the collar. Pull the BHA up to the UBHO Sub and replace the solid set screws with the ported set screws one at a time. This will prevent any flow from coming back to surface if the ported set screws are used.

The Transducer is located inside the barrel above the helix end. The Pressure Stinger is screwed on to the helix end with blue Loctite. Make sure all o-rings are installed on the Pressure Stinger - outside 210 o-ring x 4, and 115 o-ring on threads. Make sure wear shoulder is not worn down. If it is, it will not line up the ported hole on the Pressure Stinger to the ported holes on the Muleshoe sleeve. Slide the pressure test sleeve over the Muleshoe and use the hydraulic pump to apply pressure.

Configuration of the annular pressure can be setup in the "Survey Sequence" or "Toolface Sequence." The variable used for annular pressure is "GV1," the minimum bits that should be used is 13. For example, "GV1:13 Parity." *Inc*, *Azm*, *Grav*, and *MagF* should be added to the Toolface Logging Sequence. The Toolface should be added to the survey sequence.

Tap test the tool and watch GV1 come up with the pressure reading.

The re-sync option Mode 4 (3 Amps) should be run for underbalanced situations. For situations when the tool will not turn off because the well is flowing, the tool will automatically shut off after 16 minutes and look for sync again.

Annular Pressure (optional)

- E.g.: GV1:13P
- Mode 4 Re-Sync option
- Add Inc/AZM screws prior to landing tool
- Replace with ported set screws once tool is seated

Vibration Monitoring (optional)

- 0-35g
- GV6-Z axis (bit bounce)
- GV7-x, y axis (pipe whirl, lateral vibration)

NOTES

CHAPTER 2
THEORY OF OPERATION

A. MUD PULSE
B. EM
C. THEORY OF CODING & DECODING

A. MUD PULSE

This is the most common method of data transmission used by MWD (Measurement While Drilling) tools. Downhole a valve is operated to restrict the flow of the drilling mud (slurry) according to the digital information to be transmitted. This creates pressure fluctuations representing the information. The pressure fluctuations propagate within the drilling fluid towards surface where they are received from pressure sensors. On surface the received pressure signals are processed by computers to reconstructs the transmitted information. The technology is available in three varieties - *positive* pulse, *negative* pulse, and *continuous wave*.

Positive Pulse

Positive Pulse tools briefly close and open the valve to restrict the mud flow within the drill pipe. This produces an increase in pressure that can be seen at surface. Line codes are used to represent the digital information in form of pulses.

Negative Pulse

Negative pulse tools briefly open and close the valve to release mud from inside the drill pipe out to the annulus. This produces a decrease in pressure that can be seen at surface. Line codes are used to represent the digital information in form of pulses.

Continuous Wave

Continuous wave tools gradually close and open the valve to generate sinusoidal pressure fluctuations within the drilling fluid. Any digital modulation scheme with a continuous phase can be used to impose the information on a carrier signal. The most widely used; at least in high data applications such as offshore, modulation scheme is continuous phase modulation.

When under balanced drilling is used, mud pulse telemetry can become unusable. This is because usually in order to reduce the equivalent density of the drilling mud a compressible gas is injected into the mud. This causes high signal attenuation which drastically reduces the ability of the mud to transmit pulsed data. In this case it is necessary to use methods different from mud pulse telemetry, such as electromagnetic waves propagating through the formation or wired drill pipe telemetry.

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Downhole Sensor:

Compass utilizes 3 main sensor packages including GE, Microtesla and Applied Physics – these standard electronic instruments are proven in downhole survey systems ranging from wireline steering tools to MWD systems.

The sensor package contains 3-Axis Magnetic Sensor, 3-Axis Accelerometers and Temperature sensors capable of detecting the surrounding temperature, the Earth's Magnetic and Gravitational Fields with high resolution. The data output is digitized and processed to determine the vector to the earth's magnetic North Pole and the vector for the earth's magnetic forces dipping down at the earth's surface and below. This information and other measured parameters produce data such as Inclination, Azimuth, and magnetic and gravity toolface values that are transmitted to the surface via mud pulse telemetry to assist in well deviation control. Numerous quality and tool environment data variables can also be transmitted via mud pulse telemetry to quantify and qualify data values and tool health.

Processor:

The MWD processor is the controller of the MWD system and commands all functions and downhole calculations. The processor monitors the state of the flow sense to determine when mud flow has started or stopped. The condition of Flow or No Flow determines the function performed by the MWD downhole system. In a No Flow situation the system ceases transmission and activates the sensor package to measure the magnetic and gravitational forces of the Earth. These measurements are used to calculate the values for the data transmitted to the surface in the survey sequence. In a Flow situation, the processor commences the data transmission process to relay the calculated data to the surface sensors via the mud pulse telemetry created by the activation of the MWD pulser unit.

Battery Pack:

Compass uses high energy Lithium Thionyl Chloride double D size batteries in a stack of eight with a 150°C (302°F) temperature rating. The cells are diode protected to prevent reverse power charges, and are protected by a 5 Amp fuse on the power line. The battery pack will run an MWD system for over 150 hours at a standard pulse rate with a Tensor Pulser and 80 hours with a gamma probe added. With an upgraded Compass pulser, a battery pack will operate the MWD system for over 450 hours and over 300 hours with an added gamma probe. The design of the system allows for the addition of a second battery pack that will be activated when the power of the first battery drops to a predetermined level to then activate the power draw on the second battery. This allows the operator to place the batteries in various positions in the MWD tool design. This option allows the users to determine the optimum position of the directional module determined by magnetic spacing requirements. The use of flexible finned intermodule connectors allows multiple design options on the MWD system with the standards being to place the pulser on the bottom (required) and the gamma and directional module located at the optimum positions.

Pulsers

Compass maintains three types of pulsers in the MWD inventory. The original and most commonly used is the GE Tensor solenoid activated pulser. In early 2005 Compass began switching over to the Compass stepper motor activated pulser. This new design has proved to be more reliable and robust while providing extreme energy conservation by using considerably lower battery consumption. For extreme environments, with high concentrations of LCM, Compass employs the APS (Advanced Product Support) pulser. This is a top mounted direct drive rotor/stator design. This is a high energy consumption pulser, but is able to handle the harsh environments.

The GE Tensor pulser design consists of an oil-filled pulser section and an electronic driver section. The driver section contains a large multi-capacitor bank that stores energy from the battery packs and is controlled by the timing/switching circuitry to generate time pulses. This section is connected to the oil-filled section containing a double solenoid attached via spring loaded shafts to the servo-poppet. A pulse is generated when a pulse signal sent by the directional module to the pulser driver, releases energy from the capacitor bank to the solenoid assembly. The energy activates both the 'pull-in' solenoid and the 'holding' solenoid.

This imparts a magnetic field in the ‘pull-in’ solenoid that causes a piston to move up within the housing, and pull the spring loaded shafts up to allow the steel ‘clapper’ to contact the ‘holding’ solenoid. The energy to the ‘pull-in’ solenoid is stopped and the energy to the ‘holding’ solenoid
‘holds’ the clapper for the required ‘pulse length’ period. This maintains the servo-poppet in the open position, allowing the creation of the pulse by the lower end of the pulser. De-energizing the ‘holding’ coil, releases the clapper from the lower solenoid housing and causes the servo-poppet to be forced back down and closes the servo-orifice and completes the generation of the mud pulse.

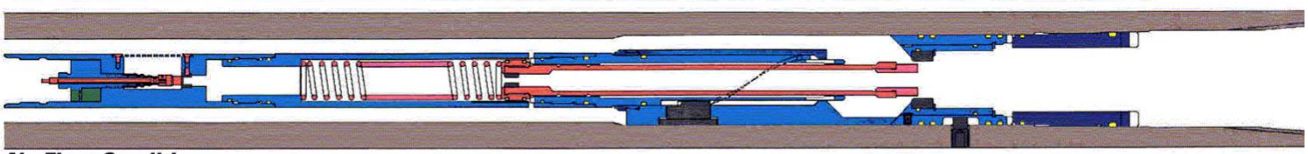
The Compass pulser is designed to ‘drop-in’ place of the GE Tensor pulser and therefore operates similar to the design. The Compass pulser also consists of an oil-filled pulser end and an electronic driver section, similar to the GE Tensor system. However, the

COMPASS pulser uses a stepper motor as the driver to actuate the servo-poppet in the creation of the mud pulse. A stepper motor is designed to rotate in ‘steps’ around as energy is pulsed to it during operation. A small capacitor stores energy to be sent to the motor in measured sequences and amounts. These energy transmissions allow the motor to rotate precisely. The energy transmissions are controlled by a small processor to ensure the exact timing and amount of rotation. This control allows the mechanism to rotate the shaft connected to the servo-poppet an exact amount to allow the servo-poppet to open at a precise measure and allow flow through the servo-orifice. The stepper motor is then reversed with the same precise actuation to close and complete the pulse sequence.

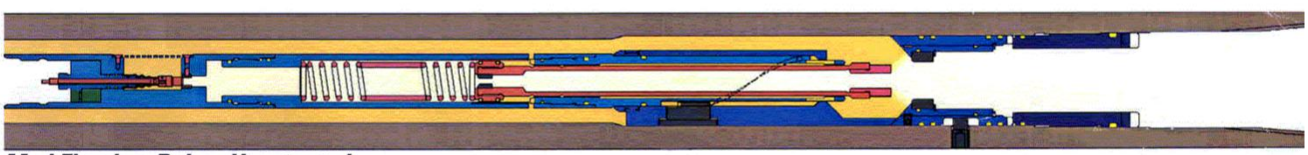
The lower end of both pulsers is comprised of spring housing that contains a main spring, and a piston cap with un-energized Poly-Pak o-rings. In the lower end of the housing is a Ceramic wear sleeve that allows the piston cap to move up and down. The piston cap is attached to the top of the main signal shaft. The main signal shaft is inserted through the helix end that is used to align the MWD tool with the scribe line of the mud motor, indicating the point of the maximum bend on the motor. When the MWD tool is inserted into the Muleshoe sleeve, a key and reverse helix assist to orient the tool to align with the toolface of the mud motor and places the poppet tip on the end of the Main Signal shaft into the carbide orifice contained in the Muleshoe sleeve.

In the No Flow situation, (refer to first display in figure below) the MWD tool has the main signal poppet fully extended into the main orifice in the muleshoe sleeve and mud infiltrates all of the areas of the lower end of the pulsers in a static situation.

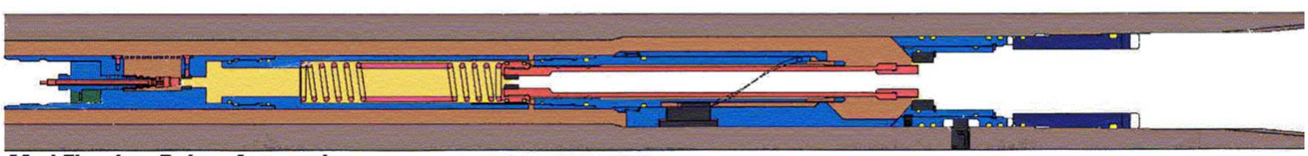
As mud flow is initiated, the mud moves around the tool, and through the main orifice. Mud inside the spring housing (plenum) and main signal shaft is drawn out as flow goes by. With the servo-poppet closed, the pressure in the plenum decreases (not a vacuum). Therefore, the pressure in the plenum is less than the pressure on the outside of the housing. The un-loaded Poly-Paks form a partial seal, to prevent seepage of fluid into the plenum. As a result of the differences in pressure from inside the plenum to the outside (-ΔP), the piston cap moves against the Main Spring to fill the volume left by the mud removed. This results in the Signal Poppet on the end of the Main Signal shaft being removed from the Main Orifice. This results in a full open flow situation in the area of the Main Orifice. During this time the Servo-poppet is in the closed position. As the flow increases, the value of –ΔP increases.



No Flow Condition



Mud Flowing, Pulser Unactuated



Mud Flowing, Pulser Actuated

When the servo-poppet is actuated, in the data transmission sequence, mud is allowed to instantly flow into the screen housing through the servo-orifice. This results in an almost instantaneous flow of fluid to fill the plenum and flow through the poppet orifice in the piston cap through the main signal shaft. The result of this flow is the $-\Delta P$ is neutralized and allows the Main spring to exert a downward force on the main signal shaft to close. Along with the extreme fluid flow velocity and the main spring, the signal shaft forces the carbide poppet tip into the flow passing through the signal orifice and decreases the total flow area (TFA) of the orifice and creates a flow interference and results in a 'pulse' or increase in pressure. This pressure pulse migrates to the surface through the drill pipe and is measured by the transducer in the standpipe.

The subsequent closing of the servo-poppet causes the mechanisms to reverse their actions and move to the positions that allow uninterrupted flow through the signal orifice.

Flow Sensors:

The GE Tensor and the Compass pulsers employ electronic flow switches. The state of flow for the tools is determined by the state of an accelerometer. When the accelerometer is in an unexcited state, the MWD would be in a 'No Flow' position, and when the accelerometer is in an excited state, the MWD would be in a 'Flow On' position. When the MWD tool is assembled, the processor supplies power to the flow switch. When the MWD tool is in the No Flow condition, the voltage through the flow switch is less than 100 millivolts. When the MWD is in a Flow On condition, the voltage through the flow switch is 4.5 – 5.2 Volts. This voltage change created by the change in the state of the accelerometer signals the processor of the changes in the flow state. The tool will function according to the flow or no flow state.

Centralizers/ Interconnect Modules:

The centralizers serve several purposes: 1) They provide wire-ways between the modules that make up the MWD tool string. 2) The provide flex points along the body of the MWD tool that allow the tool to bend when the drill collar bends around short radius boreholes. 3) With the use of bow springs or flex finned centralizer inserts, they provide centralization of the tool within the ID of the non-magnetic drill collar. 4) The use of the centralizers also provides side-wall shock and vibration absorption to protect the tool. These devices filter out the low frequency vibration energy transmitted through the BHA from the action of the bit and motor and rotational forces encountered during drilling.

Drill Collars/ UBHO:

Compass utilizes non-magnetic drill collars of different OD sizes and different ID sizes dependent upon the size of the hole being drilled and the amount of fluid flow required for the drilling. The size of the ID of the collar is extremely important to prevent severe erosion of the MWD tool in the extreme fluid velocities experienced in the hole during drilling.

The UBHO (Universal Bottom Hole Orientation) sub is connected to the lower end of the non-magnetic drill collar and contains the muleshoe sleeve with the signal orifice. Prior to attaching the UBHO to the collar, the muleshoe sleeve is inserted into the UBHO and rotated to align the key with the maximum bend on the mud motor. The muleshoe sleeve is then anchored in the UBHO with three set screws to insure that the MWD tool aligns with the mud motor. The muleshoe sleeve also contains the interchangeable main signal orifice. These orifices are interchangeable to different ID sizes dependent upon the flow expected downhole.

The Compass MWD system is the most versatile MWD system in use today when it comes to collar selection. It can be used in practically any non-magnetic drill collar with an internal diameter in the range of 2 3/16 inches minimum to 3 ¼ inches maximum. The drill collar diameter used is directly related to the amount in gallons-per-minute of the expected drill fluid flow. The recommended flow velocity should not exceed 40 feet/second to prevent excessive erosion of the tool parts in drilling fluids with normal solids content. Refer to Velocity Chart (Sec 4 P-175).

Surface Equipment:

Compass employs the new Bench Tree Receiver to replace the older and dated GE Tensor SAI design. The BTRc and the BTRD (Rig-floor Display) totally replace the older designs and incorporate an improved and faster processor to allow improved decoding capabilities. The system interfaces with the GE Tensor software packages for the downhole equipment and offers more advantages in the MWD surface system design. The system still connects to any Windows based PC and records all transmitted data and all pulse waveform and standpipe pressure data. This accumulation of data allows for excellent data comparison and calculation for improved troubleshooting efforts.

The surface gear allows for MWD operation to be configured to fit a company preference and to tailor the MWD function to suit the environment of the hole being drilled. The system links to several gamma tracking and gamma ray log presentation software packages. The Bench Tree software also allows for MWD memory dump data to be gathered and saved and used for gamma log enhancement by merging the stored gamma data with the surface gathered data to improve data density. It also allows several parameters measured by the tool downhole to be analyzed to study tool performance and potential failures.

SURFACE SENSORS:

PRESSURE TRANSDUCER:

The pressure transducer detects the pressure pulses created by the MWD downhole tool in the mud at the standpipe. The analog signal is digitized, filtered in the DRT MPU and decoded. The data is then displayed on one of several menu-driven screen displays.

HOOK-LOAD SENSOR:

The hookload sensor is a transducer affixed to the drilling rig's hydraulic system. It is used to measure the hook load or weight of the drilling assembly or drill string. The software in the MPU of the DRT allows the operator to calibrate the sensors to match the measuring devices use on the rig.

DEPTH ENCODER:

The depth encoder attached to the Geolograph line measures the movement of the Kelly up and down. In coordination with the hook-load sensor, the depth encoder allows the operator to track the drilling depth of the well and track the addition of joints of drill pipe.

DRAW-WORKS ENCODER:

The draw-works encoder is a depth-measuring device attached to the hub of the draw-works reel. This device operates similarly to the Depth Encoder, and allows the operator to track the drilling depth of the well and track the addition of joints of drill pipe as drilling progresses.

HEAVE SENSOR:

The heave sensor is a depth-adjusting device that measures the movement of floating rigs caused by tides and rough seas. It compensates the depth measurement for the movement of the rig floor.
The use of these sensors, individually or in combination with each other, allow the operator to maintain accurate measurements on the rig site in relation to the data being gathered by the MWD system.
All of the data gathered from the system can be stored on the PC, using the available GE Power Systems software programs. This data can then be used to create reports for survey calculations and formation evaluation. These reports include survey calculations, well plots and formation log plots.

Directional Information

MWD tools are generally capable of taking directional surveys in real time. The tool uses accelerometers and magnetometers to measure the inclination and azimuth of the wellbore at that location, and they then transmit that information to the surface. With a series of surveys at appropriate intervals (anywhere from every 30ft (ie 10m) to every 500 ft), the location of the wellbore can be calculated.

MWD tools are extremely complex pieces of high- tech electronics.

By itself, this information allows operators to prove that their well does not cross into areas that they are not authorized to drill. However, due to the cost of MWD systems, they are not generally used on wells intended to be vertical. Instead, the wells are surveyed after drilling through the use of Multishot Surveying Tools lowered into the drillstring on slickline or wireline.

The primary use of real-time surveys is in Directional Drilling. For the Directional Driller to steer the well towards a target zone, he must know where the well is going, and what the effects of his steering efforts are.

MWD tools also generally provide toolface measurements to aid in directional drilling using downhole mud motors with bent subs or bent housings. For more information on the use of toolface measurements, see Directional Drilling.

Drilling mechanics information

MWD tools can also provide information about the conditions at the drill bit. This may include:

- Rotational speed of the drillstring
- Smoothness of that rotation
- Type and severity of any vibration downhole
- Downhole temperature
- Torque and Weight on Bit, measured near the drill bit
- Mud flow volume

Use of this information can allow the operator to drill the well more efficiently, and to ensure that the MWD tool and any other downhole tools, such as Mud Motors, Rotary Steerable Systems, and Logging While Drilling tools, are operated within their technical specifications to prevent tool failure. This information also is valuable to Geologists responsible for the well information about the formation which is being drilled.

Formation properties

Many MWD tools, either on their own, or in conjunction with separate Logging While Drilling tools, can take measurements of formation properties. At the surface, these measurements are assembled into a log, similar to one obtained by wireline logging.

LWD Logging While Drilling tools are able to measure a suite of geological characteristics including- density, porosity, resistivity, pseudo-caliper, inclination at the drill bit (ABI), magnetic resonance and formation pressure.

The MWD tool allows these measurements to be taken and evaluated while the well is being drilled. This makes it possible to perform Geosteering, or Directional Drilling based on measured formation properties, rather than simply drilling into a preset target.

Most MWD tools contain an internal Gamma Ray sensor to measure natural Gamma Ray values. This is because these sensors are compact, inexpensive, reliable, and can take measurements through unmodified drill collars. Other measurements often require separate Logging While Drilling tools, which communicate with the MWD tools downhole through internal wires.

DOWNHOLE SENSOR/PROCESSOR MODULE:

Compass Tensor MWD Directional Modules are modular assemblies used in downhole drilling applications where minimal power supply is available while providing accurate and stable survey measurements. The assembly contains a Single Port MPU, Triple Power Supply and a Digital Orientation Module. The Single Port MPU is a modular micro-controller assembly based on the Motorola MC68HC11 microprocessor implementing GE Power Systems' qMIX™ communications protocol (qMIX/11™). The Triple Power Supply provides regulated power for the complete assembly.

Designed for the demands of the oil and gas drilling environments, the Digital orientation Module contains three axes of accelerometers and three axes of magnetometers. Calibration data is provided with each unit.

Configurations are available with a downhole Recorder board and maximum operating temperatures to 150°C or 175°C.

The electrical input voltage is 18 – 32 VDC, with an input power of <3-Watts peak, and a serial peripheral interface (SPI) with a 12-bit A/D resolution. The mechanical dimensions are 1.40" diameter by 55.61" in length. The module is designed to fit inside a 1.50" O.D. pressure housing, designed to withstand 20 Klbs. The system uses 21-pin and 15-pin MDM connectors and connects with the patented Snubber Shock assembly and Sensor End assembly.

The system is designed to withstand 1000g 0.5 msec, ½ sine shock on all axes. It can withstand vibrations of 5-20 Hz, 1" (double amplitude) and 20-200 Hz, 30 grms on all axes. The system is designed with two available operating temperature ranges: a) –55°C to +150°C, or –55°C to +175°C.

The calibrated pointing accuracy is ±0.10°, 3 sigma for the inclination measurement (up or down) and ±0.25°, 3 sigma for the azimuth measurement (left/right).

Refer to the qProg/11 section of the Maintenance manual or the Operations manual for the methods of programming the downhole and uphole processors with the latest firmware.

ELECTRICAL POWER:

Electrical power is supplied to the downhole probe via the lithium thionyl chloride Battery. The Compass MWD probe draws power from one battery pack. It can also switch to an additional battery pack when the first pack is drawn below operating capacity. Drilling exercises requiring extended battery life (>200 hours) can configure the system to use a stacked battery arrangement. The use of the Gamma Ray detection module will require tandem batteries to extend power life beyond 150 hours. The tool design only limits module arrangement to the requirement that the pulser in the Compass MWD always be on tool's downhole end.

The batteries may be alkaline or lithium thionyl chloride. Alkaline packs are limited to 120° Celsius and use seventeen D-size cells. Lithium packs are rated for 150° Celsius and 175° Celsius and use eight double-D size (DD) cells. It is estimated that a single alkaline battery pack will operate the downhole probe for about 100 hours, while a single lithium battery pack can last over 200 hours.

Battery pack life is totally dependant upon the pulse length, the tool configuration (modules used) and operational modes used.

PULSER:

The pulser consists of an oil filled pulser section and an electronic Pulser Driver Section..

OIL-FILLED SECTION:

The pulser oil filled section contains the solenoid module, which is comprised of two individual solenoids; the pull-in solenoid and the holding solenoid. When energized, the pull-in solenoid retracts a plunger that is connected, by an assembly of rods and shafts, to the servo-poppet. The holding solenoid energizes simultaneously as the pull-in solenoid retracts the assembly back. The pull-in solenoid requires the largest energy charge supplied by the capacitors in the driver, but only for 80 milliseconds. Energy is then discharged continuously to the holding solenoid for the remainder of the pulse length. To sustain this position the holding solenoid requires a minimal amount of current. The cessation of current to the holding solenoid then releases the clapper that was being held by the magnetic forces created by the holding solenoid. This completes the pulse cycle required for data transmission. The servo-poppet and shafts are held in the "up", or open, position by the force applied to the Holding Coil. While energized, a clapper maintains contact to the non-magnetic front face of the Holding Coil. The retractions of the servo-poppet initiate mud flow through the servo-orifice and into the pulser plenum below. This maneuver and resulting mudflow redirection creates the mud pulse, by inserting and retracting the signal poppet in the main orifice of the muleshoe.

DRIVER SECTION:

The Driver contains the controller boards and EFS (electronic flow switch) and a capacitor bank. The controller boards contain the timing/switching circuitry and the EFS. The capacitor bank stores the power necessary to activate the solenoids to create the pulse activation sequence. The power to the capacitor bank is supplied by the battery packs and is controlled by the microprocessor in the directional module.

GAMMA MODULE

The GE Power Systems’ Gamma Sensor employed by Compass is a high-efficiency natural gamma radiation detector. The sensor uses a Scintillator, NaCl (TI) crystal with a ruggedized photomultiplier, with a signal conditioner and power controller in the qPACK™ mounting. It can be placed in any position in the tool string above the pulser, and run with one or tandem battery packs. The choice of power supply is dependent upon the predicted duration of the drilling run downhole. This module is also used in the Gamma-Steering package, with the incorporation of the Gamma-Steering directional module and the focused gamma sub.

MULESHOE/ MULESHOE SUB

The Tensor MWD system uses a muleshoe sleeve unique to the MWD industry. The muleshoe serves a double-role in the proper function of the Tensor MWD system.

First, the muleshoe employs a helical guide to seat the MWD tool into a specific orientation to measure the toolface orientation with reference to the toolface of the MWD probe. The software design also allows the operator to measure any offset of the muleshoe to the toolface of the bottom hole assembly.

Second, the muleshoe contains the main orifice into which the pulser main signal poppet projects to create the pressure pulse. Five different orifice sizes are used in the 6 ½” and 4 ¾” muleshoe sleeves: 1.28", 1.35", 1.40”, 1.50” and 1.60” OD. The 3 ½” muleshoe sleeve has three options for orifice sizes: 1.21”, 1.23” and 1.25” OD. The main orifices are easily changed on the job site to accommodate the various flow rates that may be encountered through the course of a job.

Muleshoe subs are specially designed and cut to receive and anchor the muleshoe sleeves. The subs are designed to match the mating threads of the collars being used. We strongly recommend cutting the subs from a non-magnetic material to insure adequate spacing from the magnetometers in the MWD tool.

B. EM TOOL

Electromagnetic telemetry (EM Tool)

EM Telemetry is a method of transmitting data from a measurement while drilling (MWD) assembly that resides just above an oil well drill bit. The MWD assembly may contain various measuring instruments such as a Gamma Ray Tool, Resistivity Tool, Directional Survey Instrument, or others. EM Telemetry is capable of transmitting data up to ten times faster than mud pulse telemetry.

These tools incorporate an electrical insulator in the drillstring. To transmit data the tool generates an altered voltage difference between the top part (the main drillstring, above the insulator), and the bottom part (the drill bit, and other tools located below the insulator of the MWD tool). On surface a wire is attached to the wellhead, which makes contact with the drillpipe at the surface. A second wire is attached to a rod driven into the ground some distance away. The wellhead and the ground rod form the two electrodes of a dipole antenna. The voltage difference between the two electrodes is the receiver signal that is decoded by a computer.

An electromagnetic telemetry system for transmitting data from a downhole assembly, which is operationally attached to a drill string, to a telemetry receiver system. The data are typically responses of one or more sensors disposed within the downhole assembly. A downhole transmitter induces a signal current within the drill string. The signal current is modulated to represent the transmitted data. Induced signal current is measured directly with the telemetry receiver system. The telemetry receiver system includes a transformer that surrounds the path of the current, and an electromagnetic current receiver. The transformer preferably comprises a toroid that responds directly to the induced signal current. Output from the transformer is input to an electromagnetic current receiver located remote from the downhole assembly and typically at the surface of the earth. Alternately, voltage resulting from the induced signal current can be measured with a rig voltage receiver and combined with the direct current measurements to enhance signal to noise ratio.

EM MWD surveys are measured in a matter of seconds immediately before the next connection, and then transmitted during connection. Thus, the directional driller can decide which drilling parameters (such as weight-on-bit and rotary speed) to use as soon as the bit tags bottom. Conversely, mud-pulse MWD systems transmit surveys after connections, which increase drilling time when the driller waits to receive the directional survey before deciding which parameters to use before drilling ahead.**Dipole**

Any object or system that is oppositely charged at two points or poles, such as a magnet, a polar molecule, or an antenna element. The properties of a dipole are determined by its dipole moment, that is, the product of one of the charges by their separation directed along an axis through the centers of charge.

An electric dipole consists of two electric charges of equal magnitude but opposite polarity, separated by a short distance (see illustration); or more generally, a localized distribution of positive and negative electricity without net charge whose mean positions of positive and negative charge do not coincide.

Electric dipole with moment μ = Qd.

An electric dipole whose moment oscillates sinusoidally radiates electromagnetic waves and is known as a hertzian dipole; it is of interest in developing the theory of electromagnetic radiation. For practical purposes, a half-wave dipole, consisting of two collinear conducting rods, fed at the center, whose combined length equals half the wavelength of the radiation to be transmitted or received, is often used as an antenna element, either by itself or in an array, or as a feed for a reflector.

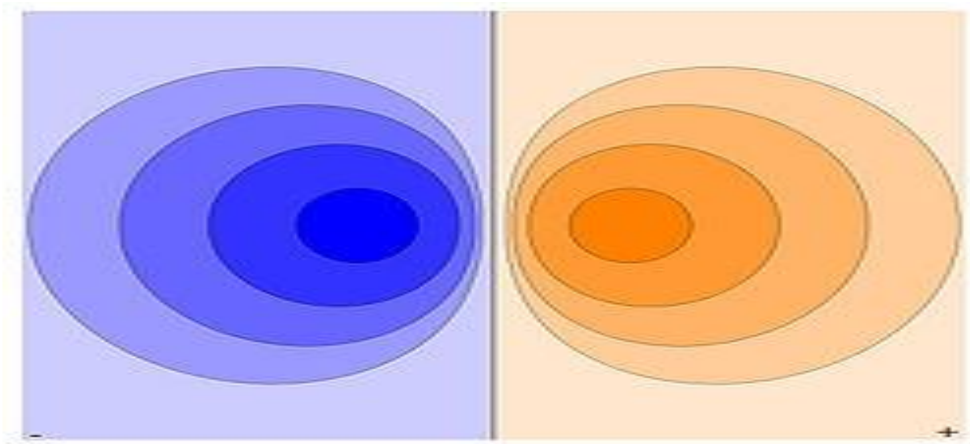
In physics, there are two kinds of **dipoles** (Hellènic: *di(s)-* = two- and *pòla* = pivot, hinge):

An **electric dipole** is a separation of positive and negative charge. The simplest example of this is a pair of electric charges of equal magnitude but opposite sign, separated by some, usually small, distance. A permanent electric dipole is called an electret.

A magnetic dipole is a closed circulation of electric current. A simple example of this is a single loop of wire with some constant current flowing through it.[1][2]

Dipoles can be characterized by their dipole moment, a vector quantity. For the simple electric dipole given above, the electric dipole moment would point from the negative charge towards the positive charge, and have a magnitude equal to the strength of each charge times the separation between the charges. For the current loop, the magnetic dipole moment would point through the loop (according to the right hand grip rule), with a magnitude equal to the current in the loop times the area of the loop.

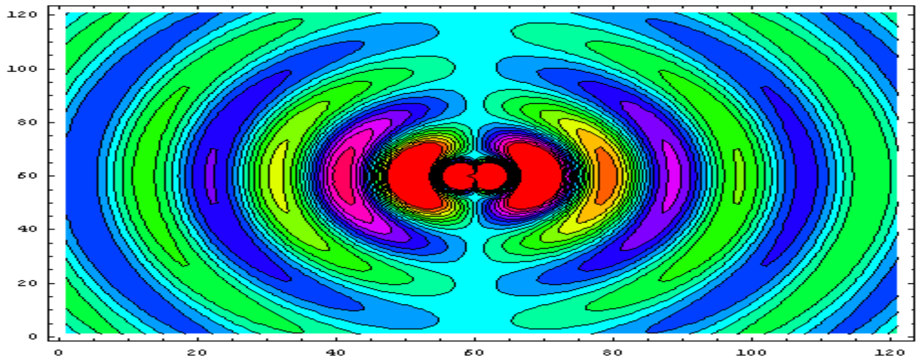
In addition to current loops, the electron, among other fundamental particles, is said to have a magnetic dipole moment. This is because it generates a magnetic field which is identical to that generated by a very small current loop. However, to the best of our knowledge, the electron's magnetic moment is not due to a current loop, but is instead an intrinsic property of the electron. It is also possible that the electron has an *electric* dipole moment, although this has not yet been observed



Contour plot of an electrical dipole, with equipotential surfaces indicated

A permanent magnet, such as a bar magnet, owes its magnetism to the intrinsic magnetic dipole moment of the electron. The two ends of a bar magnet are referred to as poles (not to be confused with monopoles), and are labeled "north" and "south." The dipole moment of the bar magnet points from its magnetic south to its magnetic north pole—confusingly, the "north" and "south" convention for magnetic dipoles is the opposite of that used to describe the Earth's geographic and magnetic poles, so that the Earth's geomagnetic north pole is the *south* pole of its dipole moment. (This should not be difficult to remember; it simply means that the north pole of a bar magnet is the one which points north if used as a compass.)

The only known mechanisms for the creation of magnetic dipoles are by current loops or quantum-mechanical spin since the existence of magnetic monopoles has never been experimentally demonstrated.



Real-time evolution of the electric field (?) of an oscillating electric dipole. The dipole is located at (60, 60) in the graph, oscillating at 1 rad/s (~0.16 Hz) (?) in the vertical (?) direction

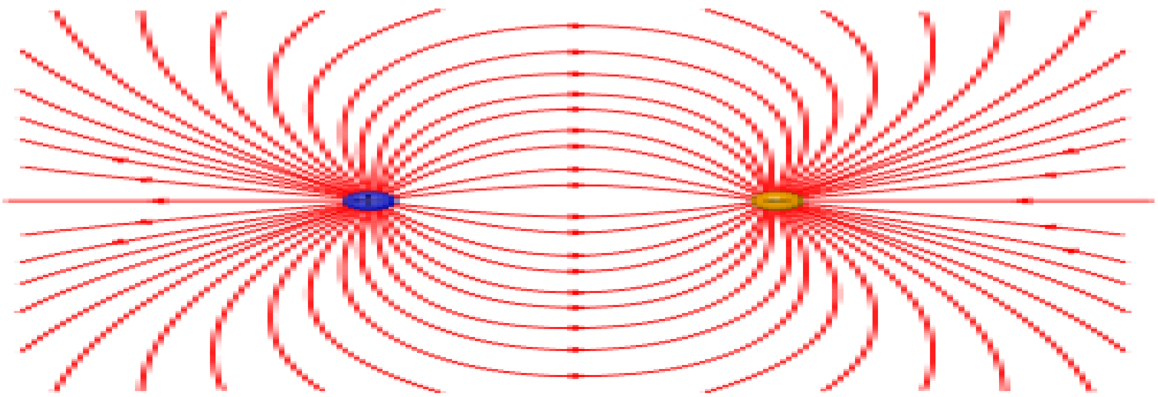
A *physical dipole* consists of two equal and opposite point charges: literally, two poles. Its field at large distances (i.e., distances large in comparison to the separation of the poles) depends almost entirely on the dipole moment as defined above. A *point (electric) dipole* is the limit obtained by letting the separation tend to 0 while keeping the dipole moment fixed. The field of a point dipole has a particularly simple form, and the order-1 term in the multipole expansion is precisely the point dipole field.

Although there are no known magnetic monopoles in nature, there are magnetic dipoles in the form of the quantum-mechanical spin associated with particles such as electrons (although the accurate description of such effects falls outside of classical electromagnetism). A theoretical magnetic *point dipole* has a magnetic field of the exact same form as the electric field of an electric point dipole. A very small current-carrying loop is approximately a magnetic point dipole; the magnetic dipole moment of such a loop is the product of the current flowing in the loop and the (vector) area of the loop.

Any configuration of charges or currents has a 'dipole moment', which describes the dipole whose field is the best approximation, at large distances, to that of the given configuration. This is simply one term in the multipole expansion; when the charge ("monopole moment") is 0 — as it *always* is for the magnetic case, since there are no magnetic monopoles — the dipole term is the dominant one at large distances: its field falls off in proportion to $1 / r^3$, as compared to $1 / r^4$ for the next (quadrupole) term and higher powers of $1 / r$ for higher terms, or $1 / r^2$ for the monopole term.

Molecular dipoles

Many molecules have such dipole moments due to non-uniform distributions of positive and negative charges on the various atoms. For example:



Electric dipole field lines
(positive) H-Cl (negative)

A molecule with a permanent dipole moment is called a **polar** molecule. A molecule is **polarized** when it carries an induced dipole. The physical chemist Peter J. W. Debye was the first scientist to study molecular dipoles extensively, and dipole moments are consequently measured in units named *debye* in his honor.

With respect to molecules there are three types of dipoles:

- **Permanent dipoles:** These occur when two atoms in a molecule have substantially different electronegativity—one atom attracts electrons more than another becoming more negative, while the other atom becomes more positive. See dipole-dipole attractions.
- **Instantaneous dipoles:** These occur due to chance when electrons happen to be more concentrated in one place than another in a molecule, creating a temporary dipole. See instantaneous dipole.
- **Induced dipoles** These occur when one molecule with a permanent dipole repels another molecule's electrons, "inducing" a dipole moment in that molecule. See induced-dipole attraction.

The definition of an induced dipole given in the previous sentence is too restrictive and misleading. An induced dipole of *any* polarizable charge distribution ρ (remember that a molecule has a charge distribution) is caused by an electric field external to ρ. This field may, for instance, originate from an ion or polar molecule in the vicinity of ρ or may be macroscopic (e.g., a molecule between the plates of a charged capacitor). The size of the induced dipole is equal to the product of the strength of the external field and the dipole polarizability of ρ.

Typical gas phase values of some chemical compounds in debye units:

- carbon dioxide: 0
- carbon monoxide: 0.112
- ozone: 0.53
- phosgene: 1.17
- water vapor: 1.85
- hydrogen cyanide: 2.98
- cyanamide: 4.27
- potassium bromide: 10.41

These values can be obtained from measurement of the dielectric constant. When the symmetry of a molecule cancels out a net dipole moment, the value is set at 0. The highest dipole moments are in the range of 10 to 11. From the dipole moment information can be deduced about the molecular geometry of the molecule. For example the data illustrate that carbon dioxide is a linear molecule but ozone is not.

Quantum mechanical dipole operator

Consider a collection of N particles with charges q_i and position vectors $\mathbf{r}_i$. For instance, this collection may be a molecule consisting of electrons, all with charge $-e$, and nuclei with charge eZ_i, where Z_i is the atomic number of the i th nucleus. The physical quantity (observable) **dipole** has the **quantum mechanical operator**:

$$\mathfrak{p} = \sum_{i=1}^{N} q_i \, \mathbf{r}_i \, .$$

Atomic dipoles

A non-degenerate (S-state) atom can have only a zero permanent dipole. This fact follows quantum mechanically from the inversion symmetry of atoms. All 3 components of the dipole operator are antisymmetric under inversion with respect to the nucleus,

$$\mathfrak{I}\;\mathfrak{p}\;\mathfrak{I}^{-1} = -\mathfrak{p},$$

where $\mathfrak{p}$ is the dipole operator and $\mathfrak{I}$ is the inversion operator. The permanent dipole moment of an atom in a non-degenerate state (see degenerate energy level) is given as the expectation (average) value of the dipole operator,

$$\langle \mathfrak{p} \rangle = \langle\, S\,|\mathfrak{p}|\, S\,\rangle,$$

where $|\,S\,\rangle$ is an S-state, non-degenerate, wavefunction, which is symmetric or antisymmetric under inversion: $\mathfrak{I}\,|\,S\,\rangle = \pm|\,S\,\rangle$. Since the product of the wavefunction (in the ket) and its complex conjugate (in the bra) is always symmetric under inversion and its inverse,

$$\langle \mathfrak{p} \rangle = \langle\, \mathfrak{I}^{-1}\,S\,|\mathfrak{p}|\,\mathfrak{I}^{-1}\,S\,\rangle = \langle\, S\,|\mathfrak{I}\,\mathfrak{p}\,\mathfrak{I}^{-1}|\,S\,\rangle = -\langle \mathfrak{p} \rangle$$

it follows that the expectation value changes sign under inversion. We used here the fact that $\mathfrak{I}$, being a symmetry operator, is unitary: $\mathfrak{I}^{-1} = \mathfrak{I}^{*}$ and by definition the Hermitian adjoint $\mathfrak{I}^{*}$ may be moved from bra to ket and then becomes $\mathfrak{I}^{**} = \mathfrak{I}$. Since the only quantity that is equal to minus itself is the zero, the expectation value vanishes,

$$\langle \mathfrak{p} \rangle = 0.$$

In the case of open-shell atoms with degenerate energy levels, one could define a dipole moment by the aid of the first-order Stark effect. This only gives a non-vanishing dipole (by definition proportional to a non-vanishing first-order Stark shift) if some of the wavefunctions belonging to the degenerate energies have opposite parity; i.e., have different behavior under inversion. This is a rare occurrence, but happens for the excited H-atom, where 2s and 2p states are "accidentally" degenerate (see this article for the origin of this degeneracy) and have opposite parity (2s is even and 2p is odd).

Field from a magnetic dipole

See also: Magnet#The Two Models for Magnets: Magnetic Poles and Atomic Currents and Magnetic Field#Physical interpretation of the H field

Magnitude

The far-field strength, **B**, of a dipole magnetic field is given by

$$B(m,r,\lambda) = \frac{\mu_0}{4\pi}\frac{m}{r^3}\sqrt{1+3\sin^2\lambda}$$

where

> **B** is the strength of the field, measured in teslas;
> **r** is the distance from the center, measured in metres;
> **λ** is the magnetic latitude (90°−θ) where θ = magnetic colatitude, measured in radians or degrees from the dipole axis (Magnetic colatitude is 0 along the dipole's axis and 90° in the plane perpendicular to its axis.);
> **m** is the dipole moment (VADM=virtual axial dipole moment), measured in ampere square-metres ($A{\cdot}m^2$), which equals joules per tesla;
> μ_0 is the permeability of free space, measured in henries per metre.

Conversion to cylindrical coordinates is achieved using

> $r^2 = z^2 + \rho^2$
> and
> $$\lambda = \arcsin\left(\frac{z}{\sqrt{z^2+\rho^2}}\right)$$

where ρ is the perpendicular distance from the z-axis. Then,

$$B(\rho,z) = \frac{\mu_0 m}{4\pi(z^2+\rho^2)^{3/2}}\sqrt{1+\frac{3z^2}{z^2+\rho^2}}$$

Vector form

The field itself is a vector quantity:

$$\mathbf{B}(\mathbf{m},\mathbf{r}) = \frac{\mu_0}{4\pi r^3}\left(3(\mathbf{m}\cdot\hat{\mathbf{r}})\hat{\mathbf{r}} - \mathbf{m}\right) + \frac{2\mu_0}{3}\mathbf{m}\delta^3(\mathbf{r})$$

where
B is the field;
r is the vector from the position of the dipole to the position where the field is being measured;
r is the absolute value of **r**: the distance from the dipole;
$\hat{\mathbf{r}} = \mathbf{r}/r$ is the unit vector parallel to **r**;
m is the (vector) dipole moment;
$\boldsymbol{\mu_0}$ is the permeability of free space;
$\boldsymbol{\delta^3}$ is the three-dimensional delta function. ($\delta^3(\mathbf{r})$ = 0 except at **r** = (0,0,0), so this term is ignored in multipole expansion.)

This is *exactly* the field of a point dipole, *exactly* the dipole term in the multipole expansion of an arbitrary field, and *approximately* the field of any dipole-like configuration at large distances.

Magnetic vector potential

The vector potential **A** of a magnetic dipole is

$$\mathbf{A}(\mathbf{r}) = \frac{\mu_0}{4\pi r^2}(\mathbf{m}\times\hat{\mathbf{r}})$$

with the same definitions as above.

Field from an electric dipole

The electrostatic potential at position $\mathbf{r}$ due to an electric dipole at the origin is given by:

$$\Phi(\mathbf{r}) = \frac{1}{4\pi\epsilon_0}\frac{\mathbf{p}\cdot\hat{\mathbf{r}}}{r^2}$$

where
$\hat{\mathbf{r}}$ is a unit vector in the direction of $\mathbf{r}$;
p is the (vector) dipole moment;
$\boldsymbol{\varepsilon_0}$ is the permittivity of free space.

This term appears as the second term in the multipole expansion of an arbitrary electrostatic potential Φ(**r**). If the source of Φ(**r**) is a dipole, as it is assumed here, this term is the only non-vanishing term in the multipole expansion of Φ(**r**). The electric field from a dipole can be found from the gradient of this potential:

$$\mathbf{E} = -\nabla\Phi = \frac{1}{4\pi\epsilon_0}\left(\frac{3(\mathbf{p}\cdot\hat{\mathbf{r}})\hat{\mathbf{r}} - \mathbf{p}}{r^3}\right) - \frac{1}{3\epsilon_0}\mathbf{p}\delta^3(\mathbf{r})$$

where **E** is the electric field and $\boldsymbol{\delta^3}$ is the 3-dimensional delta function. ($\delta^3(\mathbf{r})$ = 0 except at **r** = (0,0,0), so this term is ignored in multipole expansion.) Notice that this is formally identical to the magnetic field of a point magnetic dipole; only a few names have changed.

Torque on a dipole

Since the direction of an electric field is defined as the direction of the force on a positive charge, electric field lines point away from a positive charge and toward a negative charge.

When placed in an electric or magnetic field, equal but opposite forces arise on each side of the dipole creating a torque $\boldsymbol{\tau}$:

$$\boldsymbol{\tau} = \mathbf{p}\times\mathbf{E}$$

for an electric dipole moment **p** (in coulomb-meters), or

$$\boldsymbol{\tau} = \mathbf{m}\times\mathbf{B}$$

for a magnetic dipole moment **m** (in ampere-square meters).

The resulting torque will tend to align the dipole with the applied field, which in the case of an electric dipole, yields a potential energy of

$$U = -\mathbf{p} \cdot \mathbf{E}.$$

The energy of a magnetic dipole is similarly

$$U = -\mathbf{m} \cdot \mathbf{B}.$$

Dipole radiation

In addition to dipoles in electrostatics, it is also common to consider an electric or magnetic dipole that is oscillating in time.

In particular, a harmonically oscillating electric dipole is described by a dipole moment of the form $\mathbf{p} = \mathbf{p}'(\mathbf{r})e^{-i\omega t}$ where ω is the angular frequency. In vacuum, this produces fields:

$$\mathbf{E} = \frac{1}{4\pi\varepsilon_0}\left\{\frac{\omega^2}{c^2 r}\hat{\mathbf{r}} \times \mathbf{p} \times \hat{\mathbf{r}} + \left(\frac{1}{r^3} - \frac{i\omega}{cr^2}\right)\left[3\hat{\mathbf{r}}(\hat{\mathbf{r}} \cdot \mathbf{p}) - \mathbf{p}\right]\right\} e^{i\omega r/c}$$
$$\mathbf{B} = \frac{\omega^2}{4\pi\varepsilon_0 c^3}\hat{\mathbf{r}} \times \mathbf{p}\left(1 - \frac{c}{i\omega r}\right)\frac{e^{i\omega r/c}}{r}.$$

Far away (for $r\omega/c \gg 1$), the fields approach the limiting form of a radiating spherical wave:

$$\mathbf{B} = \frac{\omega^2}{4\pi\varepsilon_0 c^3}(\hat{\mathbf{r}} \times \mathbf{p})\frac{e^{i\omega r/c}}{r}$$
$$\mathbf{E} = c\mathbf{B} \times \hat{\mathbf{r}}$$

which produces a total time-average radiated power *P* given by

$$P = \frac{\omega^4}{12\pi\varepsilon_0 c^3}|\mathbf{p}|^2.$$

This power is not distributed isotropically, but is rather concentrated around the directions lying perpendicular to the dipole moment. Usually such equations are described by spherical harmonics, but they look very different. A circular polarized dipole is described as a superposition of two linear dipoles.

The EM tool generates voltage differences between the drillstring sections in the pattern of very low frequency (2-12Hz) waves. The data is imposed on the waves through digital modulation.

Modulation

A technique employed in telecommunications transmission systems whereby an electromagnetic signal (the modulating signal) is encoded into one or more of the characteristics of another signal (the carrier signal) to produce a third signal (the modulated signal), whose properties are matched to the characteristics of the medium over which it is to be transmitted. The encoding preserves the original modulating signal in that it can be recovered from the modulated signal at the receiver by the process of demodulation. The main purpose of modulation is to overcome any inherent incompatibilities between the electromagnetic properties of the modulating signal and those of the transmission medium. Of primary importance in this respect is the spectral distribution of power in the modulating signal relative to the passband of the medium. Modulation provides the means for shifting the power of the modulating signal to a part of the frequency spectrum where the medium's transmission characteristics, such as its attenuation, interference, and noise level, are favorable.

Two forms of modulation are generally distinguished, although they have many properties in common: If the modulating signal's amplitude varies continuously with time, it is said to be an analog signal and the modulation is referred to as analog. In the case where the modulating signal may vary its amplitude only between a finite number of values and the change may occur only at discrete moments in time, the modulating signal is said to be a digital signal and the modulation is referred to as digital.In most applications of modulation the carrier signal is a sine wave, which is completely characterized by its amplitude, its frequency, and its phase relative to some point in time. Modulating the carrier then amounts to varying one or more of these parameters in direct proportion to the amplitude of the modulating signal. In analog modulation systems, varying the amplitude, frequency, or phase of the carrier signal results in amplitude modulation (AM), frequency modulation (FM), or phase modulation (PM), respectively. Since the frequency of a sine wave expressed in radians per second equals the derivative of its phase, frequency modulation and phase modulation are sometimes subsumed under the general term “angle modulation” or “exponential modulation.”

If the modulating signal is digital, the modulation is termed amplitude-shift keying (ASK), frequency-shift keying (FSK), or phase-shift keying (PSK), since in this case the discrete amplitudes of the digital signal can be said to shift the parameter of the carrier signal between a finite number of values. For a modulating signal with only two amplitudes, “binary” is sometimes added before these terms.

Digital modulating signals with more than two amplitudes are sometimes encoded into both the amplitude and phase of the carrier signal. For example, if the amplitude of the modulating signal can vary between four different values, each such value can be encoded as a combination of one of two amplitudes and one of two phases of the carrier signal. Quadrature amplitude modulation (QAM) is an example of such a technique.

In certain applications of modulation the carrier signal, rather than being a sine wave, consists of a sequence of electromagnetic pulses of constant amplitude and time duration, which occur at regular points in time. Changing one or the other of these parameters gives rise to three modulation schemes known as pulse-position modulation (PPM), pulse-duration modulation (PDM), and pulse-amplitude modulation (PAM), in which the time of occurrence of a pulse relative to its nominal occurrence, the time duration of a pulse, or its amplitude are determined by the amplitude of the modulating signal.

This system generally offers data rates of up to 10 bits per second. In addition, many of these tools are also capable of receiving data from the surface in the same way, while mud pulse-based tools rely on changes in the drilling parameters, such as rotation speed of the drillstring or the mud flow rate, to send information from the surface to downhole tools. Making changes to the drilling parameters in order to send information to the tools generally interrupts the drilling process, causing lost time.

Compared to mud pulse telemetry, electronic pulse telemetry is more effective in certain specialized situation, such as underbalanced drilling or when using air as drilling fluid. However, it generally falls short when drilling exceptionally deep wells, and the signal can lose strength rapidly in certain types of formations, becoming undetectable at only a few thousand feet of depth.

The transmission of electrical energy by wires, the broadcasting of radio signals, and the phenomenon of visible light are all examples of the propagation of electromagnetic energy. Electromagnetic energy travels in the form of a wave. Its speed of travel is approximately 3×10^8 m/s (186,000 mi/s) in a vacuum and is somewhat slower than this in liquid and solid insulators.

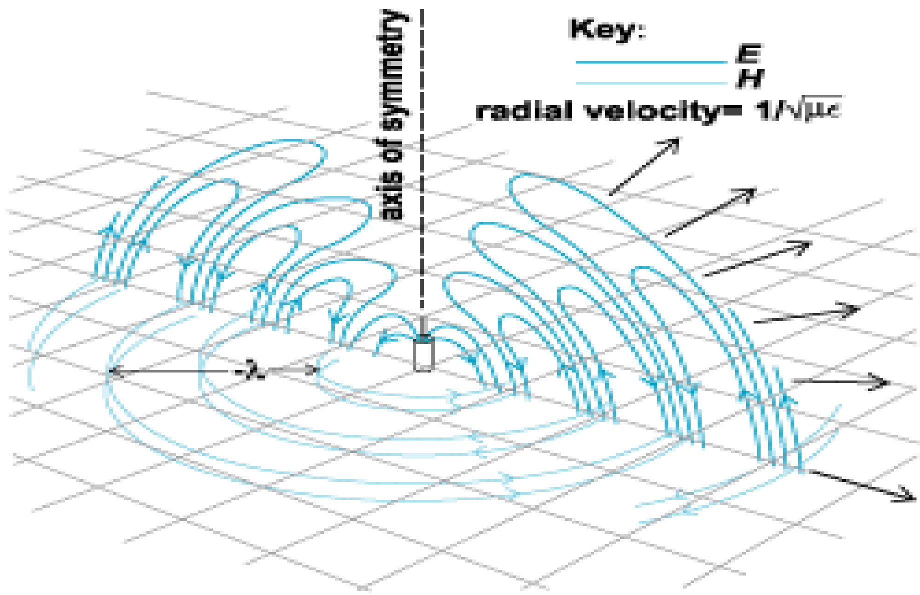
An electromagnetic wave does not penetrate far into an electrical conductor, and a wave that is incident on the surface of a good conductor is largely reflected.

Electromagnetic waves originate from accelerated electric charges. For example, a radio wave originates from the oscillatory acceleration of electrons in the transmitting antenna. The light that is produced within a laser originates when electrons fall from a higher energy level to a lower one.

The waves emitted from a source are oscillatory and are described in terms of frequency of oscillation. The method of generating an electromagnetic wave depends on the frequency used, as do the techniques of transmitting the energy to another location and utilizing it when it has been received. Communication of information to a distant point is generally accomplished through the use of electromagnetic energy as a carrier.

The illustration shows the configuration of the electric and magnetic fields about a short vertical antenna in which flows a sinusoidal current. The picture applies either to an antenna in free space (in which case the illustration shows only the upper half of the fields), or to an antenna projecting above the surface of a highly conducting plane surface. In the latter case the conducting plane represents to a first approximation the surface of the Earth. The fields have symmetry about the axis through the antenna. For pictorial simplicity only selected portions of the fields are shown in this illustration. The magnetic field is circular about the antenna, is perpendicular at every point to the direction of the electric field, and is proportional in intensity to the magnitude of the electric field, as in a plane wave. All parts of the wave travel radially outward from the antenna with the velocity equal to that of a plane wave in the same medium.

Often it is desired to concentrate the radiated energy into a narrow beam. This can be done either by the addition of more antenna elements or by placing a large reflector, generally parabolic in shape, behind the antenna. The production of a narrow beam requires an antenna array, or alternatively a reflector, that is large in width and height compared with a wavelength. The very narrow and concentrated beam that can be achieved by a laser is made possible by the extremely short wavelength of the radiation as compared with the cross-sectional dimensions of the radiating system.



Absolute permeability of the medium; ε = permittivity of the medium; γ = wavelength.">
Configuration of electric and magnetic fields about a short vertical antenna. E = electric field intensity; H = magnetic field intensity; μ = absolute permeability of the medium; ε = permittivity of the medium; γ = wavelength.

The ground is a reasonably good, but not perfect, conductor; hence, the actual propagation over the surface of the Earth will show a more rapid decrease of field strength than that for a perfect conductor. Irregularities and obstructions may interfere. In long-range transmission the spherical shape of the Earth is important. Inhomogeneities in the atmosphere refract the wave somewhat. For long-range transmission, the ionized region high in the atmosphere known as the Kennelly-Heaviside layer, or ionosphere, can act as a reflector. When an electromagnetic wave is introduced into the interior of a hollow metallic pipe of suitably large cross-sectional dimensions, the energy is guided along the interior of the pipe with comparatively little loss. The most common cross-sectional shapes are the rectangle and the circle. The cross-sectional dimensions of the tube must be greater than a certain fraction of the wavelength; otherwise the wave will not propagate in the tube. For this reason hollow waveguides are commonly used only at wavelengths of 10 cm or less (frequencies of 3000 MHz or higher). A dielectric rod can also be used as a waveguide. a system of material boundaries in the form of a solid dielectric rod or dielectric-filled tubular conductor capable of guiding high-frequency electromagnetic waves, such a rod, if of insufficient cross-sectional dimensions, can contain the electromagnetic wave by the phenomenon of total reflection at the surface.

Electromagnetic energy can be propagated in a simple mode along two parallel conductors. Such a wave guiding system is termed a transmission line. Three common forms are the coaxial cable, two-wire line, and parallel strip line. As the wave propagates along the line, it is accompanied by currents which flow longitudinally in the conductors. These currents can be regarded as satisfying the boundary condition for the tangential field at the surface of the conductor. The conductors have a finite conductivity, and so these currents cause a transformation of electrical energy into heat. The energy lost comes from the stored energy of the wave, and so the wave, as it progresses, diminishes in amplitude. The conductors are necessarily supported by insulators which are imperfect and cause additional attenuation of the wave.

standing-wave detector

(*electromagnetism*) An electric indicating instrument used for detecting a standing electromagnetic wave along a transmission line or in a waveguide and measuring the resulting standing-wave ratio; it can also be used to measure the wavelength, and hence the frequency, of the wave. Also known as standing-wave indicator; standing-wave meter; standing-wave-ratio meter.

Retrievable tools vs. Fixed mounted tools

MWD tools may be semi-permanently mounted in a drill collar (only removable at servicing facilities), or they may be self-contained and wireline retrievable.

Retrievable tools, sometimes known as *Slim Tools*, can be retrieved and replaced using wireline though the drill string. This generally allows the tool to be replaced much faster in case of failure, and it allows the tool to be recovered if the drillstring becomes stuck. Retrievable tools must be much smaller, usually about 2 inches or less in diameter, though their length may be 20 feet or more. The small size is necessary for the

tool to fit through the drillstring; however, it also limits the tool's capabilities. For example, slim tools are not capable of sending data at the same rates as collar mounted tools, and they are also more limited in their ability to communicate with and supply electrical power to other LWD tools.

Collar-mounted tools, also known as *Fat Tools*, cannot generally be removed from their drill collar at the wellsite. If the tool fails, the entire drillstring must be pulled out of the hole to replace it. However, without the need to fit through the drillstring, the tool can be larger and more capable.

The ability to retrieve the tool via wireline is often useful. For example, if the drillstring becomes stuck in the hole, then retrieving the tool via wireline will save a substantial amount of money compared to leaving it in the hole with the stuck portion of the drillstring. However, there are some limitations on the process.

Limitations

Retrieving a tool using wireline is not necessarily faster than pulling the tool out of the hole. For example, if the tool fails at 1,500 ft (460 m) while drilling with a triple rig (able to trip 3 joints of pipe, or about 90 ft (30 m) feet, at a time), then it would generally be faster to pull the tool out of the hole then it would be to rig up wireline and retrieve the tool, especially if the wireline unit must be transported to the rig.

Wireline retrievals also introduce additional risk. If the tool becomes detached from the wireline, then it will fall back down the drillstring. This will generally cause severe damage to the tool and the drillstring components in which it seats, and will require the drillstring to be pulled out of the hole to replace the failed components, thus resulting in a greater total cost then pulling out of the hole in the first place. The wireline gear might also fail to latch onto the tool, or in the case of a severe failure, might bring only a portion of the tool to the surface. This would require the drillstring to be pulled out of the hole to replace the failed components, thus making the wireline operation a waste of time.

BASIC EM TRANSMISSION THEORY

- Measuring the potential voltage across a gap.
  (Multimeter)

- The EM Signal always tries to return to the opposite side of the Gap Sub.

- As the EM Signal travels up the Drill Pipe it leaks off through the surrounding formations and returns to the opposite side of the Gap Sub.

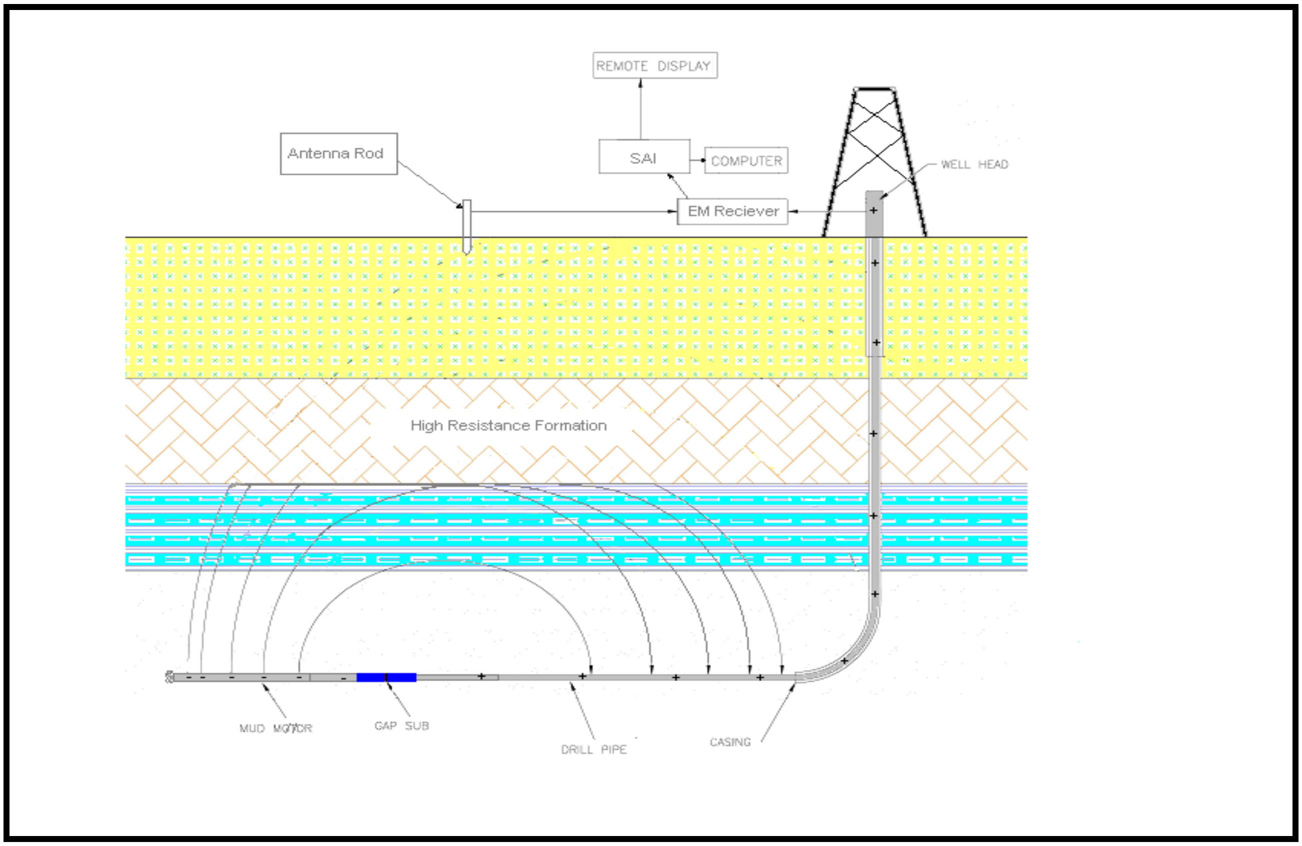
- The objective is to get enough signal to the surface so that it can be detected by the Surface Receiver.

COMPASS EM

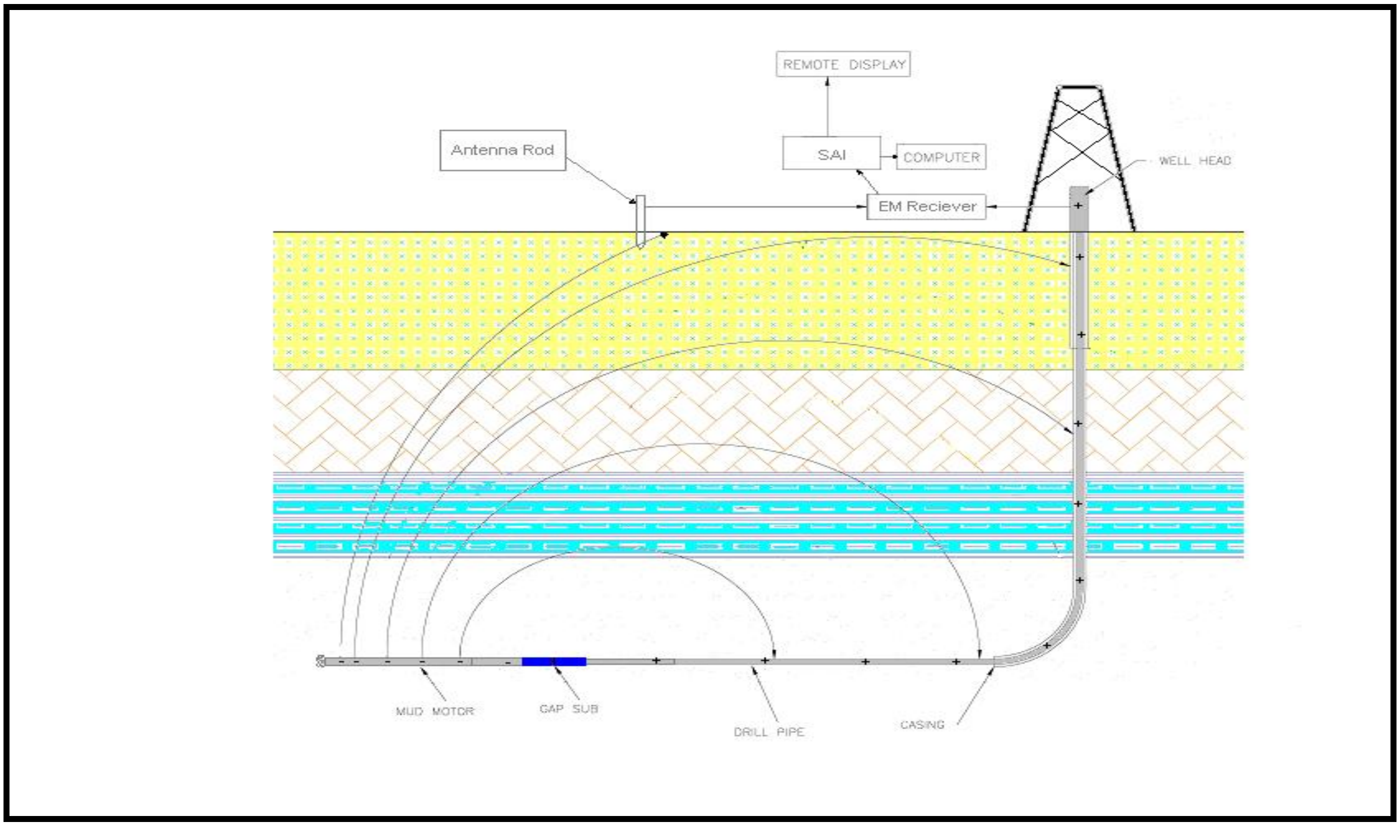
- Designed to be compatible with the positive mud pulse tool
- Uses a pulse wave low frequency 1-2 Hz (more efficient on batteries)
- Variable power selection
- Low Voltage EM: 1, 3, 5, & 8 amps
- High Voltage EM: 1, 2.5, & 4 amps
- Ease of operation

FORMATIONS

- **2 -20 ohms is ideal for Low Voltage**
- **4 -40 ohms with High Voltage**
- **High resistance acts as Open Circuit**



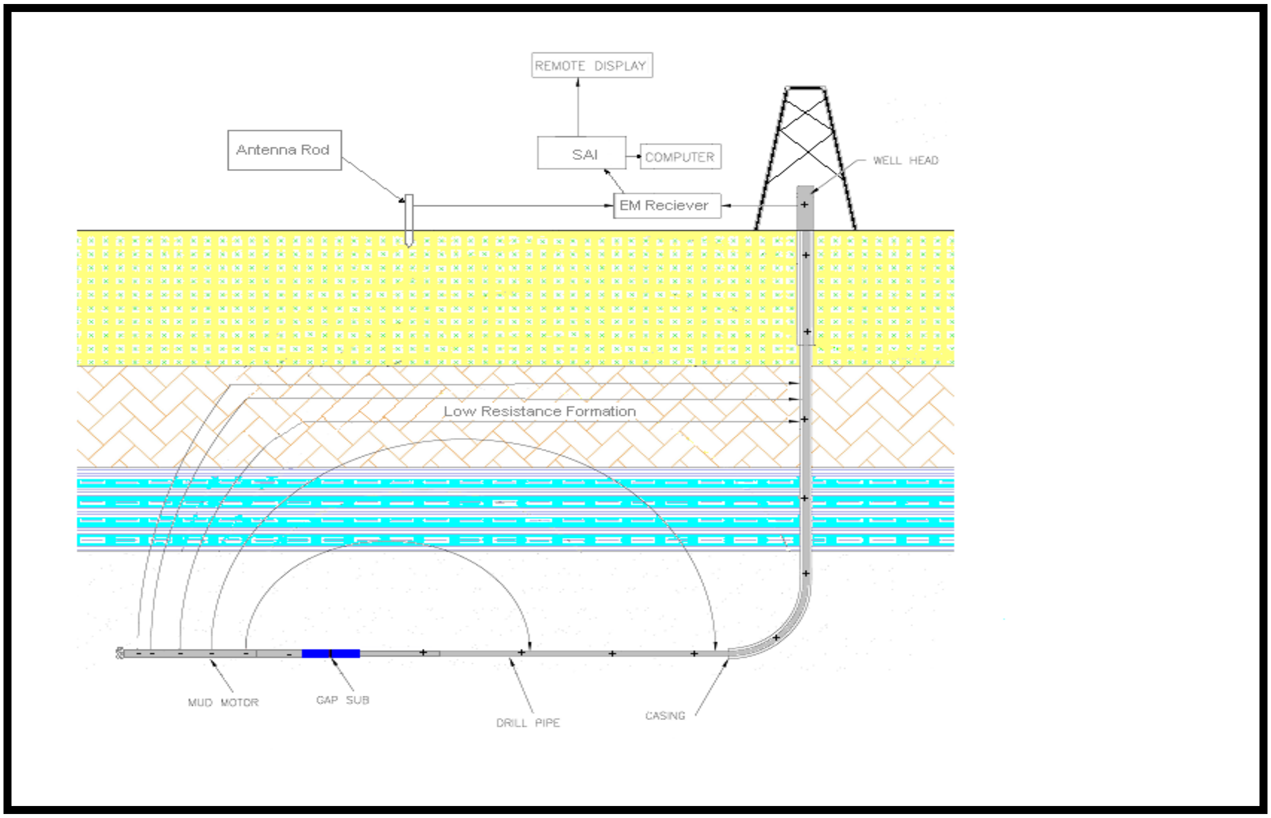
GOOD SIGNAL TO SURFACE



Good reception, all circuits connect.

POOR SIGNAL TO SURFACE

- **Low Resistance acts as a Short Circuit**

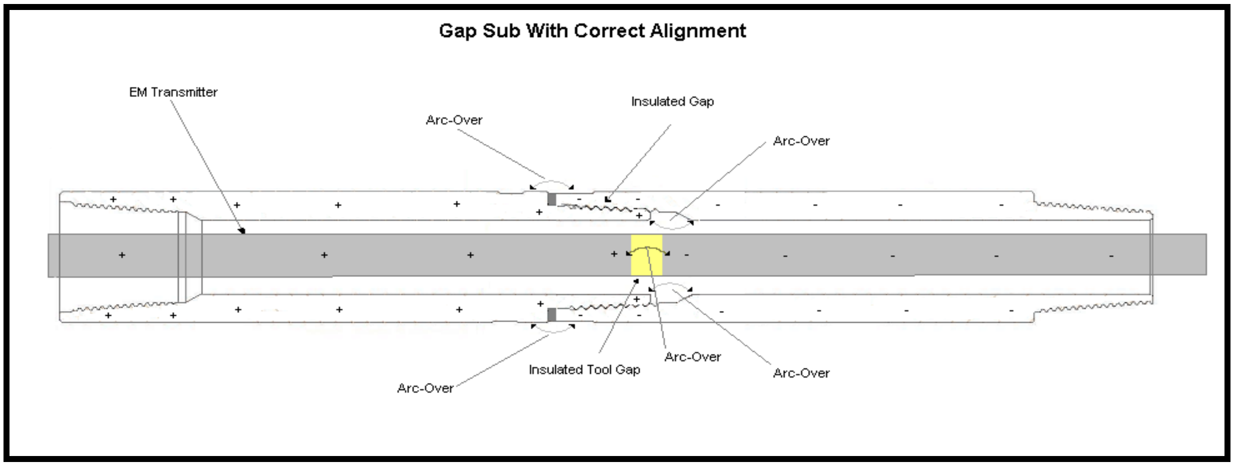


DRILLING FLUIDS

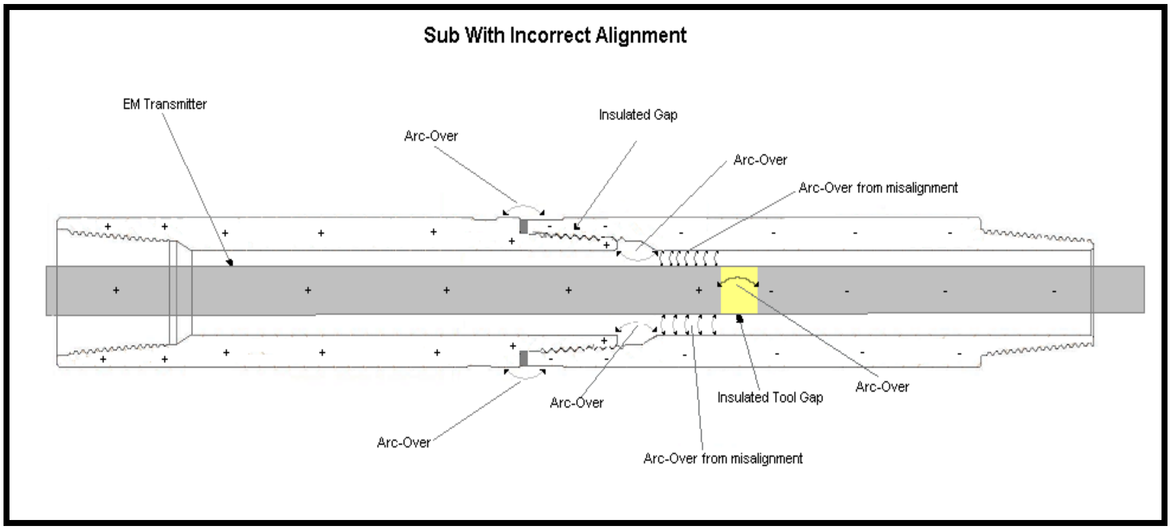
- Signal is lost into low resistance mud, similar to formations, high resistance mud (e.g. Invert) is a good insulator.

ISOLATION SUB (GAP SUB) ALIGNMENT

- **+ / - 6.0" alignment**
- **Arc over currents through mud**



- **Incorrect Alignment Degrades Signal & Wastes Battery Life**



CONTACT POINTS

Down Hole

- Bow Spring Centralizers (make sure they are tight)
- Contact Spring on Helix (replace after every run)

Surface

- BOP cable 300’ or 100m
- Attached to BOP (optional attached to ground stake next to BOP)
- Antenna cable 600’ or 200m
- Ground Stake (the deeper into the ground the better)
- Clean contact points, poor contact will result in noisy signal

EQUIPMENT TRANSPORTATION

Surface System

The EM Down-hole Tool Strings shall be transported in kit boxes. Where possible, sensitive equipment (computers, surface system) are to be transported in a protective environment. If safe to do so, tools can be transported in the cab of a pickup or in a protected place (pick-up with hard shell topper).

Down hole Tool Strings

The EM tool shall be transferred in a warm, waterproof environment. The preferred location is either in the vehicle cab or heated truck box with topper.

All tools and barrels are to be cleaned and tagged with the appropriate information. Equipment that is damaged or requiring service shall be red tagged and its condition relayed to the coordinator prior to its return.

Batteries

When a job is dispatched the operator is to review battery requirements and ensure that he has ample supply to complete the job plus budget for failures and extended runs. Typically a kit will be supplied with 2 sets in barrels, one of which may have low life remaining. It is expected that operators will try to maximize battery consumption prior to rebuild. After a battery is depleted the operator shall inform the coordinator who will decide whether or not a battery shall be rebuilt in the field or returned to the shop. The return of a battery in rebuilt or stripped condition is deemed the responsibility of the field hand and shall be completed when a kit is turned in. Batteries are to be transported in accordance with UN regulations

C. THEORY OF CODING & DECODING

For some who are used to operating other MWD systems where manual decoding is possible, not having this option available may be a little concerning. However, after working with the QSI system you will find that manual decoding is not really necessary. The QSI system can normally decode even in the worst situation with a few changes to your set-up.

To better explain how the system works the following is QSI's paper on their system.

QMWD Coding, Detection and Decoding Processes; A Brief Description

1. Background

A large number of different coding schemes have been used for encoding MWD mud pulse signals. A paper by Steve Monroe (SPE 20326, 1990) discusses the relative advantages and disadvantages of these methods, especially with regard to their "Data Rate" (data bits per second), "Pulse Rate" (pulses per data byte) and "Signal Efficiency" (data bits per pulse). The method that QDT uses is not discussed in Steve Monroe's paper but has a name similar to one described in the paper. We call our method "M-ary coding". We have chosen this method for its reasonable combination of good data rate and good signal efficiency, as well as some desirable characteristics related to having to detect only a single pulse in the presence of noise.

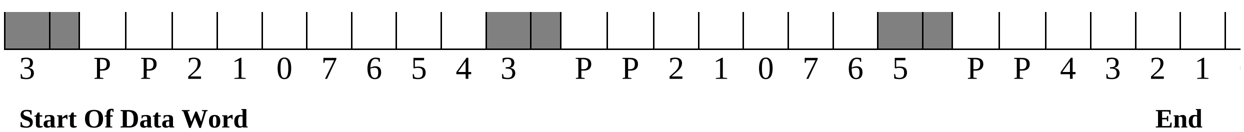
2. “M-ary Coding”

QDT’s coding method involves breaking up any data word into combinations of 2 and 3 bit symbols, each encoded by locating a single pulse in one-of-four or one-of-eight possible time slots. For example for the case of an 8 bit data word encoding a value of 221 is shown below:

Word value: 221; maximum value: 255; digital value:

128	64	32	16	8	4	2	1
1	1	0	1	1	1	0	1

This encodes in “M-ary” as 3, 3, 5 where the first 3 comes from the symbol containing 11, the two most significant bits of the digital word, then 3 from the next symbol, 011, and the final 5 from the 3 bit symbol, 101. This is visually shown as:



Where the pulses are transmitted most significant first.

In the above example we have chosen to use time slots (time resolution-intervals) equal to one half the pulse width, and have allowed for a full pulse width (two slot) pulse-interference-gap (PIG) or recovery time after each pulse. These choices were mainly based on earlier modeling and experimental work (Marsh, Fraser and Holt: SPE 17787, 1988). One important feature of this method is that we have to find only the best single pulse in a window containing four or eight possible locations for the pulse. This feature increases the robustness of the detection process at the expense of data rate and signal efficiency.

3. Synchronization of the Detection and Decoding Processes with the Transmitted Signals.

QDT uses either a triple wide pulse or four consecutive single wide pulses followed by three to eight single wide pulses to provide a method of synchronizing the surface equipment to the transmitted data sequences. The surface receiver equipment functions by looking first for one received pulse matched to the shape of the triple wide pulse, or four consecutive single wide pulses, followed by establishing a time base derived from the received positions in time of the three or more single wide pulses. The receiver also utilizes a tracking loop that removes clock drift by slowly adjusting the surface timing based on the average location in time of the received pulses.

4. Pulse Detection

The QDT receiver uses the cascade of a simple front end analog roofing filter, followed by a steep cut off tuneable low pass filter, followed by a matched filter executed in software. This methodology is discussed in the paper by Marsh, et. al. mentioned above. The matched filter has been shown to be the optimum filter for detecting signals corrupted by additive white Gaussian noise under a wide variety of criteria. Use of the matched filter has proven effective in many different MWD systems over the years. QDT has the ability to shift the tuneable filter edge during operation to help reduce the effect of inband interference. For those cases where the noise / interference is concentrated in the upper portion of the passband, manually lowering the "low pass" cut off frequency will reduce the noise / interference faster than it reduces the signal resulting in enhanced signal detection quality. The results of the pulse detection process are the application in time of the centroid of the "best" pulse located in the allowed time window, its amplitude and other characteristics. In case multiple pulses are detected in the allowed symbol window, and evaluation process is started which may enable the correct pulse to be selected.

Decoding Process

After each pulse is detected, the value of the symbol corresponding to its location is determined, and when all of the expected pulses that make up a data word have been received, the decoded value is reported to the receiver display and logging functions. The receiver display maintains files containing all decoded data words, pulse data buffers (contains the characteristics of all detected and suspected detected pulses), and pulse waveform records (contains a stripchart vs time of the output of the matched filter process.)

5. Parity Check and Error Correction Code

Each data word and header (if used) can be encoded with parity or error correction code symbols added to the data. The parity check will detect a single one-slot pulse position error contained in the detected data word. The error correction code will detect a single two-slot pulse position error, and correct a single one-slot pulse position error. The single slot error in pulse location is the most likely form of error source to be expected in the received signal.

6. Other System Capabilities

The qMWD Engineer's Reference Manual describes in detail many system attributes such as the ability to detect either positive or negative pressure pulses, the wide variety of available formats for data words and the ability to change almost any parameter of the tool while downhole using a series of timed flow off and on sequences. The system has been used to successfully encode and decode several other proprietary signal formats.

NOTES

NOTES

CHAPTER 3 – OPERATIONS MANUAL: SURFACE HARDWARE & SOFTWARE

A. BENCHTREE
B. GE
C. KEYDRILL
D. DRIGIDRILL

A – BENCHTREE

OPERATIONS MANUAL

Bench Tree Group

MWD Receiver Software

For Windows 2000 and XP

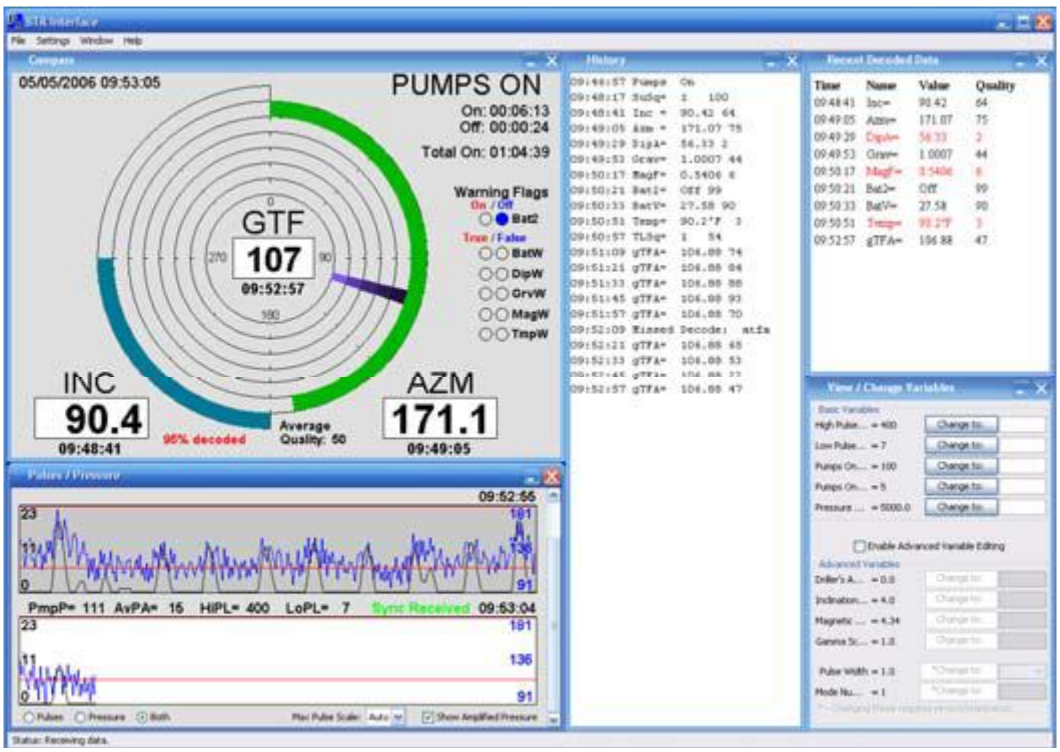


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Table of Contents

Document Overview

This document provides information on the installation and use of the software programs which interface with the Bench Tree Receiver (BTR). This document is split up into sections each focusing on a different software package. Each section will give an overview of the different program components and go into detail on how to use the different parts of the program. If you need to find any section of the document quickly, use the table of contents located on the previous page.

BTR Interface

Version 1.3

Installing the software
Insert the Bench Tree Group MWD Software Installation CD into the computer's CD drive. The computer must have Windows 2000 or XP operating system to run correctly. Follow the on screen
directions to install the software onto your hard drive. You must read and agree to the user license before
the installation can occur. If your computer does not have a java runtime environment, you will be prompted to install one. This is necessary for the program to run correctly. The installation will provide a
link to the program from both the desktop and the start menu.

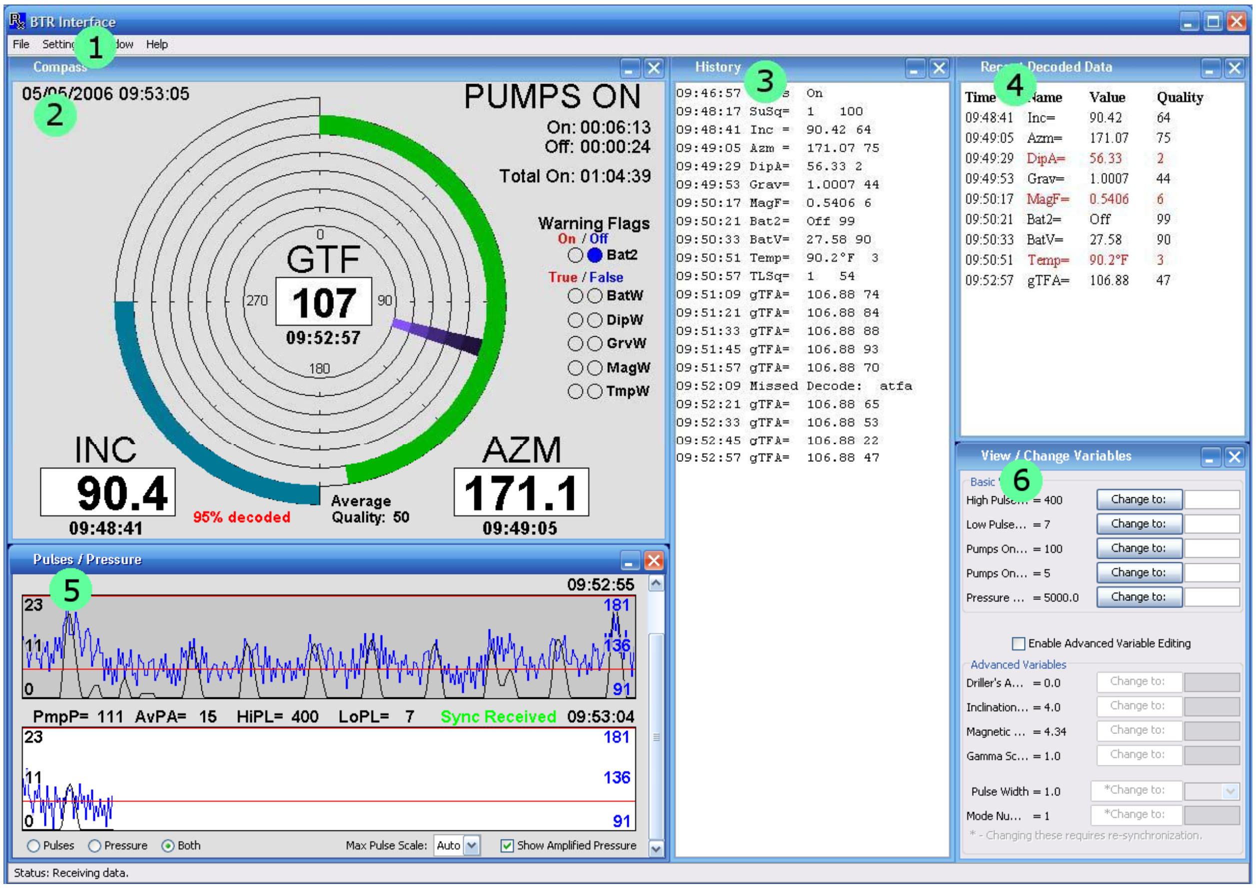
Installed locations
The program files will be installed in the directory C:\Program Files\Bench Tree Group\BTR Interface\. This option is changeable during installation, but the default location is listed here for your
reference. A link to the main program is installed on the desktop and in the start menu. The icon for the
main program is ( ) and is labelled BTR Interface. To access the start menu links, click on the *Start*
button, then click on *All Programs*, click on *Bench Tree Group* and the links will be displayed to the
right. If you wish to uninstall this program at any time, the uninstall link is located in the Bench Tree
Group links directory. Uninstalling will not delete any of your saved files. Only the program files will be
deleted during the uninstall process.

Connecting to the receiver

Using a standard Ethernet cable, connect your computer to the BTR. Turn the receiver on. Open the program and it will connect to the receiver within a minute and begin displaying data. The progress
bar displayed will show you the amount of time it may take to connect to the receiver. Once a connection
has been established, this window will automatically close. If the progress bar is still displayed after a
minute, check the Ethernet connections.

- If you still are having problems connecting, refer to the help.html which can be accessed from the
start menu under the Bench Tree Group folder. Once you are successfully connected, the status bar at the bottom of the window will display information about the received data. If it displays "Receiving data", then everything is connected properly and you are ready to start using the program. **WARNING:** Do not allow the computer to "hibernate" while this program is running. The program cannot communicate during this state and will not record data. Please shut down the program
before closing the lid of a laptop to ensure proper functionality.

PROGRAM LAYOUT



Program with labelled internal windows

1. Menus
2. Directional Compass display
3. All received history from current transmission sequence
4. Recent decoded values for the current transmission sequence
5. Graphed pulses and pressure
6. Changeable receiver variables

USING THE PROGRAM

The internal windows can be moved and most of them can be resized. If you do not wish to view one of the windows currently displayed, click on the red x in the top right corner of that window. If you wish to view one of the windows that is not displayed, go to the Window menu and click on the name of the one you wish to view. Check marks by each name will indicate all of the windows that are currently displayed. If you would like to move everything back to how it was when you first started, go to the Help menu and click on Reset Window Locations. Whenever you exit the program, the current window positions will be saved and used for the next time the program is started.

Compass Window

The Compass window graphically displays the values of inclination, azimuth and recent tool faces. The inner five rings represent the recent tool faces. The most recent tool face angle value is printed on the inside of the center ring. The outermost full ring represents the azimuth. Azimuth is shown starting at the top of the circle and the value increases clockwise. The half ring on the left represents inclination starting at 0 degrees on the bottom and is displayed up to 180 degrees at the top. The recent tool face, azimuth and inclination values are displayed as a number with the timestamp below the number in this window too.

Pump Status and Pump Timers:

On the top right of the compass window, the current pumps status is shown with the most recent on and off timers. Each value will only display the current pump status time and the previous time for the other pump status. The total on time represents the total amount of time the pumps have been on since the receiver has been running.

Warning Flags:

On the right side of the compass window, the warning flags are shown. The names of the flags are displayed with two circles to the left of each name. Both circles to the left of the flag name will be empty (same color as the background) until the flag value has been decoded. If the flag value is "True" or "On", the left circle will be filled in red. If the flag value is "False" or "Off", the right circle will be filled in blue.

Pulse / Pressure Window

Stretching the window vertically of the pulse and pressure graphs will increase the number of displayed graphs to the maximum that will fit on your screen. On the bottom of this window, there are several options to choose from. You can select to view either pulses, pressure or both together from the radio buttons on the left. You may select to turn on single scaling for all graphs and amplified pressure. Using the same scaling for all graphs will apply the same scale only to all visible graphs. Viewing the amplified pressure will automatically scale displayed pressure vertically to best fit on the graph. The red line displayed on the graph represents the low pulse limit (LoPL). It is displayed to the same scale as the pulses and only visible while viewing the pulses. The value of this line is displayed above the bottom graph in the window. The current pump pressure (PmpP), average pulse amplitude (AvPA) and current synchronization status are also displayed above the bottom graph. The top right of each graph will display the time that the last data on that line was received. The graphs are updated from left to right. Each line will show about 10-15 pulses. The data is updated at different rates depending on the pulse width of the current transmission. Graphs will only display new data when the pumps are on. The graph displaying the current data has a white background and the graphs with older data have a gray background. After the graph line is fully displayed, the graph will be moved up and a blank graph will be displayed for the current data. If you wish to view older data, scroll up using the scrollbar or a mouse wheel. You may view up to 59 previous graphs. You may also set the low pulse limit by right clicking on any of the displayed pulse graphs. This will give you a popup menu option to either set the limit there or cancel that action.

Database Status Window

The database status window is designed to provide the operator with a full overview of the current database logging status. The background color of this window will be light blue if logging is currently active and light orange if there is an issue restricting logging from occurring. There is a row of buttons on the bottom that can be used to control certain database features. The database menu can also be accessed by right clicking on this window. If any of the displayed fields have a problem which may restrict the database logging from operating correctly, a warning icon will be displayed on the left side of the text. The displayed information on the window is explained below.

Logging Enabled –

The user enabled logging status. This value can be changed via the database menu..

Database Ready –

The database must exist and have a run open for this to be enabled.

Job Number –

The name or number of the current job.

Run Number –

The current open run number. If there is no open run, a number will not be displayed and logging will not be allowed.

File Location –

The location of the actual database on the hard drive.

Disk Used –

Current size of the database and also the remaining disk space on the selected drive.

Logged Data -

Lists the types of data stored to the database. If nothing is being logged, a warning flag will be displayed.

History Window

The history window will display all of the received data. It displays all of the decoded values as well as pump status with a time stamp. This data is also stored in the History folder on your hard drive as a .prc file. The files stored on the hard drive are stored in a sub folder for each day and the name of the file is the date and time when the file was created.

Recently Decoded Data Window

This window only displays the decoded values from the survey or tool face sequences that have been decoded from the recent transmission sequence. If a newer value is received, the new value will override the older value. These are displayed for all values received since the last synchronization. The information is displayed in four columns. The first column displays the time the variable value was decoded. The second column displays the variable name from the transmission sequence. The third column shows the transmitted value. The last column shows the quality of the pulses transmitted for that variable. The value can be between 1 and 100 with the higher values indicated a better quality. If the quality is below a certain threshold, the data values will be red to alert the MWD operator of a possible problem.

View / Change Variables Window

This window displays variables from the receiver with their current values. If you wish to change any of these, fill in the box to the right of name and press Enter or click on the “Change to:” button. If the value was stored correctly in the receiver, it will appear next to the variable name. If an incorrect value was entered, you will be prompted that the value could not be stored and the correct value range will be displayed. These values are separated into two sections. The first section contains the basic variables which deal with the pump pressure and pulse heights. These can be changed during transmissions without requiring a re-synchronization. The advanced variables should be changed before synchronization to ensure the correct values are decoded. The bottom two values will automatically restart the receiver and it will lose synchronization if they are changed during transmission decodes. The newly added advanced variables are explained in detail below.

Pressure Transducer Offset (Units: PSI) –

The amount of PSI to subtract out from the measured transducer pressure. This is used to remove false pressure being reported by a damaged transducer.

Low Pass Filter Length (Length) –

The length of one of the receiver's noise removal filters. A longer filter will remove more noise and produce smoother results. A shorter filter will perform better when the pulses are on sloped pressure baseline and possibly in other situations.

Sync Amplitude Threshold (Ratio) –

The minimum ratio that the shortest sync pulse amplitude over the largest pulse amplitude must meet in order to be considered a valid sync. Increasing this number will force the sync detection to be very strict and should only be done if the receiver is false synchronizing on incorrect pulses.

MWD File Window

This window will show you the contents of the currently loaded configuration file. If you wish to view the current configuration in the receiver, press the “Refresh Configuration Data”. If you wish to save a configuration file from the receiver as a file on your computer, press the “Save Configuration To File” and it will allow you to choose a filename.

Shock Window

The shock window displays the received shocks per second values on a horizontal graph. The newest values are inserted at the right side of the graph and the older values will scroll to the left. There are two types of graphs to display: bar graph and area fill. The bar graph separates the shocks into 6 levels of damage risk. The lowest level is a short dark green bar and as the damage risk increases, the shock bars get taller and more red. The other option to display the data is using an area fill graph. This will show a line graph from each previous shock value to the next value and it will fill the underneath area with a gradient fill. As the shocks get larger, they will show more red and when they get smaller they will become more green.

STORED FILES

Up to five different types of files are stored on the hard drive. The five types have the extension .mwd, .prc, .svy, .ftr and .raw. These are all stored inside a subfolder of the History folder. If the job name was entered, all of the data from that job will be stored in the job name folder. Otherwise, each subfolder is labeled by the day the files started being logged. All files are named with the date and time when they are created. The format of the name before the extension is YYYY-MM-DD_HH.MM.SS.

The file types are explained below.

.mwd –

This is a copy of the configuration file stored into the receiver. It is useful to verify the configuration when reviewing the data at a future time.

.prc –

This is the main history file. It stores all of the data sent from the receiver. It includes timestamps for all of the data and it will store everything in this file while this program is open. This file may be created for each day or every run in the preferences window.

.svy –

This file will contain all of the received survey data. The data will be stored in tab delimited columns. Each column will have a header of the data type in that column. Should the received survey data contain different information than the previous survey, a new line with the data headers will appear in the file. Each of the header lines will always be preceded by an empty line. You may view this data in any text editing software or import it into a data sheet program.

.btraw –

This file records the voltage reading from the pressure transducer. These files are necessary to review any problems you may be having with the receiver, pumps or the tool. They are separated into files each time the pumps are established as being on. You may stop recording this from the preferences window if you uncheck the “Save Pressure Files to Disk”. This file can be viewed in the Bench Tree File Grapher program.

.ftr –

This file contains the filtered output from the BTR in PSI units. The data is recorded at 10 Hz to represent the pressure pulses. This is most useful when analyzing the .raw files for pump behavior and the effects on proper decoding. This file can be viewed in the Bench Tree File Grapher program.

Viewing Log Files

If you wish to view any of the logged data files, click on the “Data Logs” menu. This will give you the option to open the “History” folder or directly open up one of the current logs. The history folder will contain all of the previous data log files as well as the current data files. If you choose the “View Current Log” menu option, you will be presented with the type of data log to open. The log types are listed below with descriptions.

Processed –

This log contains all of the data received by the surface receiver and also some user controlled events.

Survey –

This log only contains data sent from the tool during the survey transmission sequence.

Events –

This log contains MWD operator events from multiple programs. Changes to the receiver and the down hole tool are stored into this file.

Viewing Database Survey Reports

The data logged into the database can be viewed using the data reports window. To access this window, click on the "Data Logs" menu and then select "View Reports". You will now be displayed the data from the currently open database. You can select the particular data you wish to view using the tree on the left. There are three levels of data to choose from and they are shown below. The most upper level is the run summary overview. The next level is the full run survey reports and the lowest level is the daily reports.
Each of the data report types will display the current job information at the top of the window above the other information. You can also open up a previously created database from the file menu to view and print any of the database data from the menu.

CHANGING PREFERENCES

The preferences window may be accessed by clicking on the Settings menu and then click on the Preferences menu item. This will open a new window showing you the current settings and what can be configured by the user. This section will go into detail into each section of preferences.

Compass

This section allows you to modify the displayed data on the compass window. The displayed options will not be applied until all of the settings are saved with the Save button.

Colors –

Changes the colors of the displayed item listed next to the box.

Show Warning Flags-

This allows you to display or hide the possible warning values to the right of the compass.

Dim Older Tool Faces –

Selecting this will darken each of the older tool faces. As they become older, they are also displayed darker.

Tool Face Update Order –

This allows you to choose the way the new tool faces are updated on the compass.

Data Format

This section allows you to change the displayed formatting for most of the received data.
Gravity Tool Face Display – Allows you to display the number between -180 and 180, between 180L and 180R or between 0 and 360 degrees.

Temperature Units - Select the temperature type to display: Fahrenheit/Celsius
Decimal Precision - Select the number of decimal place resolution digits to show for each data type.

Generic Variables

This preferences section shows the generic variable names, alternate display name and also the decode routing. The descriptions below go into more detail for each section.

Variable –

This column lists the default generic variable names. These cannot be changed, but may be overridden using the alternate display names.

Alt. Display –

Optional name to display instead of the standard GV#. Allows for a more descriptive name to be presented to the operator and also stored to the logged files.

Decode Routing –

If a generic variable data value represents one of the standard transmitted data types, it may be routed to the standard display windows. If no special routing is selected, the value will be decoded, stored and shown on the decoded data/history windows only.

Miscellaneous

This section allows you to view and change miscellaneous settings.

Force IP to change to desired value –

Select this to option to override the default IP to the selected value. This is usually used when the BTR Interface's IP is in conflict with another network card on the computer.

Show pressure transducer error window –

If this option is selected, a popup window will be displayed every time a pressure transducer error is detected.

Show missed synchronization window –

If this option is selected, a warning window will be displayed if the pumps are on for 3 minutes without synchronization.

Saved Files

This section will allow you to modify what data is saved to your computer's hard drive and also how to separate the data files.

Save Pressure Files to Disk –

Selecting this will record the raw and filtered pressure data to the hard drive.

Compress Data –

This will compress the raw pressure data to about 10% of the original size. The compressed data is good for storing on the hard drive but is not as good for deeper analysis of possible transmission or detection problems.

Sounds

This section allows you to turn on and off the program sounds. You are also allowed to choose your own custom .wav files to play for a particular event. You can enable or disable all sounds by checking the top box. You can also disable a particular sound by using the check box next to the sound.

Pumps On –

This sound will play when the pumps go from off to on.

Sync Pulse –

This sound is played when the sync pulse is received.

Pumps Off –

This sound is played when the pumps go from on to off.

Error –

This sound is played when an error window is displayed.

TF Update –

This sound is played every time a new tool face is received.

Missed Decode –

This sound is played every time a transmitted value is not decoded properly

Warnings

These options allow the user to configure the warning settings used to calculate if the received data is within the valid expected range for your location. The nominal values and tolerance limits are retrieved from the configuration file currently being used. You may override these values if they were not correct for the location.

Compare received data against valid data ranges –

This enables the warning flag calculation from the decoded transmission data.

Override configuration values –

Selecting this will allow the user to use a custom set of tolerance limits instead of the configuration values.

Dip Angle –

Dip angle (degrees) and (+/-) tolerance

Magnetic Field –

Magnetic field (gauss) and (+/-) tolerance

Gravity Field –

Gravity field (gee) and (+/-) tolerance

Temperature Maximum –

Maximum temperature (°C or °F) before warning is set

Battery Low Voltage –

Lowest Battery Voltage (volts) before warning is set

WITS

This section deals the with WITS (Wellsite Information Transfer Specification) serial output options. The WITS data will come out of the serial port from your computer. If you don't have a serial port located on the computer, you can purchase a USB to serial adapter to interface with other devices.

Enable WITS Output –

This will enable WITS data to be sent out the computer serial port.

Comport –

Choose the serial comport from the available ports. The serial comport must be available when the program is started for this program to recognize it.

Baud Rate –

Choose the WITS serial baud rate you are using.

WITS Data Output –

Check any of the data listed that you wish to send out the WITS port.

SHUTTING DOWN & SAVING USER SETTINGS

If you are connected to a BTR version 1.5.5 or higher, you will be able to shutdown the system from this Windows interface program. This option is located under the File menu and it is the selection called “Shutdown BTR”. The program will prompt you to verify that you are about to shutdown the system making the receiver non-operational. Shutting the system down this way will ensure that all system files are closed correctly.

HELP USING THE PROGRAM

If you have questions on how to use the program, click on the *Help* menu and select *Help Contents*. This will display a searchable help file.

After moving and resizing the windows, you may want to reset them back to their original size at some point. To do this select the *Help* menu and click on *Reset Window Locations*.

Clicking on the *About* item from the *Help* menu will display the current software version information.

FREQUENTLY ASKED QUESTIONS

***Q**: How do I view data received from the BTR?*

A: This program stores all of the data received into the History sub-folder of your installed program directory. The data is stored in folders for each day it was received in the History folder. The folder name format is YYYY-MM-DD. The files stored in this folder are described in section 6 of this document. They are all standard ASCII text documents and can be opened in any text editor. An easy way to access this folder is to click on the Data Logs menu and select the item titled "Open History Folder".

***Q**: Why won't the program connect to the receiver?*

A: There are many reasons this may happen. Some of them include: improper cable connection, receiver not powered on, firewall settings and wrong cable type. Any Windows version other than 2000 or XP will not work without manually changing your IP address. Check the troubleshooting section below for more details.

***Q**: How do I send a new configuration to the receiver and tool?*

A: Refer to "Storing configurations to receiver/tool" section in the MWD Configuration Utility section of this document.

***Q**: How do I measure and calculate the Driller's Assembly Offset (DAO)?*

A: Instructions are located in a separate help window located inside of this program. To access this window, you can click on the Help menu and select the "Calculate DAO" menu item. This will bring up a window with the instructions on how to measure the angle and also provide the controls to calculate the DAO angle in degrees using the measured values.

TROUBLESHOOTING

Problem: Program doesn't start

- Try uninstalling the program and reinstalling from the CD. If the program prompts you to install Java, you must install it. Java is required to run this program on your computer.

Problem: Program starts, but won't connect to the receiver ("Connecting to the receiver…" window is displayed)

- Verify that the Ethernet cable is a compatible cable (same type provided with the product) and it is fully plugged in at both ends.

- Verify that the receiver is on and operational (start-up screen is no longer being displayed).

- Force Windows to renew its Ethernet IP by the following steps: Go to Control Panel. Click on Network

Connections. Right click on Local Area Connection and click Disable. Right click on Local Area Connection and click Enable

- Make sure that you do not have a software firewall set up to restrict program access to the "internet". The Local Area Connection must also be enabled. The BTR Interface must be given access to communicate over the Ethernet port or it will not work.

- Allow the program to try and connect to the receiver for up to two minutes.

- If this still doesn't work, try disabling the wireless network card if it is present on your machine. If the connection has still not been made, close the program, wait 15 seconds and then restart the program.

- If you are using a Windows version other than 2000 or XP, You will need to manually change the IP address. Under the control panel, you will need to change your network properties for the Local Area Connection. Change the TCP/IP address to 192.168.0.15 with a subnet mask of 255.255.255.0. Restart your machine after this and try restarting the program.

If you are still having problems with this software, feel free to contact Bench Tree Technical Support -service@benchtree.net

MWD Configuration Utility

Version 1.4

Installing the software

This software is packaged in the MWD Software Installation CD. It is installed after running the automatic install from the CD. If you have any questions on the installation, refer to the installation section in the beginning of this manual.

Starting the Program

After installing the program, you will have shortcuts to access the program from the desktop and from within the start menu in the Bench Tree Group folder. It is recommended that you have the BTR powered on and are connected to it with an Ethernet cable before starting the program. If you wish to correctly communicate to the receiver from this software, the BTR must have a firmware version of 1.5.4 or higher. Connecting to the BTR is not required if you only wish to use the editing features of this program.

Using the Program

Upon starting the program, you will be prompted to choose a configuration file to open. Choose the MWD configuration file you wish to use or click Cancel to use default settings. The program will then display the configuration variable names and values on the right pane. The left pane of the program contains links to the section titles of similar variables. Clicking on a title on the left pane will display the related section of variables on the right pane.

Editing Variables:

You may edit any of the variables by changing the values to the right of the name. Pressing enter after changing a value will confirm the validity of the change. If the entered value is invalid or out of range, the program will prompt you with an error message. You will be given the option to have the previous value automatically reloaded or you can re-enter the value yourself. Once a variable field has been selected, information about the variable units and valid ranges will appear on the bottom bar of the program. You will not be allowed to save a file if it contains an invalid variable entry. This prevents anyone from loading an invalid configuration file onto the receiver or the tool. If you need help inputting a valid Survey or Tool Face/Logging sequence, please refer to the help section in this document entitled “Editing Sequences”. After modifying a file, you can save the file by selecting the File menu and then clicking on Save or Save As. You may also use the Control-S shortcut to save a file. The program will always prompt you for verification before it overwrites an existing file.

Storing Configuration to the receiver/tool:

Before uploading a configuration to the BTR or a tool, you must have the file currently opened in this program. If you have not saved the file before uploading, you will be prompted to save the file before the upload process can take place. You must also have the BTR powered on and connected to the BTR with an Ethernet cable. To start the upload process, click on the “Load/Store” menu and then click on the “Store to …” item. You may select to either store the configuration file to the tool or BTR only or to both simultaneously.

Retrieve Configuration from the receiver/tool:

After the BTR is powered on and connected to the computer via the Ethernet cable, you may use this program to load the configuration from the BTR. First click on the “Load/Store” menu and then select the “Load from …” item. Select a hardware type and the configuration file will be loaded into the program for you to view. You will notice the title of the program will change to “Current receiver configuration” or “Current tool configuration” after this process is complete.

TOOL COMMUNICATIONS

You may send and receive messages directly to the tool using the “Tool Communications” window. To access this window, click on the Communications menu and then click on Tool. Type in a message in the “Text to Send” box or select a pre-defined message from the drop down box. You may send the message by pressing Enter or clicking on the Send button.

A record of messages/responses is shown in the large white portion of the window. Messages sent from the MWD operator are colored green and responses from the tool are colored blue. You may clear all the stored text in the text areas by clicking on the “Clear Windows” button. If you wish to pause receiving data, click on the “Pause Transmissions” button. Partial list of tool communication commands: CCod 11;CCod?

This command must be sent before changing some values

Bat2? Requests the battery 2 status

BatV? Requests the battery voltage level

TFO? Requests the Tool Face Offset

Inct 4;Inct? Set the Inclination Threshold to 4 and requests the IncT value
SyTy? Requests the Synchronization type

HdCk? Requests the header error checking type

Bat2 “Off”;Bat2? Turn Battery 2 off and verify

Ver Request the firmware versions

DSNs? Request the tool serial numbers

EDITING SEQUENCES

The section describes the basics about the variables and syntax characters for different transmission sequences. Below is a list of the available variable names for transmitted values in the sequences. The variables come in two main types: logical and regular. Logical variable values can only represent On/True or Off/False. The variable names are on the left and a description is located in parentheses next to the variable name. The variable names are not case sensitive.

Regular Variables Logical Variables

Inc (Inclination)	Bat2 (Battery 2 state - On or Off)
aTFA (Auto tool face angle)	BatW (Battery voltage warning - True or False)
gTFA (Gravity tool face angle)	GrvW (Gravity warning - True or False)
mTFA (Magnetic tool face angle)	MagW (Magnetic warning - True or False)
Azm (Azimuth)	DipW (Dip angle warning - True or False)
Grav (Gravity)	TmpW (Temperature warning - True or False)

Temp (Temperature)
BatV (Battery Voltage)
Gama (Gamma)
MagF (Magnetic Field)
DipA (Dip Angle)

SYNTAX

Transmitted Bits:

Each regular variable requires a transmitted bit amount. This number is added directly after the variable name and is separated by a colon ':'. The valid bit range is between 1 and 21 bits.

Ex: Inc:**9** - This will request Inclination transmitted in 9 bits

Error Checking:

An optional error check can be added to either regular or logical variable transmissions. This can be added to the transmission by following the bit count with a colon ':' and then the character 'P' for parity and 'E' for ECC error checking. If desired, the whole word may be spelled out for either "parity" or "ecc". The words are not case sensitive.

Ex: Azm:8:**P** - This will send Azm in 8 bits and add an extra parity bit to the transmission for a total of 9 bits.

***Looping*:**

A group of variables may be transmitted for a specified number of times before the next variables are transmitted in a sequence. Loops may be of a specific amount, between 1 and 255, or infinitely repeat. In order to send a finite number of loops in a sequence, first type the number of loops immediately followed by a left brace '{'. This will begin a finite loop. Type in all variables names you wish to include in the loop using the standard transmission syntax and end the loop with a right brace '}'.

> Ex: Azm:8 **5**{aTFA:6 Temp:6} – This will send the Azm variable and then send the aTFA and Temp values five times.

To send an infinite loop, do not put a number in front of the left brace. Once an infinite loop is entered, it will never be exited. Any variables put after an infinite loop will never be reached. The entire tool face/logging sequence is an infinite loop by definition and it does not require surrounding braces around the whole variable sequence.

CHANGING PREFERENCES

The preferences window may be accessed by clicking on the Settings menu and then clicking on the Preferences menu item. This will open a new window showing you the current settings and what can be configured by the user. This section will go into detail in each section of preferences.

START-UP

This preferences section will show you the options that you can change for the program to alter the startup conditions.

Load Previous Window Positions –

Displays the windows in the same positions as they were when the program was closed.

Show Open File Dialog on Start-up –

This will display a file chooser window for you to open a MWD file.

Default Variable Values –

This deals with the values loaded in the displayed MWD file when no file is opened at startup. You may choose to use the program defaults or use a custom file.

Generic Variables

This preferences section shows the generic variable names, alternate display name and also the decode routing. The descriptions below go into more detail for each section.

Variable - This column lists the default generic variable names. These cannot be changed, but may be overridden using the alternate display names.

Alt. Display - Alternate display name for the generic variables. If a name is provided here, it will be displayed in the configuration file with this name and also appear in the BTR Interface using this name.

Decode Routing - This option allows the user to route a decoded generic variable value to a display window in the BTR Interface. These values may be edited in BTR Interface and are currently not stored in the configuration file so they must be entered locally on each machine.

Miscellaneous

This section will contain any options which do not fit within the other listed preferences categories.

Auto InvF="Off" Before Programming Tool –

This option will try to turn off the inverse flow switch on the tool before it is programmed with a configuration file. If the inverse flow switch is left on, the tool will not be fully programmed.

Verify Each Tool Programming Response –

This option forces all of the programmed values verified to be correct before any other values may be stored to the tool.

Show Comparison Window After Programming –

This option automatically begins the tool and receiver configuration comparison process after the tool has been programmed.

Show Transmission Sequence Information –

When this option is enabled, the transmission timings for each transmission sequence are shown beneath each sequence.

Tool Communications

This section will allow you to change the settings that are used when you are using the tool communications window.

Display Transmission Overhead –

This will show you all of the characters used to communicate with the tool including the header and handshaking characters.

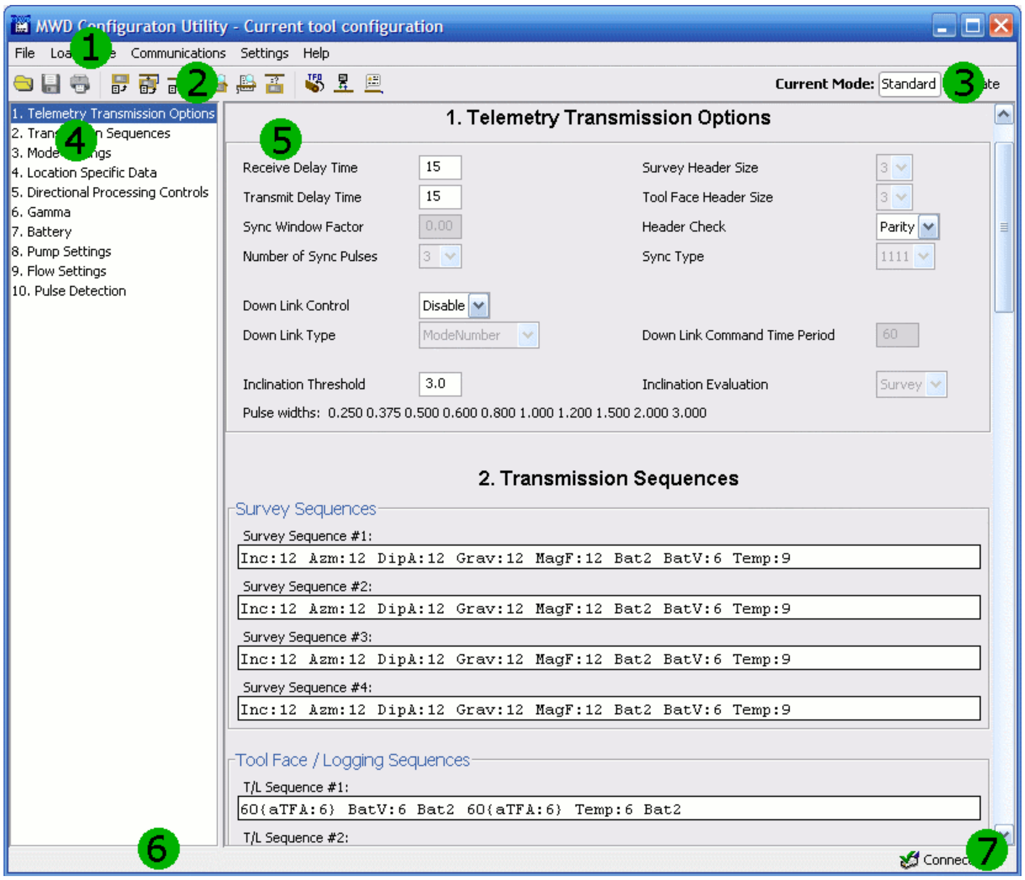
Display All Received Messages Window –

This will allow you to view a separate window only displaying received messages from the tool. It will appear below the command/response window.

Auto Send "CCod 11;" Before All Messages –

This will automatically set the capability code to all access mode allowing you to change any tool variables without manually changing the capability code.

Program Layout



MWD Configuration File Creator with labels

1. Menus
2. Toolbar
3. Optional Tool Type Selector
4. Shortcut Pane
5. Variable Definition Pane
6. Information and Status Bar
7. Connection Status to BTR

TROUBLESHOOTING

Problem: Program will not load/store anything from the receiver

First check the bottom right hand corner of the program and check the status of the connection to the BTR. If the value does not say “Connected”, then there is a problem with your Ethernet connection to the BTR. Make sure the BTR is powered on and that the Ethernet cable is firmly inserted into the computer and BTR. You may try closing the program and re-opening it if you are still having problems.

FILE GRAPHER

Version 1.1.8

Installing the software

This software is packaged in the MWD Software Installation CD. It is installed after running the automatic install from the CD. If you have any questions on the installation, refer to the installation section in the beginning of the manual.

Starting the Program

This program can be started from the Start Menu under the folder Bench Tree Group. Click on the File Grapher name to begin the program. After the program loads, you may open up any of the recorded (.btraw and .ftr) files to view them displayed on a graph of pump pressure versus time.

Using the Program

You may open up a raw file by clicking on the File menu and then click on Open. This will allow you to select a file on your computer using a file chooser. You may also open a file by dragging it onto this program from a Windows explorer window. Once the file is opened, the data will be displayed in the graph section. The pump pressure is drawn in blue over a white background. The graph shows five different pressure levels on the left scale with a horizontal line extending across the graph. The times on the bottom axis are displayed to show the relative time the pressure data was collected. This time may not be accurate if the filename has been changed.
If an associated filtered pulse file (.ftr) can be found with a pressure file, then they will both be displayed together. The pressure line will be in blue and the pulses will be in black. The scale on the left will also show both scaling in their associated colors.
Several items are located below the graph which allow you to change different aspects of the graph. You may change most of the values by entering a new value in the field and pressing Enter. For the compression value, you can use the slider to change its value. The variables are described below.

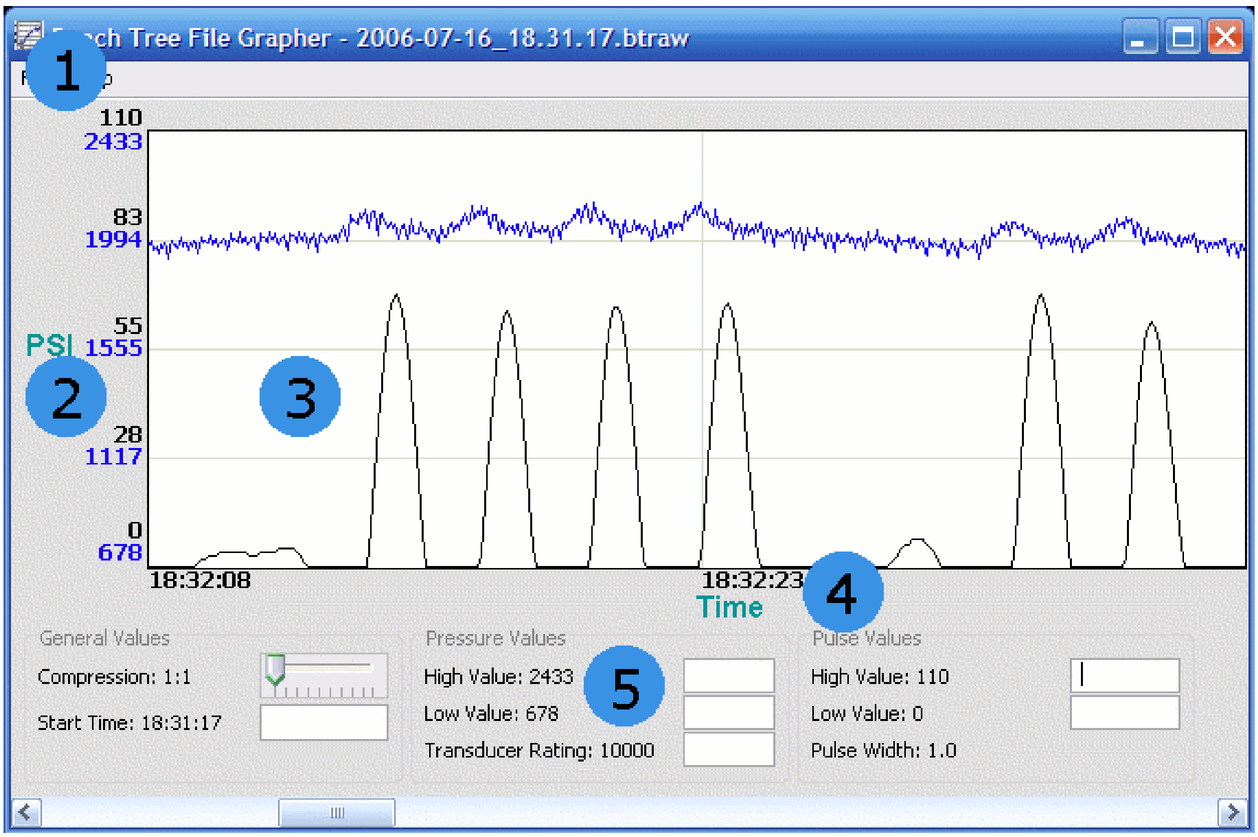
High Value –
Highest value of PSI displayed for that value type
Low Value –
Lowest value of PSI displayed for that value type
Pressure Full Scale –
The full scale of the pressure transducer used.
Compression –
Amount of data to be displayed per pixel. 1:1 is uncompressed.
Start Time –
The time used to determine when the recording was started.

Pulse Width –

The pulse width of the recorded pulse data (.ftr only).

You may use the scrollbar on the bottom of the window to view different parts of the data. The oldest data will be displayed on the left side of the graph and the newest data will be displayed on the right. You may use the right mouse button on the graph to change some of the graphing values. The top two options let you set either of the high and low PSI limits for the pressure line to that point on the graph. The middle options let you change the graph scaling for the pulses. The bottom option lets you "Zoom Out" and will extend the both high/low PSI limits for pressure and pulses to show more surrounding data.

Program Layout



Raw File Viewer with labelled components

1. Menus
2. Pressure axis
3. Graphed pressure and pulses
4. Time axis
5. Configurable display values

CALIBRATION ROLL TEST

Version 1.0.6

Installing the software

This software is packaged in the MWD Software Installation CD. It is installed after running the automatic install from the CD. If you have any questions on the installation, refer to the installation section in the beginning of this manual.

Starting the program

The program icon will be installed onto the desktop after the MWD software installer is finished. Double click the icon to begin the roll test program. The computer must be hooked up to the receiver via an Ethernet cable and the tool must be connected to the receiver using the tool programming cable. The receiver must be powered on for the program to connect to it. There will be a connecting window displayed until the program is connected correctly to the receiver.

Using the program

After the program is properly connected to the receiver and tool, the user will see the tools information displayed in the different sections of the window. The raw sensor data is displayed in the “Sensor Acquired Data” and the calculated values from the raw data are displayed in the “Sensor Derived Data”. The “Compass Rose” window will display the current azimuth, inclination and high side (gravity tool face).

Starting a New Roll Test

You may begin a new roll test by clicking on the File menu and then clicking on “New Roll Test”. This will prompt you with a window to fill out the basic roll test information for the new roll test. This information is helpful for distinguishing between tests later on, so please enter as much data as you can.

Opening a Previous Roll Test

If you wish to open a previously started roll test, click on the File menu and then click on the “Open Roll Test” item. If you do not have any previously started roll tests with the current tool, then you will be prompted to import the roll tests from an old roll test database. If you already have roll test data in the database, then you will be shown a screen of all the available tests in the database. Clicking once on
the data in the table will show you the rest of the test information in the panel on the bottom of the window. Click on the open button to open your selected test

Acquiring Roll Test Data

After you have opened a roll test, you will be given the option to acquire directional data from the tool and store it into the database. You may begin the acquisition process by clicking on the “Roll Test” menu and then clicking the “Start Acquisition” item. This will prompt you with an acquisition options. You will first need to select the method of data acquisition. Choose “Manual” to let the operator decide when to acquire the data for each data shot. The “Automatic” option will automatically store the data when the tool is in the correct direction and the data has been stable for multiple readings. Choose the “Timed” option to acquire data on a fixed interval. This is useful when the user is not close to the computer. You may also choose to acquire data from any of the following orientations: North, South, and East and Vertical. You must choose at least one of these directions to acquire any data. It is recommended that you take full data sets for each direction at least once. You may use the acquisition buttons “Acquire” and ‘Skip” to either manually acquire data or skip the current data acquisition. There will be guidance arrows displayed on the graph directing you to the next desired data acquisition position. Once you have aligned the tool to the correct positions, the arrows will not be displayed and the data should be acquired when it becomes stable. There will be a dark green rectangle in the middle of the tool face ring. This is the marking of the user selected high side of the tool. The red tool face direction wedge is the actual high side of the internal electronics and this is used for alignment because it provides more accurate roll test results.

Viewing Test Results

After finishing all of the data acquisition sets, you will be prompted to view the roll test results. The results window will show you all of the acquired data from this roll test and the variance results for several different measurements. The data is grouped by the orientation direction in which the data was acquired. Each section that has data will have the minimum, maximum and variance for each column at the bottom of the table. This statistics section has a different color background than the data. The roll test summary results are listed at the bottom of the window. The data types being tested for calibration are listed on the left side of the results table. If the data acquired for that data type is within range of the maximum limits, then a green check will appear on the right side of that row. If the data is out of the acceptable range, then a red x will appear to the right side of the table. Any data marked as “Bad” will not be used in the calculations for these results. You may view the results of any previous roll test without being connected to the receiver or the tool by clicking on the File menu of the main window and then clicking on the “View Previous Test Result”. This will display the result page for that particular test.

Editing Test Data

If a roll test is currently open, you may choose to view all of test data in the edit data window. You can view this window by clicking on the “Roll Test” menu and then click on the “Edit Test Data” item. This will display all of the data in a table. You can mark any of these data as “bad” by clicking the check box in the bad column of the table. You must click on the “Ok” button to save any edits that you have made. All of the data marked as bad will not be used in the test results calculation.

Editing Test Header Information

At any time, you may edit the currently opened roll test's header information by clicking on the "Roll Test" menu and then the "Edit Header Data" item. This will show you the same header dialog window that you filled out to create this roll test. Correct any data that you want to change and then click on the "Ok" button to save the data.

Printing Test Results

You may print any of the test results while viewing the test results page by clicking on the File menu and then clicking on Print. You will be given the option to choose your printer from the new window that is displayed. You may also print the results of a currently open roll test by clicking on the Roll Test menu in the main window and then clicking on the Print Test item. This will send the results straight to the printer without having to view the results page.

Viewing Data Scatter Plots

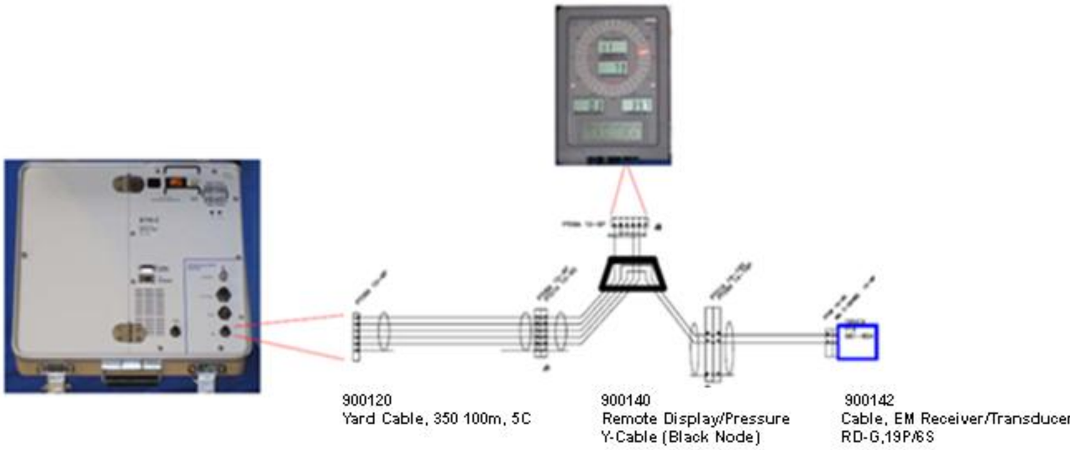
While viewing the test results from a roll test, you can also show the acquired data on graphical plots. To show the graphical plot window, select "Show Scatter Plots" from the File menu. This will open a new window showing five different graphs. The top three graphs (Dip Angle, Magnetic Field and Gravity) will have data from all three azimuth directions plotted on the same graph. The bottom two graphs (Azimuth and Inclination) will display the data from individual azimuth directions on each graph. Click on the tabs to change the displayed direction data.
The white areas in each graph represent the maximum valid spread of the data for each measurement type. If the data is out of range, it will be displayed in the grey area and the background of the graph will turn light red. The numbers on the y-axis represent the measured value ranges for that direction type. The x-axis labels represent the tool face angle. There are vertical markers on the graph for every 45 degree tool face segment which corresponds to the positions the roll test data shots are taken at.

Program Layout

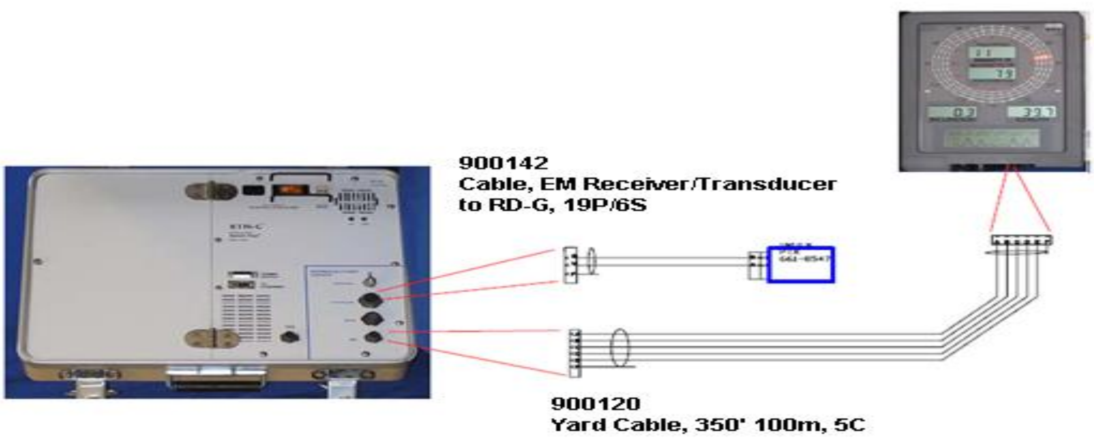
Main Window

1. Menus
2. Compass Window
3. Tool Sensor Derived Data
4. Tool Sensor Acquired Data
5. Test Header Information
6. User Instructions
7. Acquisition Control Buttons
8. User Notes

APPENDIX

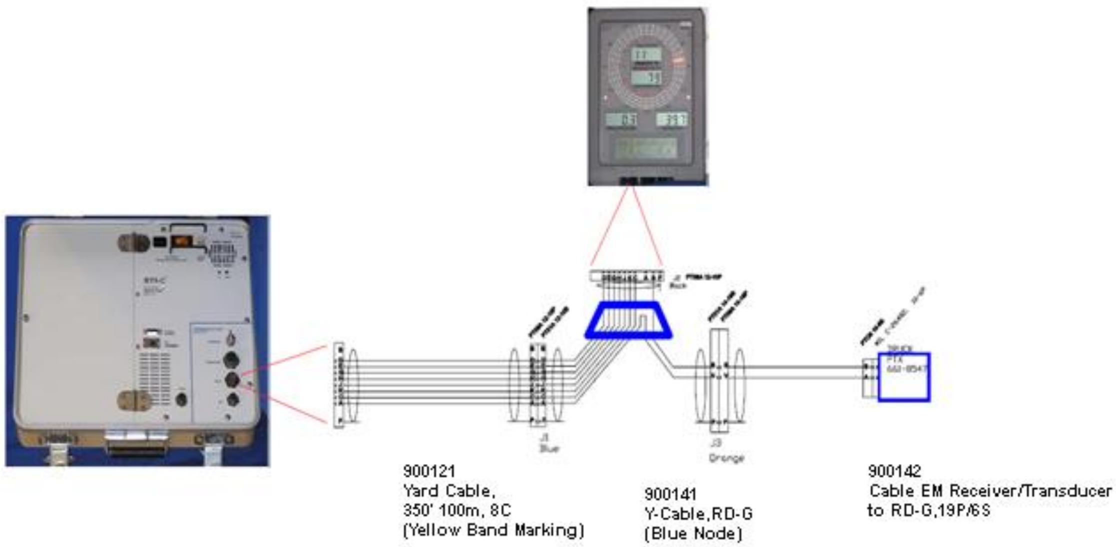


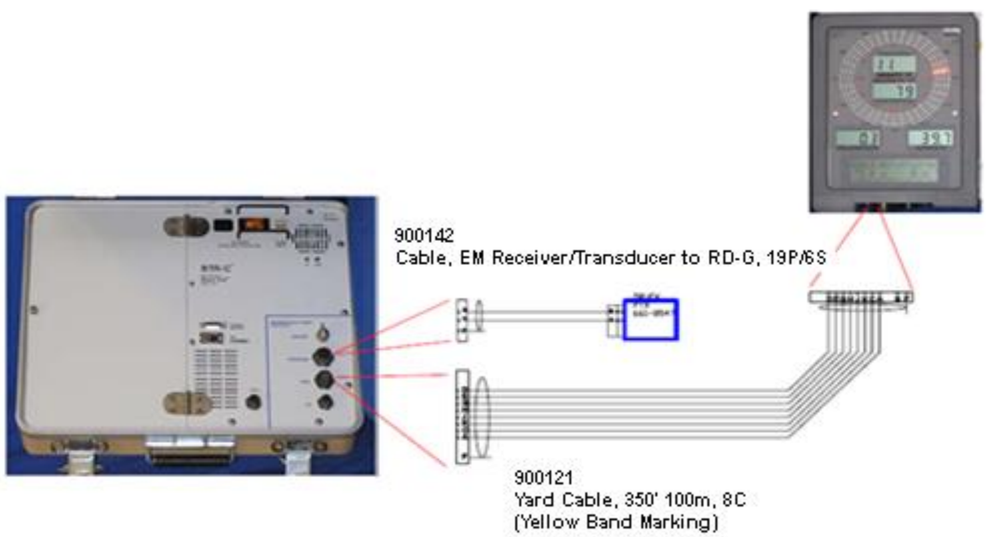
NOTE: BACKLIGHT OF RD-G GRAPHIC PANEL NOT ACTIVE WITH THIS CONFIGURATION.



NOTE: BACKLIGHT OF RD-G GRAPHIC PANEL NOT ACTIVE WITH THIS CONFIGURATION.

DRAWING 1. STANDARD 5 CONDUCTOR CONFIGURATION

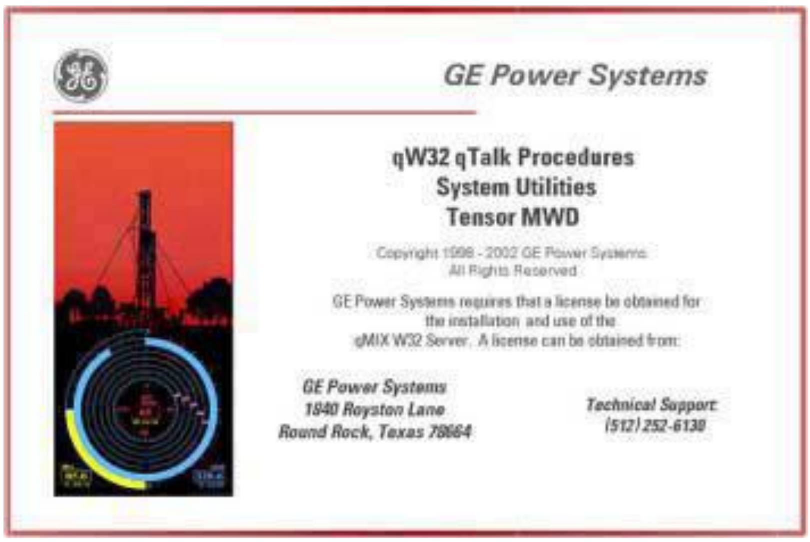




DRAWING 2. BACKLIGHT CONFIGURATION, 8 CONDUCTOR CABLE

B - GE

qW32 Server
qTalk Procedures



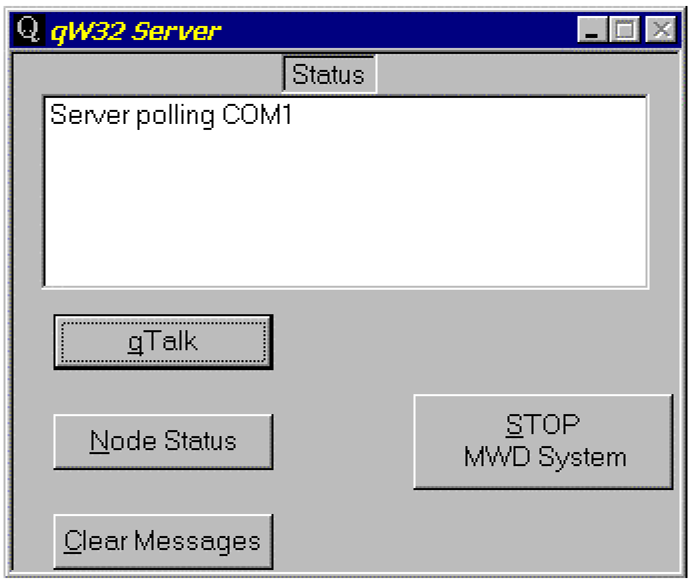
Version 3.00 July 2003

qTalk NOTICE TO ALL qMWD™ USERS

qTalk is still an available DOS system program. It is needed to operate the BootLoad program and load the firmware to the individual processors, 05, 09, and 20. The same commands are still available and still apply. At the end of this section, you will find the directions for operating the DOS version of the qTalk program. Following is a description of the new W32 qServer system that operates via the qNIC device attached to the qBus cable, commonly called the dongle.

INTRODUCTION

qTalk System Utilities is the program used to communicate with the various nodes on the qTalk for Win95 version, now contained in the qW32 Server program.
To access the qW32 Server, simply place the mouse arrow on the qW32 Server Icon located on the Task Bar and click once. The following window will appear.

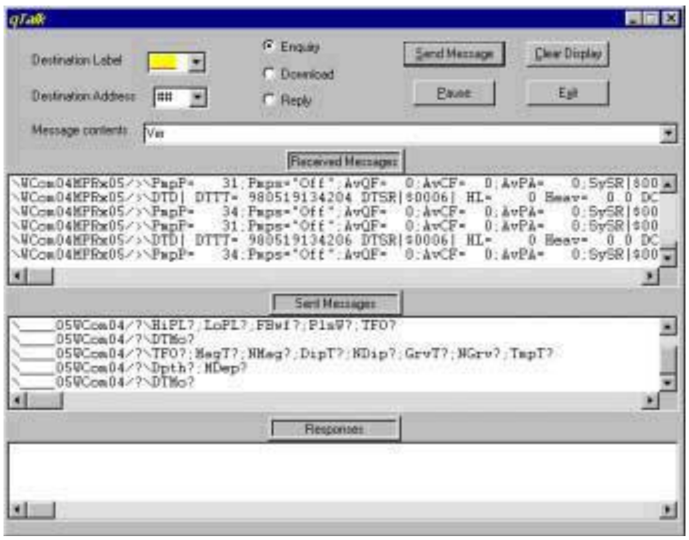


The Win32 qTalk display is entirely different from the previous DOS version, and is more versatile. By simply clicking on the qTalk button or pressing the q key the following window will appear.

qTalk/W32 Window

qTalk/W32 is a limited version of qTalk for 32 bit windows.
qTalk contains one small, single-line window above three large, main windows.
The single-line, *Message contents* window allows the operator to choose messages to send to the systems, selecting from numerous hard-coded options, or entering mnemonics as listed at the end of this chapter. The upper large window, *Received Messages,* displays all messages sent and received in a constantly scrolling fashion. The operator can pause the scrolling by clicking the Pause button. The middle large window, *Sent Messages*, records all messages sent by the PC either from the program, QDTW32 or those issued by the operator via the *Message*

Contents window.
The lower large window, *Responses*, records all responses from the respective nodes that respond to queries sent from the PC. As long as the qServer is booted these messages and responses will be saved in the scrolling fashion.

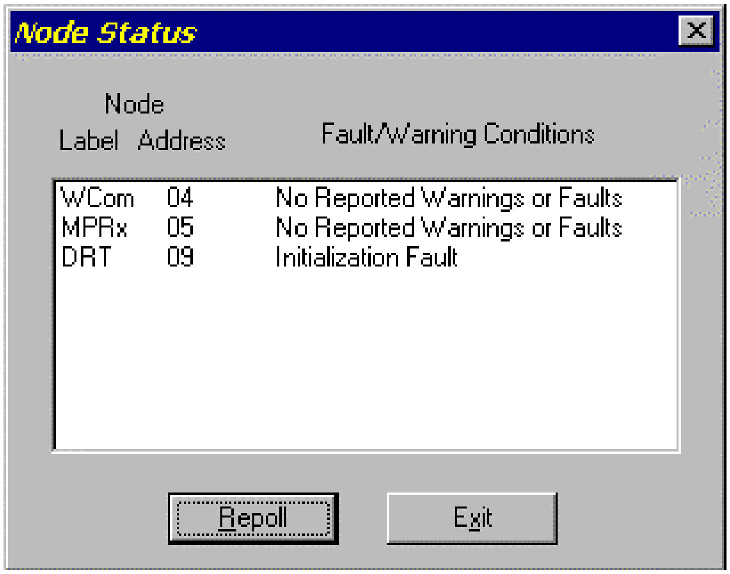


The operator can send queries or commands to particular node addresses by selecting destination labels or destination addresses. The operator can perform most commands with the 'wild card' ## selection and the ____ open label.
The Pause button pauses the scrolling of messages, making inspection of previous messages easier.
The Clear Display button clears the main message windows.
The Exit button quits qTalk/W32.
Other commands:
Logging qTalk/W32 Messages to a File
Playing Back a qTalk Log File
Changing the BAUD Rate
Checking Node Status

Node Status Window
This screen identifies all on-line nodes on the qBus and displays any warnings or faults that each node may have. This screen is the equivalent to sending the message:

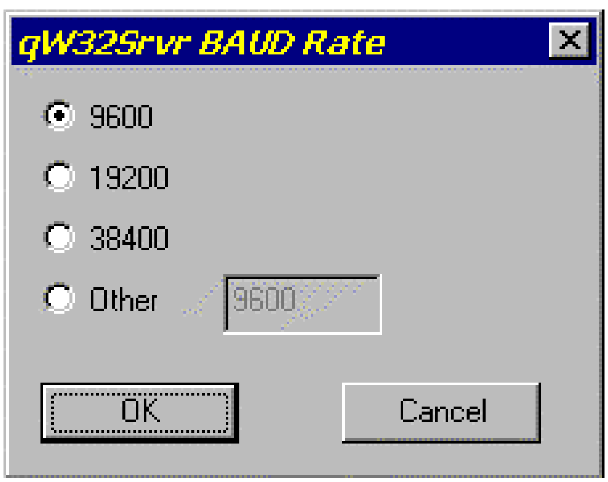
____##/?\qdfr? qdwr?

However, instead of showing the fault and warning register values, this screen displays a brief description relating to each warning or fault bit set in the registers.



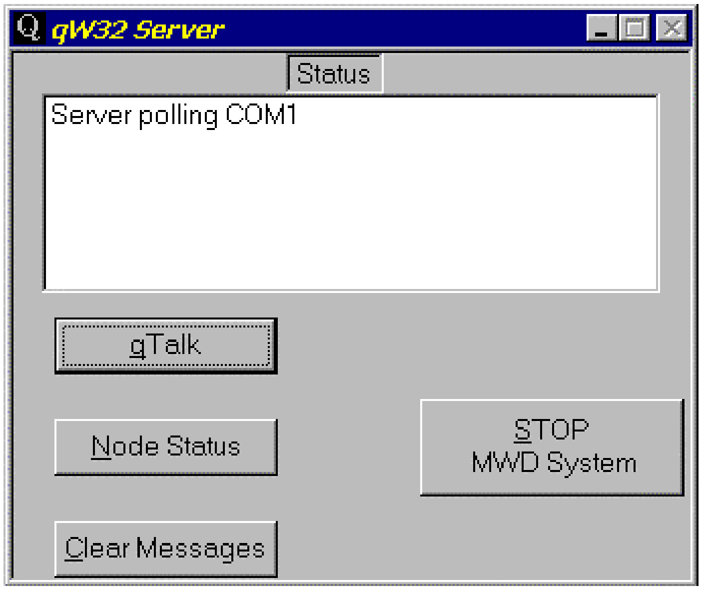
Changing the BAUD Rate

To change the baud rate, start qTalk and then hold down the <Alt> key and type the letter ‘b’. This key combination brings up the qW32Srvr BAUD Rate dialog box. Select one of the BAUD rates, or type your own, and click on ‘OK’.



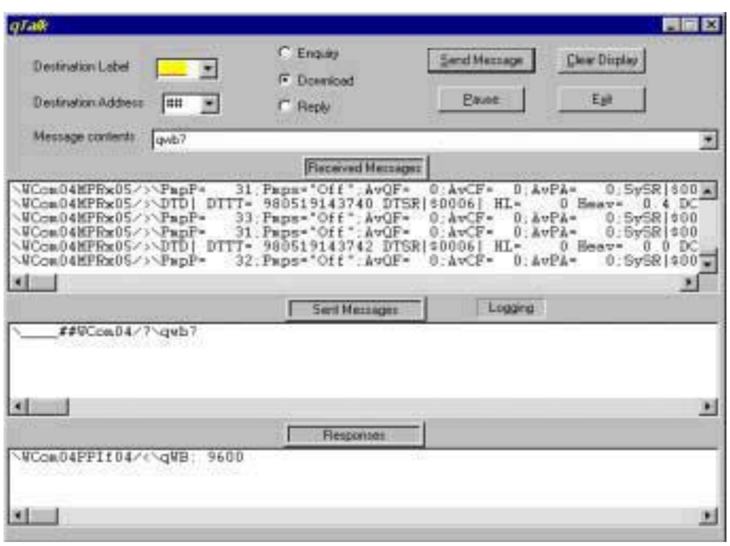
Clear the Status Window

Click the Clear Messages button on the main qW32Srvr dialog to clear all warning and error messages from the Status window.



Logging qTalk/W32 Messages to a File

To start logging to disk, type <Alt-L> while running the qTalk/W32 window. The default qTalk log file name is qW32Talk.Log. To turn logging off, type <Alt-L> again. Care should be taken in generating a qTalk log, as these logs tend to grow large very rapidly. Notice the Logging windowpane next to the Sent Messages display.



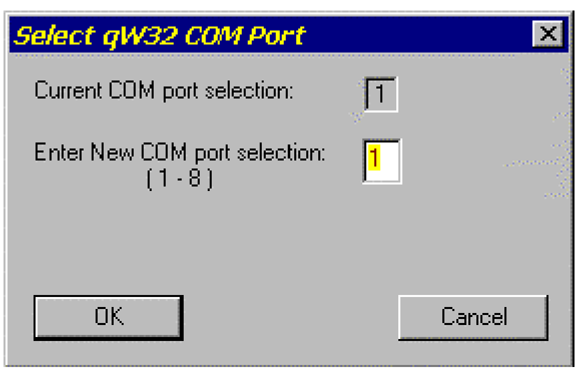
Playing Back a qTalk Log File

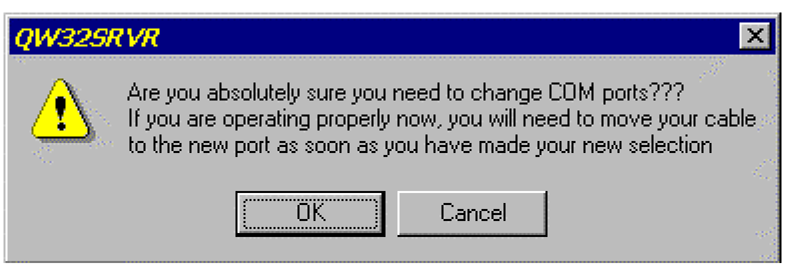
To play back a qTalk/W32 log file, type <Alt-D> from the qTalk window and select the desired log file. The default qTalk log file name is qW32Talk.Log. Playback sends all logged messages to all qMWD/W32 client programs at a steady rate. Typing <Alt-D> again turns off the playback feature.

COM Port

Access the port used to communicate with the qBus nodes by clicking on the system menu icon (the gray and black Q icon) at the top left corner of the qW32Srvr Server window and then selecting the menu item COM Port. You must know which COM Port is used to communicate with qBus nodes before you make the change. In the case of notebook or laptop computers, a PCMCIA card is generally used to communicate with qBus nodes. Use the Win95 Device Manager to determine which port has been assigned for this card. (Refer to Win95 documentation.) The qW32Srvr will default to COM1 when run the first time after the initial installation of qMWDW32. If the COM Port is changed, the new COM Port is saved in the system registry and is used each time the qW32Srvr is run.

Note: Insure the COM Port change is required. If the system is operating properly, do not change the COM Port unless otherwise directed.





Manually Stopping the qW32Srvr

Clicking the STOP MWD System button causes the server to exit, or quit running. In normal operation, the operator should not need to use this button. The server keeps a list of running qMWD/W32 programs. When the last program exits, the server exits as well.

qTalk DOS
INTRODUCTION

qTalk System Utilities is the program used to communicate with the various network nodes that make up the QDT MWD system. Partially enter into this program via the **qBus Monitor (Alt-7)** in the qMWD_PC program. Use qTalk System Utilities to talk directly to the MWD probe to troubleshoot the probe or any other node on the system. Practice with this program, using the manuals provided by GE Power Systems, to gain familiarity and master the troubleshooting process. This manual contains a list of mnemonics with definitions to help select the proper labels to query the nodes.

Multipoint Mode

qTalk Multipoint mode allows the PC to function like a standard qMIX device on the bus, as either the master node or a slave node. A background 'host' process handles communications interrupts, parsing and, formatting of messages. It uses its own link label (LnkL) and link address (LnkA) for communicating with other Multipoint nodes. The PC keyboard and screen act either as a passive bus monitor or as an interactive, point-to-point port (with a unique link label) for communicating with the host process. Normal Operation and Colors During normal Multipoint operation, the qTalk display monitors all bus activity, with incoming characters in yellow and outgoing characters in light blue. The operating mode for qTalk is displayed, near the top-right corner of the screen, as a light blue character indicating one of four states:

M Master Mode
S Slave Mode
I Idle Mode
C Chat Mode

Note: qTalk displays the operating mode letters in upper or lower case according to the presence or absence of communication:

• Upper Case: Currently in communication with other devices
• Lower Case: Not currently in communication with other devices

Observe that the operating mode letter changes case when you disconnected the qBus cable.

For an active qMIX bus, the master node sends calling and polling sequences to the slave nodes. If another node is master and polls the qTalK' link address, qTalk responds with light blue EOT characters. If qTalk itself is master, it sends the calling and polling sequences in blue, while any responses from the slave nodes are in yellow. In either master or slave modes, messages going to or from the PC node are handled automatically by qTalk.

Some PC displays may not scroll fast enough to keep up with the qMIX calling and polling sequences at 9600 Baud. If a display lag develops, the qTalk buffer stores up to 8192 delayed characters, after which the message *(break)* appears in red to indicate that a section of data has been dropped in order to catch up. Pressing either the F5-CrLf (Cr = Carriage Return, Lf = Line Feed) or F7-Filt key combinations can reduce lag in the display.

The *(break)* message also appears when a break sequence is received on the serial communications line. A repeated string of breaks usually indicates operation at an incorrect baud rate. Other warning messages that appear in red indicate problems with the printer or with a disk file. In host mode, normal interactive dialog occurs in green, while red indicates an error response.

Host Mode

In addition to simply monitoring the Multipoint bus activity, the operator may send and receive messages by routing them onto the bus through the qTalk "Host" mode.
In Host mode, the PC keyboard and screen are treated as a point-to-point port which has the label 'Talk' and uses the address defined in the qMIX 'LnkA' control variable. That is, LnkA is the number assigned to the PC using the 'Node Address' conventions described in the Help in the qMWD_PC program. The Multipoint port on the serial bus continues to operate as normal.

In qBus Monitor, you can enter the Host mode by pressing the F4 key. In qTALK, you can enter the Host mode by pressing either the F4 key or the ESC key.
Once in Host mode, the communication display halts and presents a ">" prompt character to solicit messages from the user. Communications are still present, but are not displayed on screen. Only those nodes respond which have information relating to the operator request. These nodes precede their responses with their source routing information.

Use Host mode to investigate certain aspects and conditions on the qbus. Practice using Host mode to gain proficiency with this system. Numerous routines allow the operator to enter command lines and interrogate the surface system and, when connected, the downhole system. Following are a couple of methods used to call up the command line.

Typed Displayed Purpose

Command Line - _\ ____##/?\ Inquiry to all nodes
\05\ ____05/?\ Inquiry to node 05

Note: Target any node with its specific node address number.
Following any of these command lines, the operator can enter a label that relates to a specific function in that particular node. Alternatively, the operator can enter a label that relates to all nodes. If a particular node does not respond to an inquiry, that node probably does not use that particular command or function related to that label.
To exit Host mode, press the 'F4' key or type '\M'. Once out of Host mode, the PC returns to displaying ongoing communications.

Scrolling Previous Commands

The qTalk program allows the operator to recall up to 10 previously invoked commands. Press the up arrow (_) to scroll backward or the down arrow (_) to scroll forward.

The operator can alter particular labels to perform troubleshooting or testing functions. Enter the command code of 10 to alter labels. To check the capability level, enter the label CLev after the command line, followed by a **?**. To change the capability level, follow the instructions below.

Note: Be very careful when altering labels. Do not alter labels indiscriminately.

Command Code

CCod 10 allows the operator to enter commands, change label values and switch positions. Enter this command after the command line followed by an exclamation point (!).

Example: >\ ##/?\CCod 10!

Note: **Extreme Care** must be taken when in this operating mode!

Soft Keys

The soft keys on the right side of the screen allow the operator to manipulate the operation of qTalk. However, some of the keys need not be used for normal operation. (Note difference of display in qTalk2 and qBus Monitor). For normal operation, the operator needs to use only:

F4 – Host

This key stops the scrolling of the display to allow the operator to perform the desired commands. Toggling the switch will alternate the command.

F7 – Filter

This key eliminates the unanswered link addresses that are polled. Only the nodes that are active in qMIX will be displayed.

F8 – Pause

This key stops the scrolling of the data to allow the operator to view data.

Shift+F1 – Exit

This allows the operator to exit the program.

Shift+F4 – VChk

This command performs a system check on all of the nodes attached to the system.

Shift+F5 – qDFR

This command performs a system check on all of the nodes attached to the system.

Note: SF4 and SF5 commands are the same routines performed on the system in the Node Status screen in the qMWD_PC program.

Shift+F9 – Term

This command places the system into the Terminal Mode. Only operators with extensive training in the operation of qTalk should enter this routine.
Lists of qTalk variables and mnemonics are available in the QDT Training Manual and the qMWD Engineer's Reference Manual Vol. 2, Appendices B2 and V. Use these labels in the inquiry mode to gain familiarity and confidence in operating qTalk.

qTalk Terminal Mode

Use the qTalk program terminal mode only for extensive troubleshooting or for loading the GE Power Systems software to the system. Only trained personnel should use terminal mode or the procedures for loading the GE Power Systems software.

The operator can easily distinguish the qTalk terminal mode display from the Multipoint mode display. The qTalk terminal mode display is monochrome, not color, and has unique menu options.

QTalk Terminal Mode Menus

Press the F10 key to toggle between the two available qTalk Terminal mode menus. The two menus read as follows.

Terminal Menu 1 Terminal Menu 2

F1 Exit F1 Exit
F2 Remote F2 Remote
F3 Auto LF (Off) F3 Display (All)
F4 Echo (Off) F4 EOL Chr (Cr)
F5 Print (Off) F5 Idle!
F6 Baud (9600) F6 qMIX!
F7 Data Bits (8) F7 Chat!
F8 Stop Bits (1) F8 Errors ( )
F9 Parity (None) F9 Go to Multipoint
F10 Next Menu F10 Next Menu

QTalk Startup Menus

Following are the soft-key toggle options as displayed at startup.
The options are in parentheses. Default options are in **bold** type.
Startup Menu 1

F1 Exit qTalk
F2 **Remote** Local
F3 Auto LF (**Off**) (On)
F4 Echo (**Off**) (On)
F5 Print (**Off**) (On)
F6 Baud (600) (1200) (2400) (4800) (**9600**) (19200) (38400) (115k2)
F7 Data Bits (**8**) (7) (6) (5)
F8 Stop Bits (**1**) (2)
F9 Parity (None) (Even) (Mark) (Spce) (Odd)
F10 Toggles the Next Menu
Startup Menu 2

F1 Exit qTalk
F2 **Remote** Local
F3 Display (**All**) (**I&D**) (Dat) (Hex)

F4 EOL Chr (Cr) (ETX) (EOT)
F5 Idle! – stop qMix, allow node access
F6 qMIX! – restart qMix after idle
F7 Chat! – select a node
F8 Errors ( )
F9 Go to Multipoint – re-access Multipoint program
F10 Toggles the Next Menu

WARNING: After establishing communications with a particular node, and before exiting the qTalk program, the operator **MUST** reestablish qMIX communication by selecting the qMIX softkey (F6). Otherwise, the node will be idle and may appear non-functional. Cycling the power to the system should cold boot the system for all of the nodes and reestablish qMIX operations. Care should be taken to know which labels were changed, if any, and which labels should be changed back to their original values or settings. Observe that while performing the configuration routine, the program changes only those labels listed in the configuration. Observe the configuration routine using two PCs connected to the SASB qBus outlets, with one PC in qTalk or qBus monitor.

Every operating company should allow one individual access to these procedures, for the purpose of upgrading the firmware of the systems. Each operator should have at least minimal qTalk training to enhance his troubleshooting capabilities.

Commonly Used mNemonic Labels

A

AcqD! Acquire Directional Steering (T/L) Data Command
AcqS! Acquire Directional Survey Data Command
AcqG! Acquire Gamma Data Command
Ax Accelerometer X axis corrected & scaled Data
Ay Accelerometer Y axis corrected & scaled Data
Az Accelerometer Z axis corrected & scaled Data
Azm Directional Sensor Azimuth Data (refer to TAzm)

B

Bat2 Auxiliary Battery Switch Control/State
BatD Battery Data Block
BatV Battery Voltage
BHiV Battery High Voltage Measurement
BLoV Battery Low Voltage Measurement
BThr Low Battery Voltage Threshold

C

CCod Capability Code Number

D

DipA Dip Angle
DLC Downlink Controls Parameter Block
DLTP Downlink Time Period
DSns Directional Sensor Information Block

G

Gama Gamma Data Value
GamD Gamma Data Block
GamD Gamma Data Block
Grav Gravity Data
gTFA Gravity Toolface Angle

I

Inc Inclination Data
InvF Inverted Flow Switch

LnkA qMIXTM Link (node) Address
LnkL qMIXTM Link (node) Label
LnkM qMIXTM Link Mode (following a Reset)
Loc Job Site Location Information Block
LoPL Receiver Low Pulse Amplitude Limit (editing control)

M

MagD Magnetic Data Block
MagF Total Magnetic Field
MDec Magnetic Declination
Mod1 Telemetry Controls Parameter Block for Mode #1
Mod2 Telemetry Controls Parameter Block for Mode #2
Mod3 Telemetry Controls Parameter Block for Mode #3
Mod4 Telemetry Controls Parameter Block for Mode #4
ModC Main Telemetry Mode Controls Parameter Block
ModN Telemetry Mode Number at power on

P

PLen Pipe Length
PlsC Pulse Controls Parameter Block
PlsW Pulse Width in effect
PmpD Pump Data Block
Pmps Pumps Status - On/Off
PmpP Pump Pressure
PmpT Pumps-On Threshold
PTO Pressure Transducer Offset correction
PW1 Pulse Width for Telemetry Mode #1
PW2 Pulse Width for Telemetry Mode #2
PW3 Pulse Width for Telemetry Mode #3
PW4 Pulse Width for Telemetry Mode #4

Q

qDCR qMIXTM Device Control Register
qDFR qMIXTM Device Fault Register
qDSR qMIXTM Device Status Register
qDWR qMIXTM Device Warning Register
qLNM qBus Host-Mode Log Name, XXXXXXXX.QBM
qLPA qBus Host-Mode Log Path, *.QBM
qMem qMIXTM Memory I/O Function (diagnostic)
qMIX! Go To Normal qMIXTM Mode Command
qSCR qMIXTM System Control Register
qSFR qMIXTM System Fault Register
qSSR qMIXTM System Status Register
qSW qMIXTM Software Version String (refer to Ver)

R

ROPd Constant Distance ROP Averaging Number
ROPn Constant Time ROP Averaging Number
RTOC Receiver Toolface Offset Computation Control
RTTF Receiver Toolface Offset Computation Control

S

SFlw Simulated Flow control (test & diagnostic)
Site Job Site Information Data Block
SN Processor Hardware Serial Number
SSN1 Survey Sequence Number for Telemetry Mode #1
SSN2 Survey Sequence Number for Telemetry Mode #2
SSN3 Survey Sequence Number for Telemetry Mode #3
SSN4 Survey Sequence Number for Telemetry Mode #4
SSq1 Survey Sequence Definition String #1
SSq2 Survey Sequence Definition String #2
SSq3 Survey Sequence Definition String #3
SSq4 Survey Sequence Definition String #4
StWt String Weight Threshold
SuDT Directional Survey Delay Time
SuWd Survey Word Data Block

T

TFO Toolface Offset
TFS Toolface display type Switch (in qDRT)
Time Date and Time Stamp (YYMMDDHHMMSS)
TLWd Toolface/Logging Word Data Block
TmpT High Temperature Threshold
TSN1 Toolface/Logging Sequence Number for Telemetry Mode #1
TSN2 Toolface/Logging Sequence Number for Telemetry Mode #2
TSN3 Toolface/Logging Sequence Number for Telemetry Mode #3
TSN4 Toolface/Logging Sequence Number for Telemetry Mode #4
TSq1 Toolface/Logging Sequence Definition String #1
TSq2 Toolface/Logging Sequence Definition String #2
TSq3 Toolface/Logging Sequence Definition String #3
TSq4 Toolface/Logging Sequence Definition String #4
TVD True Vertical Depth
TxDT Telemetry Transmit Delay Time from flow on

V

VChk() Non-Volatile Variable Check Function (diagnostic)
Ver() Software/Firmware Version Function (information)

Z

ZazD! Clear azimuth data display command (in qDRT)
Zdia! Zero the Diagnostics Data Block Command
ZGaD! Clear gamma data display command (in qDRT)
ZInD! Clear inclination display command (in qDRT)
ZMbD! Clear message box command (in qDRT)
ZReD! Clear resistivity data display command (in qDRT)
ZTFD! Clear toolface data display command (in qDRT)

QProg/11
SYSTEM UTILITIES
Version 3.00 July 2003

qProg/11TM System Utilities
Programming M68HC11 Processors

GE Power Systems requires that a license be obtained for the installation and use of the qProg/11TM M68HC11 Programming Utility. Licenses may be obtained from:

GE Power Systems
1840 Royston Lane
Round Rock, TEXAS
78664-9555

Introduction to qProg/11

The qProg/11 program is a general-purpose utility used to program application software/firmware into the EEProm of 68HC11 microcontroller-based processor boards.

qProg/11 adapts easily to new target hardware simply by defining the target specifications. When qProg11 is executed to program a target, it first locates the target specification, which defines the files, baud rates, memory configurations, and other information required to program the target.
The standard sequence used is as follows:

1) Load the application software/firmware from disk.
2) Download the 1st stage bootloader and receive back acknowledge character when it begins to execute.
3) Download the 2nd stage bootloader and receive back acknowledge character when it begins to execute.
4) Download the application software/firmware.
Variations of the above sequence are possible based on the command line used to invoke qProg/11. For example, a page zero RAM program can be loaded into the 68HC11 and executed using the command line options /BO, /B1, and /B2. See the following section about the command line for more information.
Before using qProg/11 with a new processor board, the processor board must be defined by creating a target ID and specification. See the section on configuration for specific information.

Installation of qProg/11 Program

qProg/11 is customarily installed on a hard disk drive in the c:\BootLoad directory and is, by default, set up to run in this directory. qProg/11 can be installed in any directory, however certain path data and batch files may require minor modifications.
Copy the distribution files to the hard disk as follows (assuming the source disk is inserted in drive 'b', and the destination is the c:\bootload directory):
md c:\bootload (if directory does not exist)
xcopy b: c:\bootload /v/s

If installed in a directory named in the DOS PATH statement, the program can be executed from anywhere on the disk. If not installed in such a directory, the full path to qProg11.exe or batch files can be used to invoke the program.

Configuration

qProg/11 is designed to easily adapt to new and varied hardware. This adaptation is accomplished through the use of an ASCII data file named qPrg11ID.dat. qPrg11ID.dat is a standard ASCII file, which provides all the information about the targets to be programmed. The file is divided into two sections.

The first section consists of a list of target identification data structures, each identified by a unique target ID. The format of the structure is as follows:

- "Target ID" 1 to 16 characters.
- Target crystal frequency (Hz): determines baud rate for 1st stage.
- "[path]1st stage bootloader program" (.s19 file).
- "[path]2nd stage bootloader program" (.s19 file) or null if 2nd stage not needed.
- Baud rate for 2nd stage or zero.
- "[path]default program to load" (.s19 file) or null.
- Baud rate to load program or zero if same as baud for last stage.
- "Memory Specification ID for target" see format documentation to follow.
- "[path]HC11 Config. Reg. programming file" (.s19 file) or null.
- Default configuration register value for the /PC command line option.

The second section of the qPrg11ID.dat file is a list of memory specification data structures. The memory specifications are referenced through the "Memory Specification ID for target" field in the target identification data structure (defined above). Multiple Targets can use the same memory specification data structure. The format of this structure is as follows:

- "Memory specification ID for target" referenced by the target ID structure.
- Number of pages (0x01 if not a paged memory).
- Page size (in bytes)
- Low inclusive address of the memory.
- High inclusive address of the memory.
- Number of check characters or 0
- Check character type or 0 (1 for checksum)
- Address of 1st check character.
- Disable/Enable character by default (0 or 1)
- Fill character value

The qPrg11ID.dat file can be edited using any ASCII-type editor. Target IDs are modified or new targets added by simply making modifications or additions to the target ID and Memory specification lists. See the qPrg11ID.dat file itself for more information on the file format, list termination, etc. The file must reside in the same directory as the qProg11.exe file.

When defining a new target, it may be necessary to create new versions of the 1st and 2nd stage bootloaders as well as the HC11 config. register programming file. As an aid, the following source files are provided and can be used as templates for the new files:

Boot11_1.asm -Example: 1st stage bootloader
BT80-2_2.asm -Example: 2nd stage bootloader
Cnfg$XX.asm -Example: HC11 Cnfg. Register programmer

Command Line

The following command line is used to execute the qProg/11 utility:
qProg11 target_id filename.ext /s1/s2/..../sn
where:

(i) "target_id" is the target identification string and may contain up to 16 alphanumeric characters. The target ID is primarily used to define the names of the bootloader files and the memory configuration for the target processor.

(ii) "filename.ext" identifies the source file to be transferred to the target processor
and may be preceded by a path designation. This file specification may be omitted if it is specified in the target specification, or if the /BO option switch is used.

(iii) /s1, /s2 and /sn designate option switch settings and are only required to change the default settings. A list of available options can be obtained directly from qProg/11 by entering 'qProg11' by itself on the command line.

The available options are:

/1

/2 The *Port select* switches. Selects the desired serial communications port to be used.

/C

/NC The *Checksum enable* and *Checksum disable* switches. The *Checksum enable* switch is the default and indicates qProg/11 should write checksums. The type of checksum and destination address is individually specified for each device in the target processor.

/F

/NF The *Fill* and *No Fill* switches. When *No Fill* is used, only the bytes defined by the .s19 file are programmed. The default is individually specified for each target. *Fill* will cause all bytes in a memory or memory page which are not defined in the source file to be filled with the character specified for the target.

/G

/NG The *Go* and *No Go* switches. *No Go* is the default. When *Go* is used the program will proceed automatically without operator prompts. The processor should be in the proper mode before executing the command line. *Go* is used often once the programming procedure has been defined.

/O

/NO The *Overlay* and *No Overlay* switches. *No Overlay* is the default. The *Overlay* switch enables overlays. That is, qProg/11 will not generate errors if the same address is written more than once. qProg/11 assumes that if the same address is written more than once that the bootloader is controlling paging.

/P

/NP The *Paging enable* and *Paging disable* switches. The *Paging enable* is the default and indicates the file (filename.exe specified on the command line) contains code which is to be written to multiple pages at the same bus address. The file should also contain the appropriate page control bytes. Page control bytes are defined as a single byte with the base address of a device as its destination. The value of the byte indicates the new page for the following bytes to be programmed.

/V

/NV The *Verify enable* and *Verify disable* switches. The *Verify enable* switch is the default and causes qProg/11 to display a verification window to allow verification for the programming configuration. When neither the

/V nor the /NV switches are used, the /G switch automatically disables verification (an exception to the default).

/Q The *Quiet Mode* switch. The switch indicates that no prompts should be output to the display and that only one error output is possible.

/NB The *No Boot* switch. This prevents the program from attempting the transfer the bootloader programs to the target processor. It is only used when the bootloader programs have already been transferred and are running. This switch causes qProg/11 to proceed directly to programming the file (filename.exe) specified on the command line. This option is typically used when programming a processor with multiple files, and prevents the need to repeatedly reset the processor in boot mode.

/BO The *Boot Only* switch. This option is used when it is desired to load only the bootloader. qProg/11 will terminate after the last boot stage is loaded (after the 1st stage if the 2nd stage is not specified).

/PC:[XX]
The *Program Config.* switch. This option is used to program the 68HC11 configuration register. The processor must be in the Bootstrap mode (See the section entitled 'Invoking Boot Mode'). If only /PC is typed, the default value specified for the target is programmed. If

/PC:XX is used, the hex value XX is programmed.

/B1:[path]filename[.ext]
The *1st stage bootloader override* switch. This switch causes qProg/11 to replace the default 1st stage bootloader with the file specified. the file must be an '.s19' type file.

/B2:[path]filename[.ext]
The *2nd stage bootloader override* switch. This switch causes qProg/11 to replace the default 2nd stage bootloader with the file specified. The file must be an '.S19' type file.

/D:[path]filename[.ext]
Specifies a diagnostic output file path name.

All switches allowed with the program may be entered on the command line and will be passed to the program. *Spaces are not allowed in the option switch portion of the run string!*

When qProg/11 runs, the terminal will display the following sequences:

> (i) The source file is read while displaying the progress, number of lines read, number of bytes read and number of memory pages to be programmed.
>
> (ii) Provided the operator did not enter the *Go* or *No Verify* switches, the operator may next verify the programming information by viewing the status windows on each memory. At this point, entering "G", for *Go,* causes the program to enter the bootloader stage.

(iii) Provided the operator did not enter the *No Boot* switch, the program will begin transferring the next 2 stages of the bootloading processes. Provided the operator did not enter the *Go* switch, the program will instruct the operator to reset the target processor and enter "C", for

Continue, when the processor has been reset. If the process fails to get the expected response after loading the first stage bootloader, it will stop and ask the operator for instructions (Abort, Ignore or Retry). If the second stage fails to load or respond as expected, the program will abort.

(iv) Once the boot loading process is complete, the program begins transferring the contents of the source .s19 file and displays the programming progress for each memory or memory page being programmed. Generally, the data transfers occur at 38.4K baud and transfer 32 data bytes per exchange in a single binary string. The programming rate will vary depending on the types of EEPROMs being programmed. However, typical programming rates for Atmel and Xicor 28Cxxx devices will be about 1K data bytes/second.

Invoking Boot Mode

The M68HC11 is programmed using the serial communications interface and a multiple-stage boot loader process. The M68HC11 processor has an internal bootloader program (68HC11 bootstrap mode) which may be invoked when reset (power on reset or external reset) with the 68HC11 MODA and MODB inputs pulled low. The MODA and MODB inputs are usually accessed via test points or through lines brought out through a connector. This program loads the next stage boot loader program (1st stage bootloader) to the 256 byte, internal, 68HC11 RAM. It, in turn, loads the larger programming process (2nd stage bootloader) to the larger external RAM. These programs are loaded by the "qProg/11" PC program.

Once the 2nd stage bootloader is loaded and running in RAM, there is no need to start over by resetting the 68HC11 in bootstrap mode. Subsequent programs can be programmed by re-executing qProg/11 using the /nb command line option. qProg/11 will then skip directly to the programming step by communicating with the 2nd stage bootloader already loaded.

Recovering From Problems

The following points may be helpful in the event a programming problem occurs.

(i) When qProg/11 terminates, a message is displayed indicating the condition at the time of termination. When programming succeeds, the message is "Programming Complete". If an error occurs, the error message and an error number are displayed. The error number definitions are as follows:

a. Serial communication function I/O error return codes. The error codes from -1000 through -1099 are reserved for the "qSIO" error codes.

"qSIORx" codes start at -1000>>>>
1000 General or undefined Rx error
1001 Character time-out during Rx
1002 Receiver over run error
1003 Receiver framing error
1004 Receiver parity error
1005 Received break error
1006 Rx FIFO overflow
1007 Time-out waiting for data reply

"qSIOTx" codes start at -1030>>>>
1030 General or undefined Rx error
1031 Character time-out on data transmit
1032 Receiver over run error during Tx
1033 Receiver framing error during Tx
1034 Receiver parity error during Tx
1035 Received break error during Tx
1036 Tx FIFO underflow

"qSIO" miscellaneous codes start at -1080>>>>
1080 Error on data transfer verification
b. File I/O error return codes. The error codes from -1100 through -1199 are reserved for the "qFIO" error codes.

Open error codes start at -1100>>>>
1100 General or undefined file error
1101 DOS did not open a file for read
1102 DOS did not open a file for write
1103 DOS did not open a file for append
1104 DOS did not/could not open an existing file for Read/Write
1105 /*DOS did not open a new or destroy existing file for Read/Write
1106 /*DOS did not/could not open an existing or new file for Read/Write

Read file error codes start at -1120>>>>
1120 /* General or undefined read error */

Write file error codes start at -1140>>>>
1140 General or undefined write error

Miscellaneous file error codes start at -1160>>>>
1160 Operator disallowed writing to an existing file

c. Terminal I/O error return codes. The error codes from -1200 through - 1299 are reserved for the "qFIO" input error codes. The error codes from -1300 through -1399 are reserved for the "qFIO" output error codes.

Terminal input error codes start at -1200>>>>
1200 General or undefined input error
1201 An input string exceed the max size that could be processed

Terminal output error codes start at -1300>>>>
1300 General or undefined input error
d. Prog/11 specific error codes.

qProg/11 specific error codes start at -20001>>>>
20001 Memory allocation error
20002 Source file read error
20003 Source file record format error
20004 Source file character count error
20005 Source file character error
20006 Source file checksum error
20007 Missing memory definition error
20008 All pages full error
20009 Page boundary error
20010 Data overlay error
20011 Switch string format error

20012 Switch type error
20013 Missing file name error
20014 File open error
20015 Run string error
20016 Data acknowledge error
20017 Bootload error
20018 Check character type error
20019 Target ID match error
20020 Operator abort
20021 Page number error
20022 Device overlap error
20023 Data in page byte error

(ii) If you forget to enter the *No Boot* switch when loading more than one file, the program will stop and request operator direction. Abort the program and try again using the /nb switch. In *most* cases, this will work. However, since the first stage boot loader program is most likely transferred at a different baud rate than program files, there is no guarantee.

(iii) If problems persist, please call GE Power Systems and ask for assistance from Technical Services. Please call from nearby the PC being used to program the *target* processor(s) so that we may talk you through the problem.

GE Power Systems
Bill Ryer
Customer Technical Service – Tensor Systems
Reuter-Stokes
1840 Royston Lane
Round Rock, TEXAS
(512) 252-6188 (phone)
(512) 251-7396 (fax)
(512) 845-2892 (cell)

qProg/11 TM
Compatibility Notice

qProg/11TM is designed to be a general purpose PC utility program for loading programs into Motorola M68HC11 MCU-based equipment such as the qMWDTM receiver, remote terminal and the downhole transmitter. Please note that while GE Power Systems' general practice is to test programs on several different brands and models of computers, GE Power Systems cannot guarantee that qProg/11TM, or any other programs, will be 100% compatible with all brands of PCs. If you have questions concerning the compatibility of the software with a particular brand of PC, please direct them to:

GE Power Systems
1840 Royston Lane
Round Rock, TEXAS 78664-9555
(512) 251-4131.

QDT - qMWDTM V01.XX
Quick-Start Instructions
Installing qMWD/PCTM Programs & Files

Windows 95/98 / Windows NT
For clients using the Windows 95/98 Windows NT versions of the QDT MWD software, just insert the CD containing the software in to the CD port of the PC and follow the highlighted prompts to properly install the programs. The qProg11 programs will be located on the C:\ drive. To operate the qProg11 programs: Windows 95 users: Boot the PC in the DOS mode using the F8 soft key to prevent Windows from starting and go to the Prompt Only mode. Windows 98 / Windows NT users: Just Reboot the system in the DOS mode for the features to operate. DOS 6.22

For clients still using DOS 6.22, use the following steps to load the programs to the PC in the DOS mode using the supplied floppy disks.

1) Insert the **"qMWD/PC Disk 1 of 2 Diskette"** into drive A: (or B:).

2) Type: **a:install a: c: <Enter>**. The directory qMWD\qMWD_PC will be created on the C: drive, if it does not already exist. The qMWD/PCTM programs and files will load into this directory. If the directory already exists, then a backup directory will be created to save the old programs.

3) After the files are loaded from Disk 1 of 2, the installation procedure will prompt you to install the second of the two qMWD/PC diskettes. The

qMWDCnfgTM and **qDirK_IOTM** programs and files will also be loaded into the c:\qMWD\QmWD_PC directory (all PC programs are now normally loaded on a single directory.

4) Run these programs through the **qMWD_PC, qMWDCnfg** and the **qDirK_IO** batch files while in the qMWD\qMWD_PC directory. Enter these batch files completely, as displayed, to insure that the batch file is executed correctly. Some Menu programs activate complete utilization of the batch files. REMEMBER, these routines cannot be activated through windows, yet.

Installing qProg/11TM

1) Insert the **qProg/11 Diskette** into drive A:.
2) Unless it already exists, create a **c:\Bootload** directory on the c: drive by typing **cd\<Enter> md bootload <Enter>**.
3) Switch to the c:\Bootload directory by typing **cd bootload <Enter>**.
4) Copy the contents of the **qProg/11 Diskette** by typing: **xcopy a:/v**.

Installing qMWD/11TM

1) Insert the **qMWD/11 Diskette** into drive A:.
2) Type: **a:install a: c: <Enter>**. The files containing the programs for the transmitter processor, receiver processor and the DRT processor will be stored in the directory qMWD. These files will be needed to access required program files used by the three processors in the QDT MWD system.

Updating Embedded qMWDTM Firmware Programs

GE Power Systems recommends that the firmware programs in all qMWD™ hardware, such as receivers, displays and the down-hole tool be upgraded to versions in effect with the qMWD™ V01.60a release.

Note: Only “qMPTx-2R” program is V01.60a. All other firmware programs are as released with the qMWD/11 V01.60 distributions and are identified as V01.60 in their application I.D. strings.

To determine whether the qMWD™ equipment is loaded with the latest firmware, use the **Ver()** function to identify the firmware versions using the qTalk/PC™ (refer to Appendix Q in the qMWD manual). Appendix P in the qMWD ™ Engineer’s Reference Manual provides complete instructions for programming the MC68HC11-based systems used in the qMWD™ hardware. The following information presumes an understanding of those programming procedures.

Note: The qTalk/PC and qProg/11 programs required to upgrade embedded firmware programs will **ONLY** function properly when operating from the **DOS-Only mode**.

In Windows 95, perform the following steps to boot the DOS system without starting the Windows system:

Note: This procedure will NOT work on Windows 98, Windows NT or Windows 2000.

1) Select “Shut Down.”
2) Click “Restart the Computer.”
3) Click “Yes.”
4) Wait for the beep and the “Starting Windows” indication.
5) Press the “F8” key within 1 second from the beep.
6) Select “Command Prompt Only” and press the “Enter” key.

CAUTION: The “**HLOC**” and “**HLSC**” control parameter values are determined and set in the qMPRx-D3 program at the factory for DRT units ordered with (and licensed for) Depth-Tracking capability.

If upgrading from versions **PRIOR** to V01.40, please be sure to record these values before proceeding with the upgrade procedure and re-enter them at the conclusion of the procedure.

IF LOST, please contact GE Power Systems, ask for repair/maintenance, and request the values of these parameters. Please have the unit serial number readily available. These steps are not required for updating systems containing V01.40 or later.

Connecting the System Hardware Components

Setup the system as you normally would with the Driller's Remote Terminal (DRT) configured to the Safe Area Supply Box (SASB) and the Survey Electronics module configured to the Programming Cable. Connect a PC containing the correct version of qMWD software to the qBus cable. In this situation the downhole tool (MPTx) and the DRT with the integral qMWD receiver (MPRX) are all connected to the system and can communicate through qTalk.

Note: If you are using a Flow Simulation Box, insure that the simulated flow control is set to Flow Off.

Loading Software To The qMWD Receiver (MPRx Node 05)
Switch to the ***C:\qMWD\qMPRx-D3*** directory. The data in this file will load into the processor used for the decoding routines in the qMWD receiver.
Run qTalk by typing qTalk2 (If the string **c:\ qTalk** is in your Path in the Autoexec.bat file, it will boot automatically). Press *F4* to invoke the *Host Mode.* Press *Shift+F5* to interrogate all nodes on the network. Be sure that at least node ***MPRx05****,* responds. For Versions BEFORE V01.40, record the variables “HLOC” and “HLSC”. Query the labels via qTalk and reenter the values after upgrading the software version.

Invoking the Boot! Mode for the qMWD Receiver (MPRx05)
Follow these instructions *implicitly*!

1) Run qTalk by typing: **qTalk2**. (C:\qTalk should be in the path. If it is not, go to the qTalk directory, C:\qTalk\ and type **qtalk2**.)
2) Switch To Terminal Mode by pressing: **Shift+F9**
3) Set the Baud Rate to 9600 by pressing: **F6** (Baud softkey)
4) Switch to Second Menu by pressing: **F10** (Next Menu)
5) Idle the qBus by pressing: **F5** (Idle!) (Press rapidly 3-4 times, minimum.)
6) Invoke the Chat Mode by pressing: **F7** (Chat!)
7) At the prompt, enter the Link address by typing: **05**. The node selected will return a command prompt.
8) Invoke Boot Mode by typing: **CCod 11 Boot!** and pressing the **<Enter>** key. If successful, then the target processor will NOT return a prompt.
9) Exit qTalk by pressing: **F1**.
DO NOT PRESS ANY OTHER KEYS!! Insure that you are in directory C:\qMWD\qMPRx-D3, then proceed to the next step in these instructions.
10) Load the qMIX/11™ Operating Parameters, Receiver Operating Parameters, and the qMWD™ Receiver Program by typing **ProgAll** and pressing the **<Enter>** key.
11) Turn the system power **Off** and then **On** again.

Loading Software To The qMWD Driller's Remote Terminal (DRT Node 09)

1) Switch to the **C:\qMWD\qDRT-3** directory. The data in this file will load into the processor used to display the various routines in the qMWD Driller's Remote Terminal.
2) Run qTalk by typing: **qTalk2**. (C:\qTalk should b in your path).
3) Invoke the Host Mode by pressing **F4**.
4) Interrogate all nodes on the network by pressing **Shift+F5**.
Be sure that nodes MPRx05, MPTx20, and DRT 09 all respond.
Should one of these nodes not respond, check all of the connections, and repeat this step.
5) Invoke the Boot! mode for the qMWD Display Processor (DRTx09).
6) Run qTalk by typing: **qTalk2**. (C:\qTalk should be in the path. If it is not, go to the qTalk directory, C:\qTalk\ and type **qtalk2**.)

7) Switch To Terminal Mode by pressing: **Shift+F9**
8) Set the Baud Rate to 9600 by pressing: **F6** (Baud softkey)
9) Switch to Second Menu by pressing: **F10** (Next Menu)
10) Idle the qBus by pressing: **F5** (Idle!) (Press rapidly 3-4 times, minimum.)
11) Invoke the Chat Mode by pressing: **F7** (Chat!).
12) At the prompt, enter the Link address by typing: **09**. The node selected will return a command prompt.
13) Invoke Boot Mode by typing: **CCod 11 Boot!** and pressing the **<Enter>** key. If successful, then the target processor will NOT return a prompt.
14) Exit qTalk by pressing: **F1**.
DO NOT PRESS ANY OTHER KEYS!! Insure that you are in directory C:\qMWD\qDRT-D3, then proceed to the next step in these instructions.
15) Load the qMIX/11™ Operating Parameters, Receiver Operating Parameters, and the qMWD™ Receiver Program by typing **ProgAll** and pressing the **<Enter>** key.
16) Turn the system power **Off** and then **On** again.

Loading Software To The qMWD Transmitter (MPTx Node 20)

1) Switch to the C:\qMWD\qMPTx directory. The data in this file will load into the processor used for the encoding routines in the qMWD transmitter.
2) Run qTalk by typing **qTalk2** (c:\qTalk should b in your path).
3) Press **F4** to invoke the Host Mode.
4) Press **Shift+F5** to interrogate all nodes on the network.
Be sure that nodes MPRx05, MPTx20 and DRT 09 all respond, if they are connected. Should one of these nodes not respond, check all of the connections and repeat this step.
Note: You do not need all nodes to be connected to load the firmware to the targeted node.
5) Invoke the Boot! Mode for the qMWD Transmitter (MPTx20).
6) Run **qTalk**. C:\qTalk should be in the path. If it is not go to the qTalk directory, C:\qTalk\ and type qtalk2.)
7) Switch to Terminal Mode by pressing **Shift+F9**.
8) Set the Baud Rate to 9600 by pressing **F6** (Baud softkey).
9) Switch to Second Menu by pressing **F10** (Next Menu).
10) Idle the qBus by pressing **F5** (Idle!). (Depress rapidly 3-4 times.)
11) Invoke the Chat Mode by pressing **F7** (Chat!).
12) At the prompt type the Link address **20** and press the **<Enter>** key. The node selected will return a command prompt.
13) Invoke Boot Mode by typing **CCod 11 Boot!** and pressing the **<Enter>** key. If successful, then the target processor will NOT return a prompt.
14) Exit qTalk by pressing **F1**.

DO NOT PRESS ANY OTHER KEYS!!
15) Verify that you are in the correct directory:
x C:\qMWD\qMPTx for the standard QPN 100080-02 module
x C:\qMWD\qMPTx-2 for the new “Mark-2” QPN 100640-01 module
x C:\qMWD\qMPTx-2R for the new “Mark-2” QPN 100640-02 module
with recorder memory.

For all Software Versions PRIOR to V01.30
Do **NOT** use the **ProgAll** batch file command to load these files to the downhole tool! Doing so would reset the calibration factors to default values. Instead, continue with the steps below.
1) Load the qMIX/11TM Operating Parameters by typing **ProgqCtl**, pressing the **<Enter>** key and following the program instructions.
2) Select **GO**.
3) Select **Continue**.
4) Load the qMWDTM Transmitter Operating Parameters by typing **Progeep /nb**, pressing the **<Enter>** key and following the program instructions.
Note: Be sure to type the space between Progeep and /nb.
Note: /nb means “no boot.”
5) Select **GO**.
6) Load the qMWDTM Transmitter Program by typing **Prog /nb**, pressing the **<Enter>** key and following the program instructions.
Note: Be sure to type the space between Progeep and /nb.
7) Select **GO**.
8) Turn the System Power **Off** and then **On** Again

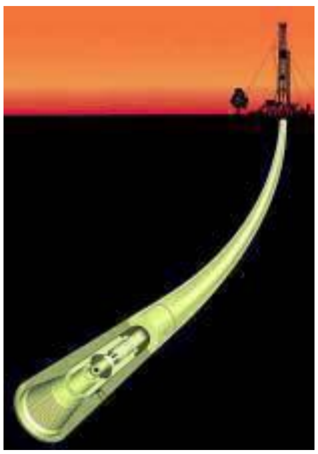
For all Software Versions V01.30 and Later
1) Load the qMIX/11™ Operating Parameters, Receiver Operating Parameters, and the qMWD™ Receiver Program by typing **ProgAll** and pressing the **<Enter>** key.
2) Run qTalk by typing **qTalk2**.
3) Invoke the Host Mode by pressing **F4**.
4) Verify No Errors in qDFR and qDWR by pressing **Shift+F5**.
This procedure interrogates all network nodes for the qMIX register values.
All values for qDFR and qDWR should be returned as a *$0000* hex value.
5) Check for Control Parameter Value Errors by pressing **Shift+F4**.
This procedure will cause all nodes to check for valid operating parameters using the VChk() function (refer to Appendix I).
All nodes should return *VChk(All Okay)*.
Note: DO NOT cycle the power or reset the processor, as the onscreen directions in the qProg/11 program may instruct you, when using this bootloader method!!!!

Loading Software To The Turbine Assembly (Node 27)

1) Switch to the C:\qMWD\qTCR directory. The data in this file will load into the processor used for the various routines in the qMWD Turbine Module.
2) Run qTalk by typing **qTalk2** (c:\qTalk should b in your path).
3) Press **F4** to invoke the Host Mode.
4) Press **Shift+F5** to interrogate all nodes on the network.
Be sure that nodes MPRx05, MPTx20, DRT 09 and qTCR27 all respond, if they are connected. Should one of the nodes not respond, check all of the connections and repeat this step.
5) Invoke the Boot! Mode for the qMWD Turbine Module (qTCR27).
6) Run qTalk by typing: **qTalk2**. (C:\qTalk should be in the path. If it is not, go to the qTalk directory, C:\qTalk\ and type **qtalk2**.)
7) Switch to Terminal Mode by pressing **Shift+F9**.
8) Set the Baud Rate to 9600 by pressing **F6** (Baud softkey).
9) Switch to Second Menu by pressing **F10** (Next Menu).
10) Idle the qBus by pressing **F5** (Idle!). (Depress rapidly 3-4 times.)
11) Invoke the Chat Mode by pressing **F7** (Chat!).
12) At the prompt type the Link address **27** and press the **<Enter>** key.
The node selected will return a command prompt.
13) Invoke Boot Mode by typing **CCod 11 Boot!** and pressing the **<Enter>** key.
If successful, then the target processor will NOT return a prompt.
14) Exit qTalk by pressing **F1**.
Do NOT press any other keys!!
15) Verify that you are in the correct directory: C:\qMWD\qTCR.
16) Load the qMIX/11™ Operating Parameters, Receiver Operating Parameters, and the qMWD™ Receiver Program by typing **ProgAll** and pressing the **<Enter>** key.
17) Turn the system power **Off** and then **On** again.

B.3 - ROLLTEST

Tensor MWDRoll32
System Utility



Version 3.00 July 2003

Overview

MWDRoll32 is a standalone piece of software used to verify correct operation of *Measurement-While-Drilling* (MWD) tools manufactured by GE Power Systems. Using MWDRoll32 entails performing various tests, both logical and physical, prior to the use of MWD tools. MWDRoll32 diagnostics reports from a correctly functioning tool will fall within the guidelines for satisfactory operation, while a non-functioning or mal-functioning tool will fail to reach these guidelines. MWDRoll32 software places only limited demands on client computer systems and does not require new or powerful machines for its operation.

Hardware Requirements

• PC compatible computer
• qNIC cable
• Safe Area Power Supply (SAPS)
• Tool Programming cable

Hardware Setup

1) Connect one end of the qNIC cable to an available qBus port on the SAPS.
2) Connect the other end of the qNIC cable to an available COM port on the computer.
3) Connect the tool programming cable to the SAPS and the MWD tool.

Software Requirements

• Microsoft Windows 95/98 or NT 4.0
Minimum Windows Settings
• Screen resolution of 640x480 pixels
• Video color depth of 8 bits (256 colors)
Recommended Windows Settings
• Screen resolution of 1024x768 pixels
• Video color depth of 16 bits (65536 colors) or more

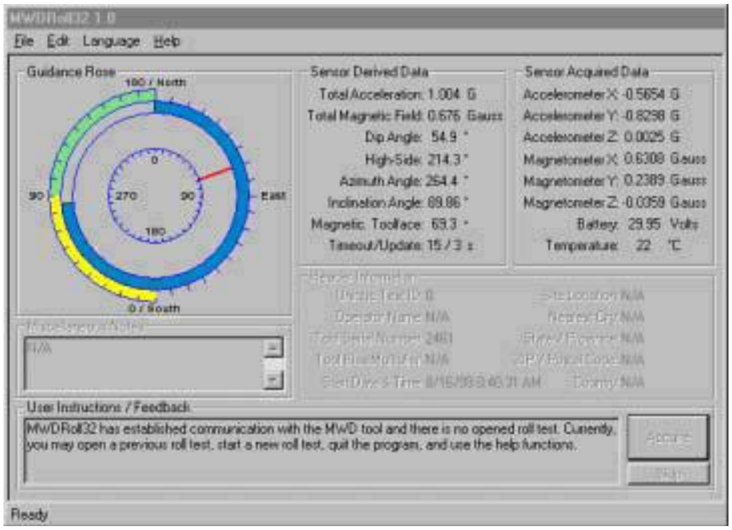
What's New?

MWDRoll32 is not an upgrade from MWDRoll. It is an entirely new program. MWDRoll32 encompasses almost all the functionality of the older MWDRoll, plus additional features described below.

• O/S platform upgrade from MS-DOS to Windows 95/98/NT
• New UI presenting a graphical/alphanumerical display
• MWD tool communication now handled via qW32Server application
• New "Remote" data acquisition mode
• No need to save data manually, it is all automatically saved into a database
• Added header/data editing
• New print previewing feature
• Printed reports now present information in more comprehensive fashion
• New feature allows opening, editing, and updating previous roll tests
• Added help and user manual
• Multilanguage support

Main Display

The main display is the only window that gives the user information about the status of the MWD tool. This display was designed to give the user **all** relevant information about the current roll test and the MWD tool. When MWDRoll32 is started, you will notice that the display consists of six subsections, each designed to give the user particular information.



The six subsections are as follows:

• **Guidance Rose:**Designed as an alternative to the alphanumeric displays, this display gives a graphical view of the three-dimensional orientation of the MWD tool.

• **Sensor Derived Data:** This display gives the user real-time critical information that would be difficult to calculate manually.

• **Sensor Acquired Data:**Some of the corrected sensor values of the MWD tool are displayed in this display.

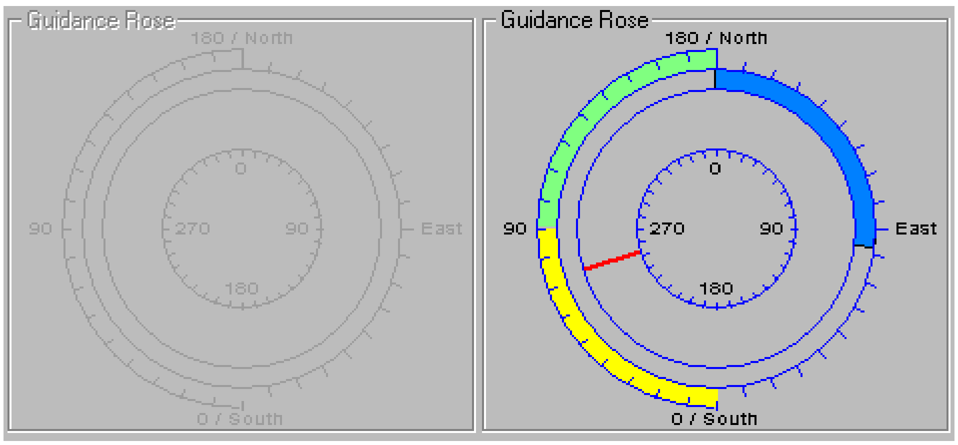
• **Header Information:** Information about the current roll test is displayed in this section.

• **Miscellaneous Notes:** Any notes entered via the header information dialogs are displayed in this section.

• **User Instructions / Feedback:** This constantly updated section informs the user of MWDRoll32 status and of operations currently allowed. Manual acquisition of data is also available via two buttons.

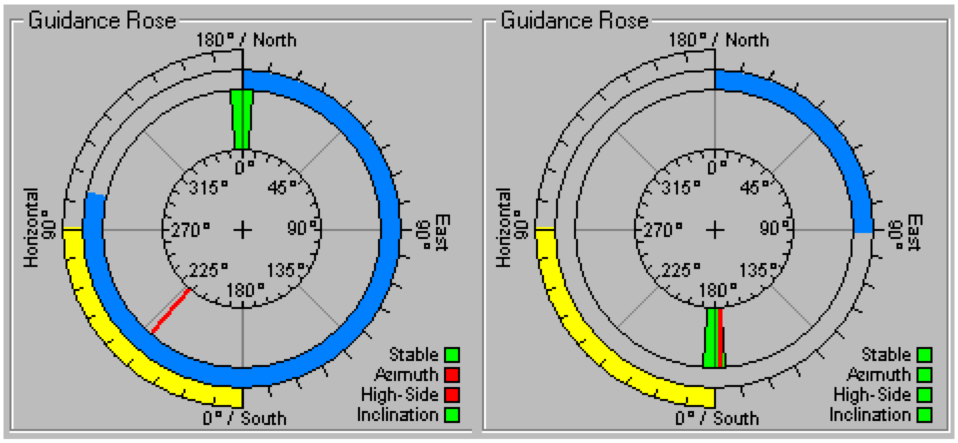
Guidance Rose Display

The Guidance Rose is designed to give the user a more intuitive and easy-to-read perspective on the MWD tool's orientation in space. When MWDRoll32 has established communication with the tool, this display will be active.
When not acquiring data, the display will resemble one of these two images:



The "ghosted" image (left) is displayed when no tool is attached or in communication. The colored image (right) is displayed when a tool is attached and in communication. In the display, you will find three essential pieces of information:
Inclination:
A vertical semicircle on the display's left side contains two colors, yellow and green. The intersection of the two colors indicates the tool's inclination. In the picture above, the inclination is at roughly 90°. If the tool is oriented upwards, the yellow arc will span 180° to the top. If the tool is orientated downwards, the green arc will span 180° to the bottom. Azimuth:
The blue arc in the outermost complete circle indicates the azimuth. It always starts from the top (0°) and wraps clockwise around to the current azimuth angle. In the above picture, the azimuth is approximately 97°.
High Side:
The red line in the inner circle indicates the High Side. When the tool is rotated, this line will move and constantly display the roll angle of the MWD tool. In the above picture, the High Side is approximately 253°.

When acquiring data, the display will resemble one of these two images:



When acquiring data, the rose displays five additional indicators.
The most prominent indicator is the green pie section, which indicates the *recommended* High Side for the current data shot. During a roll test, the pie section rotates through 8 ordinal positions evenly spaced at 45° intervals. The user must align the High Side (red line) indicator within the green pie section. The other four indicators are colored boxes located in the lower right corner of the rose display. These four boxes give the user feedback on recommended data acquisition positions. Box colors indicate proper (green) or improper (red) positioning:

• Top box: Stability status
• Second box: Azimuth status
• Third box: High Side status
• Bottom box: Inclination status

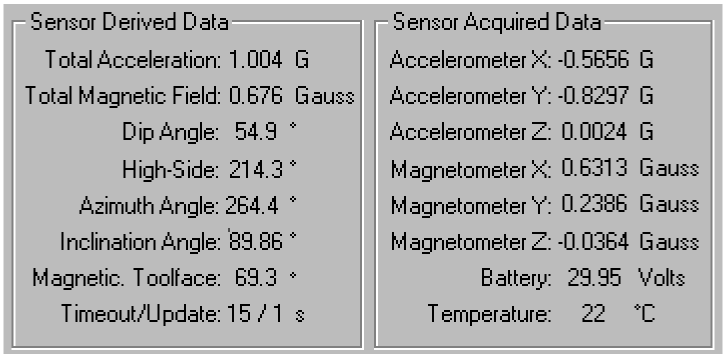
The two images above show an attempted data shot in the east orientation.
The image at left shows some boxes in red, indicating that the tool is not ready to acquire data. Though the tool is stable and the inclination is correct, the azimuth and High Side are incorrect.
The user then rotates the tool towards the east orientation. The blue azimuth arc rotates to indicate east and the azimuth box turns green, indicating proper azimuth positioning for data acquisition.
Next, the user rotates the tool until the High Side lies within the green pie section. The High Side box turns green.
The image at right shows all four boxes green, indicating favorable conditions for acquiring data. To acquire the data, click the “Acquire” button.

Sensor Displays

The main display provides the user with all relevant sensor information in one window composed of two columns:

Sensor Derived Data shows information calculated from the acquired data.

Sensor Acquired Data display shows critical sensor values.



Sensor Derived Data:

- **Total Acceleration:** The overall acceleration due to gravity
- **Total Magnetic Field:** The overall magnetic field
- **Dip Angle:** The angle between the tool and the earth's surface
- **High Side:** The angle calculated from the gravitational tool-face
- **Azimuth Angle:** The horizontal angle of the tool
- **Inclination Angle:** The angle with respect to vertical
- **Magnetic Tool-Face:** The angle calculated from the magnetic tool-face
- **Timeout/Update:** The number to the left of the slash (/) indicates the time before communications will timeout. The number to the right of the slash indicates the last refresh interval

Sensor Acquired Data:

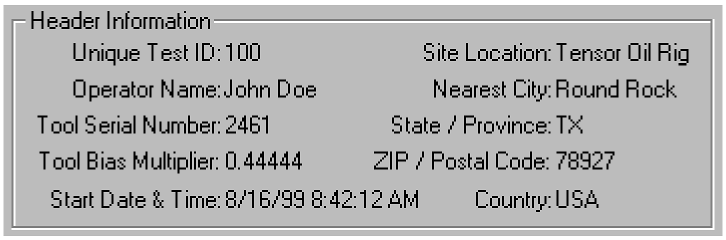
- **Accelerometer X, Y, & Z:** Displays corrected gravity values from the accelerometer sensor of the MWD tool
- **Magnetometer X, Y, & Z:** Displays corrected magnetic field values from the magnetometer sensor of the MWD tool
- **Battery:** Displays battery power, in volts
- **Temperature:** Displays the temperature of the tool in degrees Celsius

Header Information and Miscellaneous Notes Display

The Header Information and Miscellaneous Notes displays present the user with information pertaining to the started or opened roll test.

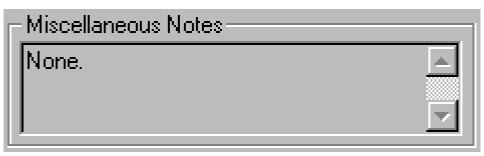
Header Information Display

Located below the sensor displays, the Header Information display shows the information entered in the Header Information dialog. Once again, this display presents the user with all relevant header information in one window.



Miscellaneous Notes Display:

Located to the left of the header information display and below the Guidance Rose, the Miscellaneous Notes display shows any notes entered into the Header Information dialog.



User Instructions / Feedback Display

The bottommost display gives the user information about the current status of MWDRoll32. At all times, the user can check this display to see what is happening and what can be done.

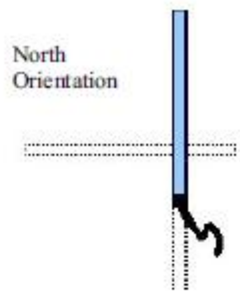
The two buttons to the right, **Acquire** and **Skip**, are used when acquiring data in Interactive mode. When in this mode, the display indicates the required orientation and the number of data shots to perform. The user observes the Guidance Rose or Sensor Derived Data display to determine whether a data shot can be made. If a shot can be made, the user can click the Acquire button to save the data and proceed to the next shot. However, the user may choose instead to click the Skip button, to proceed to the next shot without saving data from the current shot.

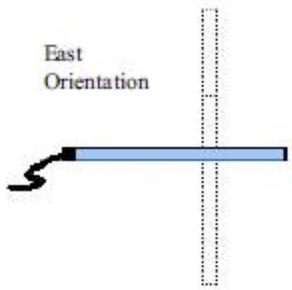
Default Mode
Until the user starts or opens a roll test, MWDRoll32 displays only current MWD sensor data. While an experienced user might be able to determine whether the tool has a problem simply by visual inspection of the data, roll tests allow the user to determine the tool status with certainty and precision.

Starting a New Roll Test

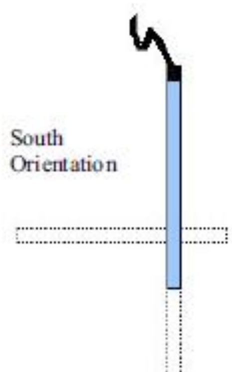
Starting a new roll test involves three basic steps:
1) Click the **Start New Roll Test…** item from the **File** menu.
The Header Information dialog will appear.
2) Enter all information and click the **OK** button.
The Roll Test Options dialog will appear.
3) Select the desired options and click the **OK** button.
MWDRoll32 enters into data acquisition mode. Depending on the options selected, data will be acquired in Interactive or Remote mode. For more information on how to acquire data, see the Acquiring Data help.

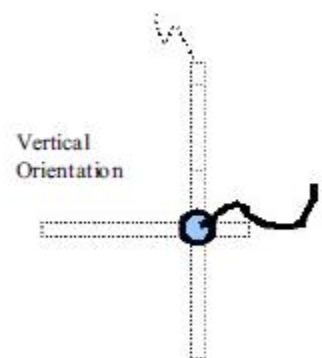
Tool Orientation
Important: follow the tool orientation instructions displayed in the User Instructions/Feedback window. The Roll Test is designed to gather data at prescribed positions. MWDRoll32 analyzes the data with respect to the tool being in those positions. Data gathered out of position will skew the results and give a false indication that the tool is out of calibration. Please follow the Roll Test instructions explicitly so that an accurate test can be performed.





Take shots in the eight (8) ordinal positions for each of the three horizontal orientations Follow the instructions for performing a Roll Test. Take two (2) shots in the vertical position. Note the position of the sensors relative to the position changes during the roll test. The results of the roll test are based on the tool being rotated through the prescribed positions.

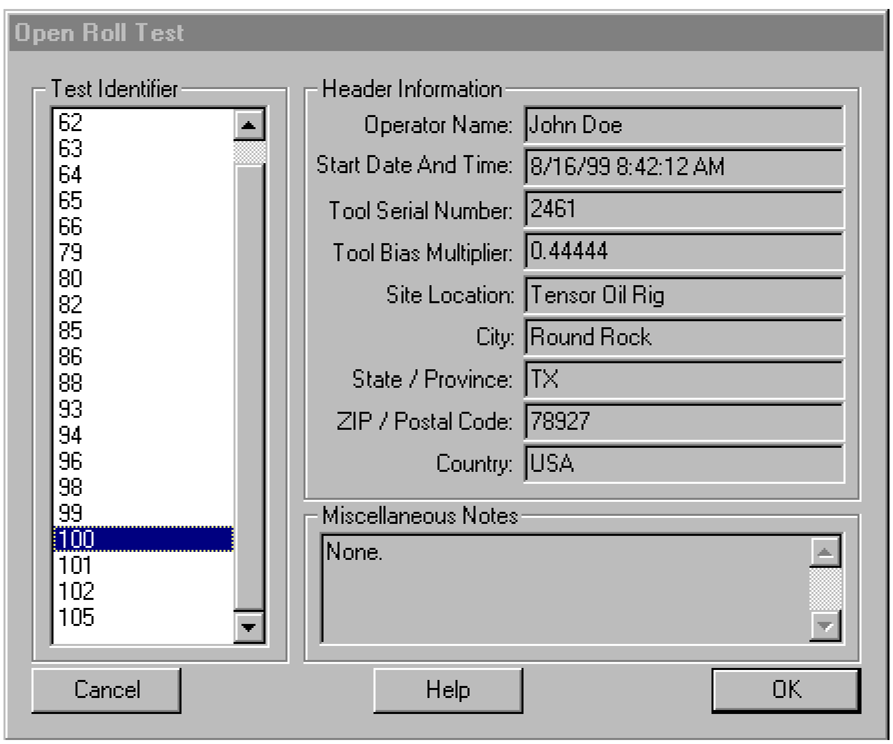




Opening a Completed Roll Test
Even after a roll test has been completed, MWDRoll32 allows the user to re-open it and perform all tasks, just like in a new test. For example, if a user performs a roll test, prints it, and later determines that some of the data is bad, he is able to re-open the test and take more data shots. The user can also change the header and re-print the report.

To open a previous test:
1) Click the **Open Previous Roll Test...** item from the **File** menu. The Open Roll Test dialog appears.

Note: MWDRoll32 must contain at least one completed roll test to open the Open Roll Test dialog.

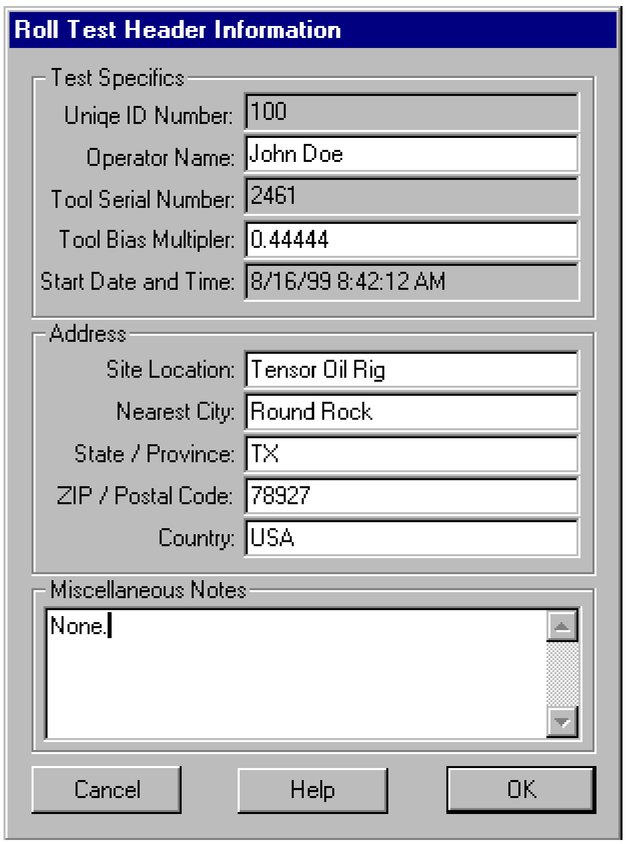


2) Select a test by number in the Test Identifier column and click the **OK** button.

Note: When you select a test number, that test's Header Information and Miscellaneous Notes appear. Use this information to help identify the test you want to open.

Editing Header Information

The Roll Test Header Information dialog opens when the user starts a new test or re-opens a completed test and chooses to edit the Header.
To open the Roll Test Header Information dialog:
1) Open a Previous Roll Test.
2) Select the **Header Information…** item from the **Edit** menu. The Roll Test Header Information dialog appears.



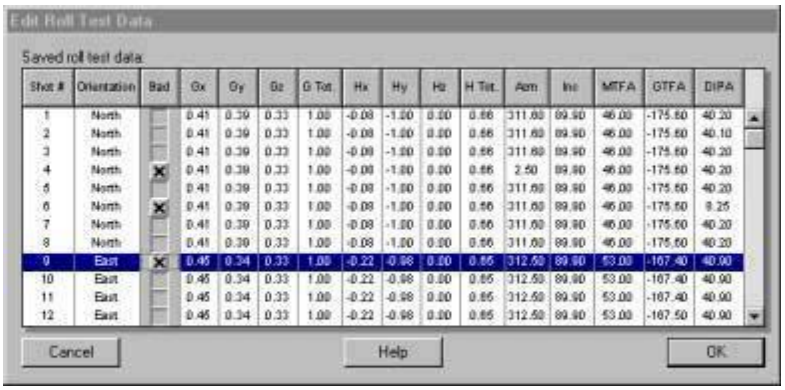
Note: Always enter complete header information and descriptive notes. This information helps you identify a test should you need to re-open it.

Note: MWDRoll32 completes the following three fields automatically:
• Unique ID Number
• Tool Serial Number
• Start Data and Time

Editing Test Data

Unfortunately, roll tests do not always work exactly as expected. Bad data due to magnetic interference, human misalignment, or any other source could plague a roll test of a perfectly good tool. This eventuality can be handled by flagging bad test data.

Starting the dialog:
1) Open a Previous Roll Test by clicking the **Data Sets…** item from the **Edit** menu. The Edit Roll Test data window opens, displaying a row for each data shot. Each row lists several pieces of data under column headings.



Edit Roll Test Data

Saved roll test data:

Shot #	Orientation	Bad	Gx	Gy	Gz	G Tot.	Hx	Hy	Hz	H Tot.	Azm	Inc	MTFA	GTFA	DIPA
1	North		0.41	0.39	0.33	1.00	-0.08	-1.00	0.00	0.66	311.60	89.90	46.00	-175.60	40.20
2	North		0.41	0.39	0.33	1.00	-0.08	-1.00	0.00	0.66	311.60	89.90	46.00	-175.60	40.10
3	North		0.41	0.39	0.33	1.00	-0.08	-1.00	0.00	0.66	311.60	89.90	46.00	-175.60	40.20
4	North	X	0.41	0.39	0.33	1.00	-0.08	-1.00	0.00	0.66	2.50	89.90	46.00	-175.60	40.20
5	North		0.41	0.39	0.33	1.00	-0.08	-1.00	0.00	0.66	311.60	89.90	46.00	-175.60	40.20
6	North	X	0.41	0.39	0.33	1.00	-0.08	-1.00	0.00	0.66	311.60	89.90	46.00	-175.60	8.25
7	North		0.41	0.39	0.33	1.00	-0.08	-1.00	0.00	0.66	311.60	89.90	46.00	-175.60	40.20
8	North		0.41	0.39	0.33	1.00	-0.08	-1.00	0.00	0.66	311.60	89.90	46.00	-175.60	40.20
9	East	X	0.45	0.34	0.33	1.00	-0.22	-0.98	0.00	0.65	312.50	89.90	53.00	-167.40	40.90
10	East		0.45	0.34	0.33	1.00	-0.22	-0.98	0.00	0.65	312.50	89.90	53.00	-167.40	40.90
11	East		0.45	0.34	0.33	1.00	-0.22	-0.98	0.00	0.65	312.50	89.90	53.00	-167.40	40.90
12	East		0.45	0.34	0.33	1.00	-0.22	-0.98	0.00	0.65	312.50	89.90	53.00	-167.50	40.90

Data Column Description Units
Shot #: The incremental number corresponding to the data shot.
Orientation: The tool's orientation the data shot. (N/S/E/V/U)
Bad: A check box that allows the user to discard the data shot. (True/False)
Gx, Gy, Gz: The MWD accelerometer sensor's X, Y, and Z-axis value. (G)
G Tot: The total acceleration calculated by the accelerometer values. (G)
Hx, Hy, Hz: The MWD magnetometer sensor's X, Y, and Z-axis value. (Gauss)
H Tot: The total magnetic field calculated by magnetometer values. (Gauss)
Azm: The azimuth angle of the tool. (°)
Inc: The inclination of the tool. (°)
mTFA: The magnetic tool-face angle. (°)
gTFA: The gravitational tool-face (High Side) angle. (°)
DipA: The dip angle with respect to the magnetic field of the earth. (°)

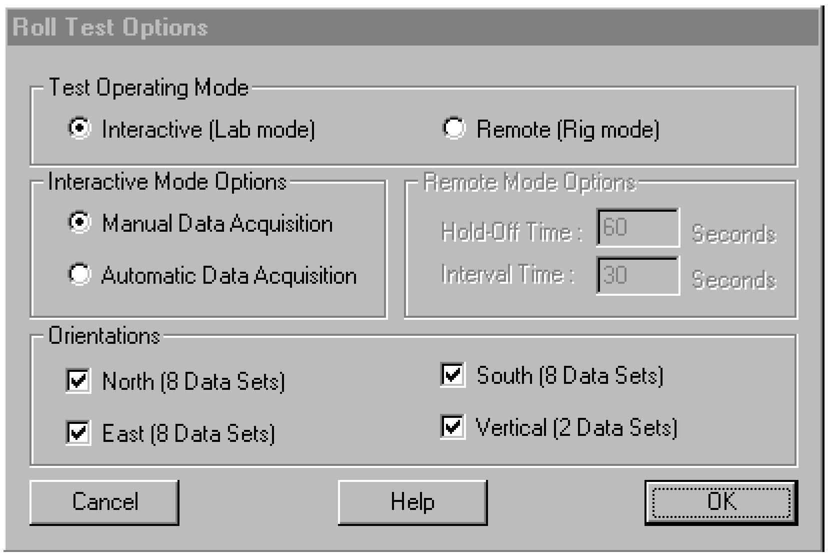
Removing Bad Data:
When you observe a set of bad data, place a checkmark in the **Bad** field of the data set. The data set remains marked as bad until the user unmarks it. MWDRoll32 does not delete data sets marked as bad, but does omit them from all calculations. Data sets marked as bad remain part of the acquired data and appear on printed reports marked as bad.

Roll Test Options

Data acquisition can be initiated in only two ways:

• **Automatically** - if starting a new test, MWDRoll32 guides the user through a sequence that opens the Roll Test Options dialog (pictured below) and starts data acquisition.

• **Manually** - if a roll test is already open, the user may choose to start acquiring data by selecting the **Start Data Acquisition…** item from the **File** menu. The Roll Test Options dialog (pictured below) opens.



Test Operating Mode

In the Roll Test Options dialog, the user first selects an operating mode:

• **Interactive** mode allows the user to manually acquire data as each orientation becomes ready. This selection may be convenient when the test is conducted near the computer.

• **Remote** mode allows automatic data acquisition at timed intervals. This selection may be convenient when the test is conducted far from the computer.

Interactive Mode Options
When selecting Interactive mode, the user must set the interactive mode options. The default selection is manual data acquisition.
Manual Data Acquisition requires the user to click either the Acquire or Skip button for each tool position.

Automatic Data Acquisition automatically acquires the data after allowing the user a set interval of time to properly position the tool in each orientation.

Remote Mode Options
When selecting Remote mode, the user must set remote mode options.

Hold-Off Time: Enter the time (in seconds) the user needs to proceed to the MWD tool location before testing actually starts.

Interval Time: Enter the time (in seconds) between each automatic data acquisition.

Note: MWDRoll32 will automatically record data at the end of each interval whether the tool is properly positioned or not.

Orientations:
By default, MWDRoll32 acquires data for all four orientations unless the user chooses to acquire data from fewer than four. For example, if, after a roll test is completed, the data from one of the four orientations is discovered to be bad, the user is able to re-acquire data for that one orientation only.

Starting the test:
Once all options in the Roll Test Options dialog have been set, the user may start the test by clicking the **OK** button. To find out how to acquire data, see the Acquiring Data help.

Acquiring Data
Once a roll test has been started (see Starting a New Roll Test), data acquisition begins. The method used to acquire data depends on the user's selection of Interactive or Remote mode.

Interactive Mode Data Acquisition

1) Position the tool in the orientation specified in the User Instructions/Feedback display. Place the MWD tool flat (set inclination to 90°) and set the azimuth to reflect the orientation:

• For North, set the azimuth to 0°
• For East, set the azimuth to 90°
• For South, set the azimuth to 180°
• For Vertical, the azimuth value is ignored.

2) Set High Side: refer to the Guidance Rose display and rotate the tool until the red High Side marker is within the green pie section.
3) Click the **Acquire** button to record the data or click the **Skip** button to discard the data. The green pie section moves to the next position.
4) Repeat the previous step for each position until the green pie section has returned to the original position.
5) Refer to the User Instructions display for further instructions.

Remote Mode Data Acquisition

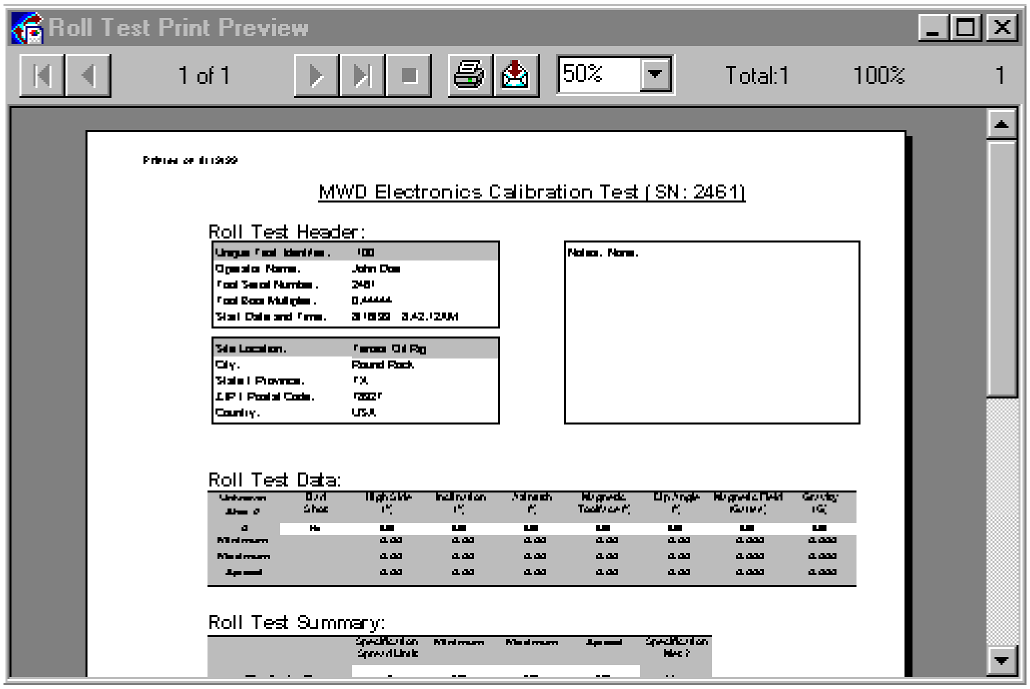
Prepare to use your watch to monitor the seconds passing as you position the tool into each orientation. Stay within the allotted Hold-Off and Interval times.
1) Click the **OK** button on the Roll Test Options dialog.
2) Position the MWD tool in the first orientation.
3) Wait for the Hold-Off time to elapse and for MWDRoll32 to acquire the data for the first orientation.
4) Rotate the tool by 45° during the interval time.
5) Wait for MWDRoll32 to acquire the data.
6) Repeat the previous two steps until MWDRoll32 has acquired data for all orientations.

Printing and Exporting Reports

Print a report for every completed roll test. MWDRoll32 saves all data but a printed report is useful for reference.

Previewing

To view a preview of the test report, click the **Print/Export Report…** item from the **File** menu. A window containing a preview pane and print control buttons appears.



Exporting

To export the report, click the **envelope** icon. MWDRoll32 prompts you to enter the export format and destination.
To export to another file format, enter the path and filename for the new file.

Printing

Preview the report to verify that the data is correct.
To print, click the **printer** icon. A window with print options appears. Select from the options and click **OK**.
To close the Print/Export window, click the **X** button.

Troubleshooting

The following known issues may cause problems under infrequent circumstances.

Error Messages:
The Jet VBA file vbajet.dll or vbajet32.dll failed to initialize when called.
Try re-installing the application that returned the error.
This error is due to a problem registering the DAO file ddao350.dll.
To correct this problem:
1) Close MWDRoll32.
2) Click the Windows **Start** button (on the lower left corner of the screen).
3) Click the **Run** item.
4) Enter **regsvr32 ddao350.dll**.
5) Click **OK**.
6) Re-start Windows.
7) Re-start MWDRoll32.

Appearance Problems
MWDRoll32's main displays look discolored, odd, or indistinguishable.
This problem is probably due to bad color settings. To correct your PC color settings:
1) Close MWDRoll32.
2) Click the Windows **Start** button (on the lower left corner of the screen).
3) Click the **Settings** item.
4) Click **Control Panel** item. The Control Panel window opens
5) Click the **Display** icon. The Display Properties window opens.
6) Click the **Settings** tab at the top of the Display Properties window
7) Verify that the Colors field is set to at least 256 colors or 8 bit.
Ideally, it should be set to either 65536 Colors, 16 Bit, or High Color.
8) Click **OK**. The Display Properties window closes.
9) Close the Control Panel window.
10) Re-start Windows.
11) Re-start MWDRoll32.

MWDRoll32 does not fit within the Windows desktop and some items are not visible.
This problem is due to the resolution of the video adapter. To correct your PC screen resolution setting:
1) Close MWDRoll32.
2) Click the Windows **Start** button (on the lower left corner of the screen).
3) Click the **Settings** item.
4) Click **Control Panel** item. The Control Panel window opens
5) Click the **Display** icon. The Display Properties window opens.
6) Click the **Settings** tab at the top of the Display Properties window
7) Verify that the Screen Area field is set to at least 640 x 480.
Ideally it should be set to 1024 x 768.
8) Click **OK**. The Display Properties window closes.
9) Close the Control Panel window.
10) Re-start Windows.
11) Re-start MWDRoll32.

After a print, the print preview pane displays oddly.

After sending a report to the printer, MWDRoll32 does not refresh the print preview window. To view the print preview window again:
1) Click the **Close** button.
2) Click the **File** menu.
3) Click the **Print/Export Report** item.

Bug Reporting
Please contact GE Power Systems if you find a recurring problem in MWDRoll32. First, make sure you can reproduce the problem, then email the following details to: william.ryer@ps.ge.com
• Your name and email address for correspondence
• Description of the recurring problem including any relevant information
• Steps needed to reproduce the problem
• Details of the computer system running MWDRoll32
• Any additional information
Please include as many details as possible in your email.

Magnetic Declination and other Magnetic Information
The declination and other magnetic information for your geographic location can be found on the Internet site for the National Geophysical Data Center of NOAA. The address is www.ngdc.noaa.gov/seg/potfld/geomag.html.
Click the heading *Magnetic Declination*. Enter your latitude and longitude to obtain the declination and other information. For assistance in determining your correct latitude and longitude, click the link on this web page to either the U.S. Gazetteer or the Getty Thesaurus.

MWD Electronics Calibration Test (SN: 2004) (Created on 08/18/00)
Roll Test Header:
Unique Test Identifier: 254 Notes: Software Test
Operator Name: SAM Site Location: Mag2
Tool Serial Number: 2004 City: Austin
Tool Bias Multiplier: State / Province: TEXAS
Start Date and Date:
8/15/00 3:17:21

Roll Test Data:

North

Shot #	Bad Shot	High Side	Inclination (°)	Azimuth (°)	Magnetic Toolface (°)	Dip Angle (°)	Magnetic Field (Gauss)	Gravity (G)
1	No	357.80	90.00	0.80	177.30	59.50	0.49	1.00
2	No	44.60	90.00	0.80	224.20	59.50	0.49	1.00
3	No	91.20	90.00	0.80	270.80	59.50	0.49	1.00
4	No	130.90	90.10	0.80	310.50	59.50	0.49	1.00
5	No	175.80	90.00	0.90	355.30	59.50	0.49	1.00
6	No	222.70	90.00	0.90	42.10	59.50	0.49	1.00
7	No	266.40	89.90	0.90	85.90	59.50	0.49	1.00
8	No	313.30	89.90	0.80	132.90	59.50	0.49	1.00
Minimum		44.30	90.00	180.60	41.10	59.50	0.493	1.002
Maximum		357.50	90.20	180.60	356.10	59.60	0.494	1.003
Spread		313.20	0.20	0.00	315.00	0.10	0.001	0.001

East

Shot #	Bad Shot	High Side	Inclination (°)	Azimuth (°)	Magnetic Toolface (°)	Dip Angle (°)	Magnetic Field (Gauss)	Gravity (G)
9	No	358.30	90.30	90.50	147.90	59.60	0.49	1.00
10	No	45.80	90.30	90.60	195.40	59.60	0.49	1.00
11	No	87.50	90.30	90.60	237.10	59.60	0.49	1.00
12	No	132.00	90.30	90.50	281.60	59.60	0.49	1.00
13	No	179.60	90.30	90.60	329.20	59.50	0.49	1.00
14	No	228.90	90.20	90.60	18.40	59.50	0.49	1.00
15	No	270.30	90.20	90.60	59.80	59.50	0.49	1.00
16	No	315.40	90.20	90.50	104.90	59.50	0.49	1.00
Minimum		45.80	90.20	90.50	18.40	59.50	0.493	1.002
Maximum		358.30	90.30	90.60	329.20	59.60	0.494	1.002
Spread		312.50	0.10	0.10	310.80	0.10	0.001	0.000

South

Shot #	Bad Shot	High Side	Inclination (°)	Azimuth (°)	Magnetic Toolface (°)	Dip Angle (°)	Magnetic Field (Gauss)	Gravity (G)
17	No	357.50	90.10	180.60	177.90	59.60	0.49	1.00
18	No	44.30	90.10	180.60	224.60	59.60	0.49	1.00
19	No	85.60	90.20	180.60	265.90	59.60	0.49	1.00
20	No	130.50	90.20	180.60	310.90	59.60	0.49	1.00
21	No	175.70	90.10	180.60	356.10	59.60	0.49	1.00
22	No	220.80	90.10	180.60	41.10	59.60	0.49	1.00
23	No	271.00	90.00	180.60	91.40	59.60	0.49	1.00
24	No	318.30	90.00	180.60	138.60	59.50	0.49	1.00
Minimum		**44.30**	**90.00**	**180.60**	**41.10**	**59.50**	**0.493**	**1.002**
Maximum		**357.50**	**90.20**	**180.60**	**356.10**	**59.60**	**0.494**	**1.003**
Spread		**313.20**	**0.20**	**0.00**	**315.00**	**0.10**	**0.001**	**0.001**

Vertical

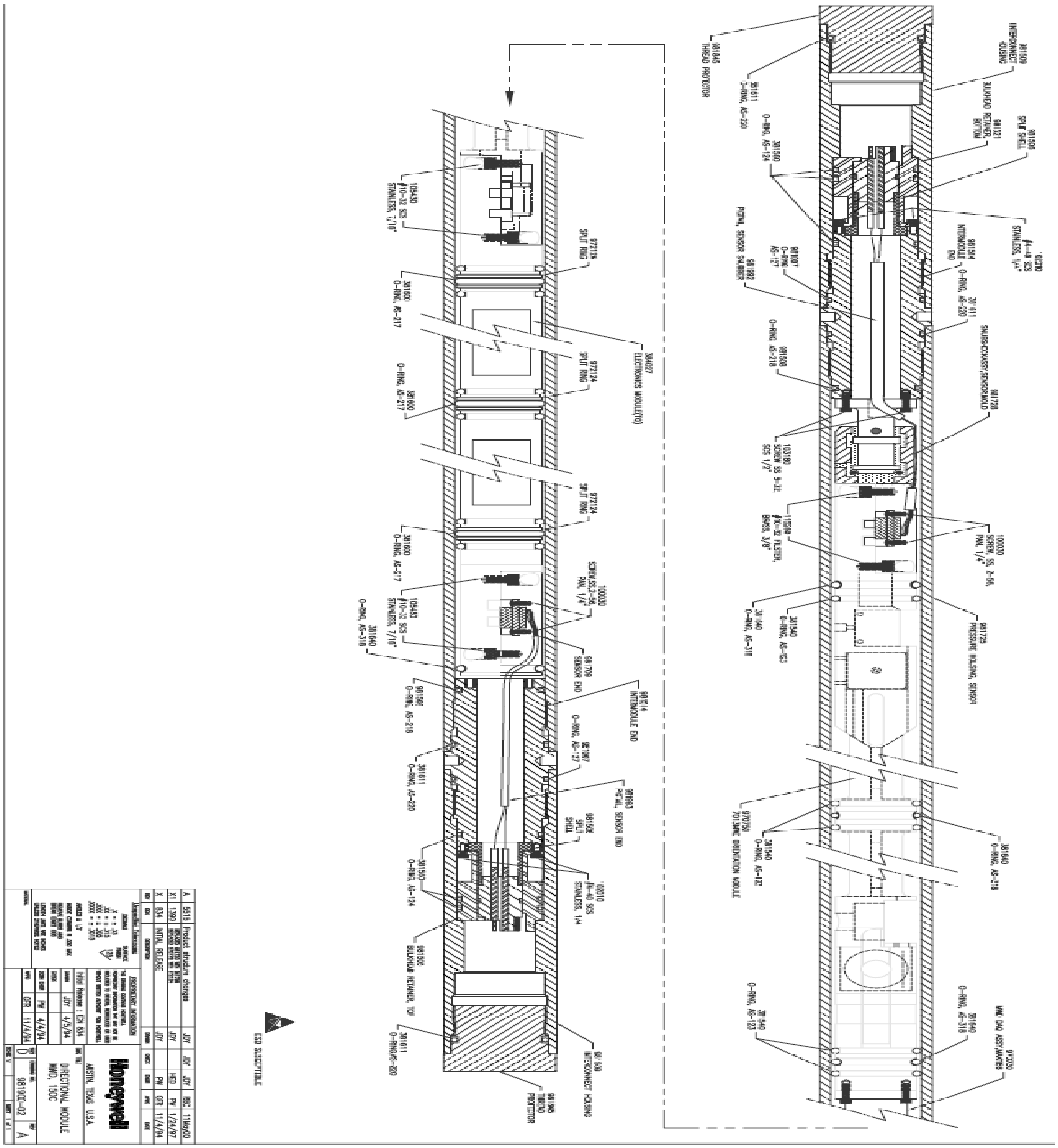
Shot #	Bad Shot	High Side	Inclination (°)	Azimuth (°)	Magnetic Toolface (°)	Dip Angle (°)	Magnetic Field (Gauss)	Gravity (G)
25	No	128.10	0.30	27.30	155.70	59.60	0.49	1.00
26	No	127.90	0.30	27.50	155.70	59.50	0.49	1.00
25	No	128.10	0.30	27.30	155.70	59.60	0.49	1.00
Spread		**0.20**	**0.00**	**0.20**	**0.00**	**0.10**	**0.000**	**0.000**

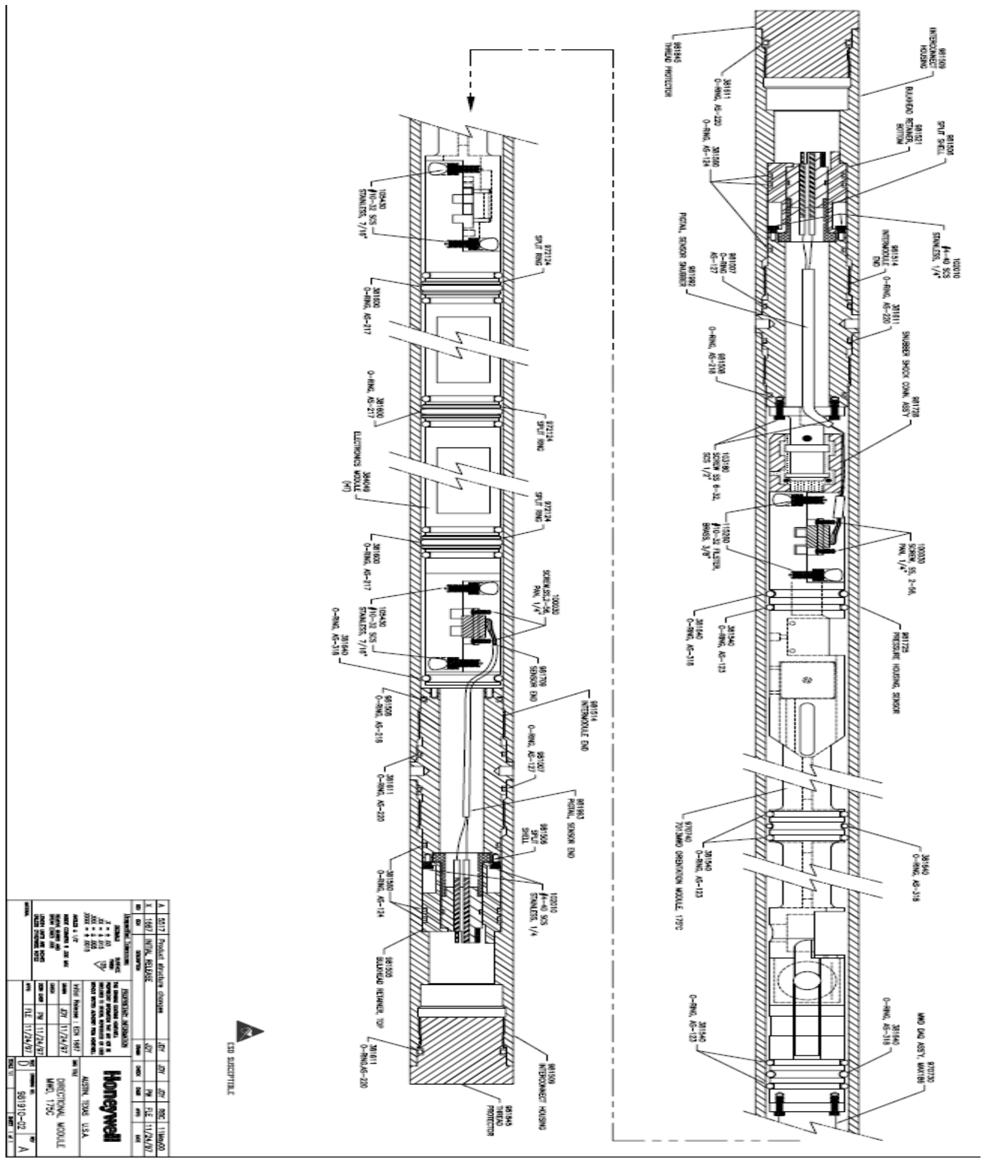
Roll Test Summary:

	Specification Spread Limit	Minimum	Maximum	Spread	Specification Met?
Dip Angle (°)	1.2	59.50	59.60	0.10	**Yes**
Magnetic Field (Gauss)	0.007	0.493	0.494	0.001	**Yes**
Gravitational Field (G)	0.012	1.001	1.003	0.002	**Yes**

		North Spread	East Spread	South Spread	
Inclination (°)	0.2	0.20	0.10	0.20	**Yes**
Azimuth (°)	0.4	0.10	0.10	0.00	**Yes**

Roll Test Specification Evaluation:
MWDRoll32 has determined that the MWD tool is calibrated and accurate enough to meet GE-Tensor requirements.





NOTES

C. KEYDRILL

Operational Manual

KDT MWD Mud Pulse Receiver

For Window 2000, Window XP, and Vista

Revised: February 16, 2009

Manufactured By:
KeyDrill Technology LLC
831 Spring Mist CT
Sugar Land, TX 77479

Phone: 281-253-2066

The Fifth Edition

KDT RECEIVER SPECIALS

The KeyDrill Receiver (KDT Receiver) provides many special features for easy and reliable operation.

1. KDT Receiver provides the best synchronization and detection abilities in the market.

2. KDT Receiver can run in “Plug and Play” mode. This means that KDT Receiver can run automatically without the operator’s help.

3. The KDT Receiver will save the data in the “C:\PROGRAM FILES\KEYDRILL TECHNOLOGY LLC\KDT\JOBDIR\YYYY-MM-DD directory. (YYYY-MM-DD represents year, month and day).

4. KeyDrill Receiver will automatically load all of **today’s** decoded data, and display it on the KDT Receiver screen on the “History” and “Survey” windows whenever the operator restarts KDT receiver software.

5. KDT Receiver software records all Pump On time on both RUN and Daily bases.

6. KDT Receiver can output WITS or Gamma Output data format.

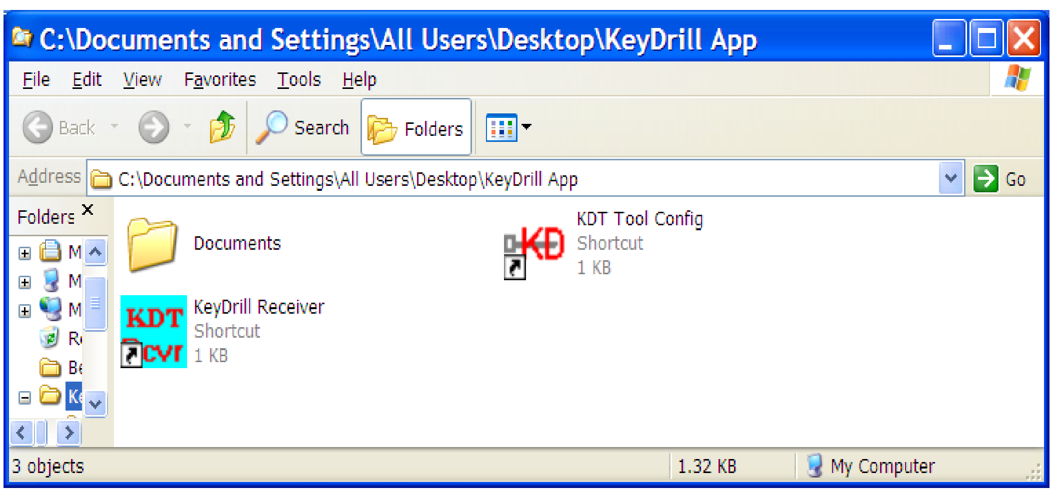
KDT RECEIVER OPERATIONAL PROCEDURES

1. Link the pressure transducer cable and the tool program cable to the computer box.

2. Plug the power cord into the computer box.

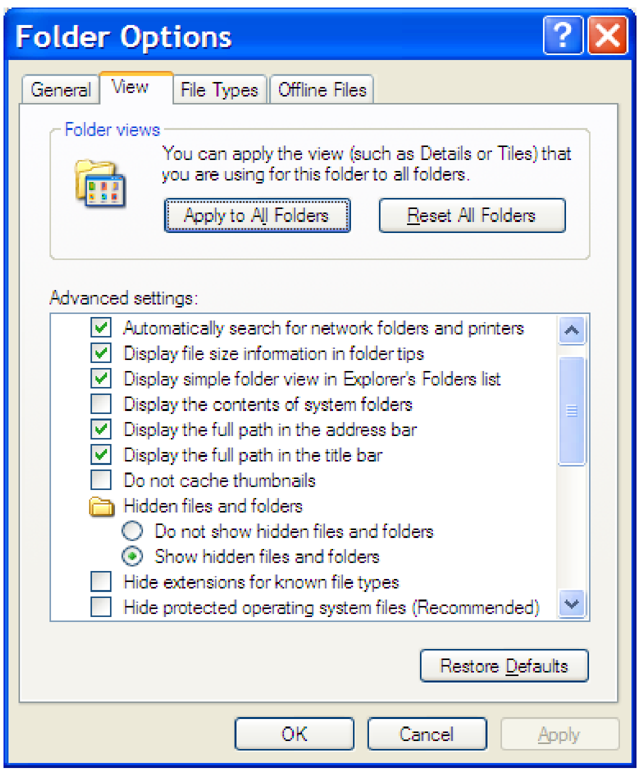
3. Turn on your computer, and wait until the computer is running smoothly, e.g. complete its virus scan procedures etc.

4. Find **KeyDrill App** folder. All program icons are located in this folder. It includes all the operational manuals as well.



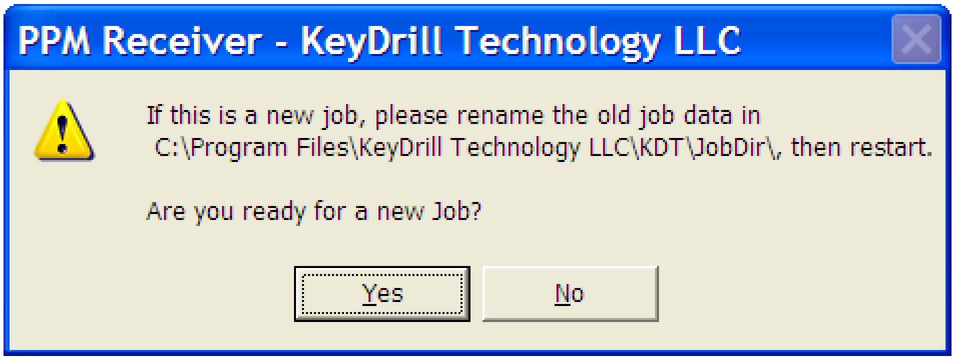
5 Program your MWD tool. If it is an industrial standard MWD tool, you can program it using KeyDrill's "**KDT Tool Config**" software  .

6 **[If the third party's configuration file is used, please copy the configuration file to "C:\Program Files\KeyDrill Technology LLC\KDT\" directory, and double-clicking to reopen it in KeyDrill's tool configuration program.]** (Make sure that the content of "C:\Program Files\KeyDrill Technology LLC\KDT\ConfigLoc.dat" file is point to the file.) If you use KeyDrill's configuration software, all these procedures are automatically set. (*Please remember to* ***uncheck*** *the "**hide the extension from the known files types**" in the following figure. It is located in the "Tools" menu of File Explorer so that you can see the file extension "mwd"*)

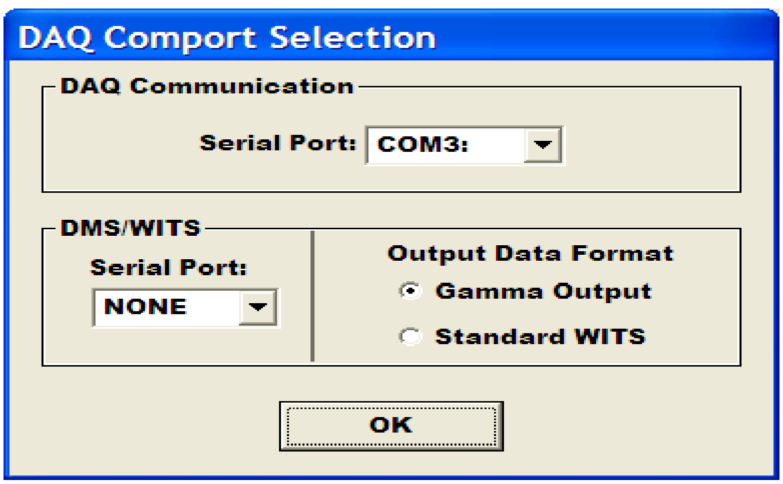


7 Start KDT receiver software by double clicking the icon 

. If you start the job for the first time after configuring a tool, the following window will appear. Click "Yes" to continue.



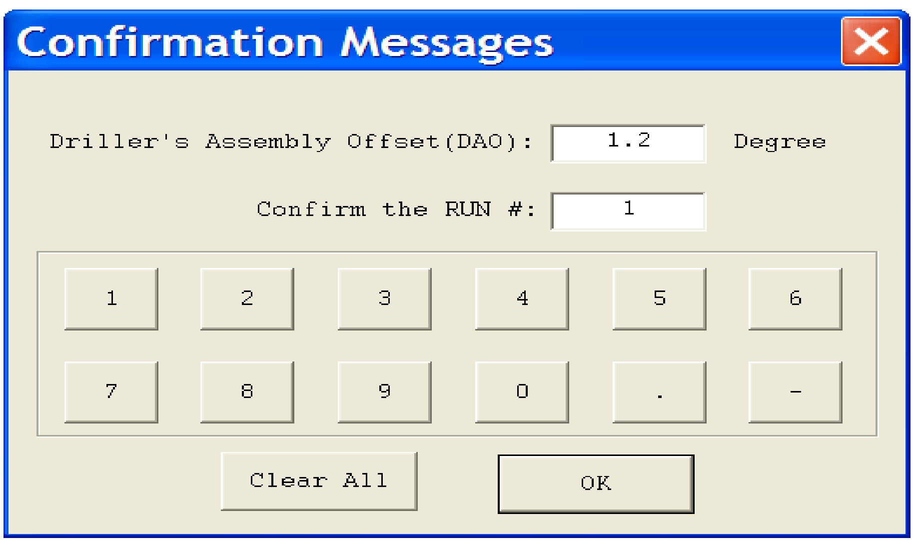
8 Select a DAQ data acquisition port (for example, COM2 for Compass Guidance's system), and a WITS output port from the following dialog. They have to be on different ports. The Output Data Format could be a Gamma Output or a Standard WITS.



If the same COM ports were selected for DAQ and WITS, WITS port would be disabled.

9 The following dialog shows the tool configuration file used for KDT receiver. The file name and location is saved in the file "C:\Program Files\KeyDrill Technology LLC\KDT\ConfigLoc.dat" file.

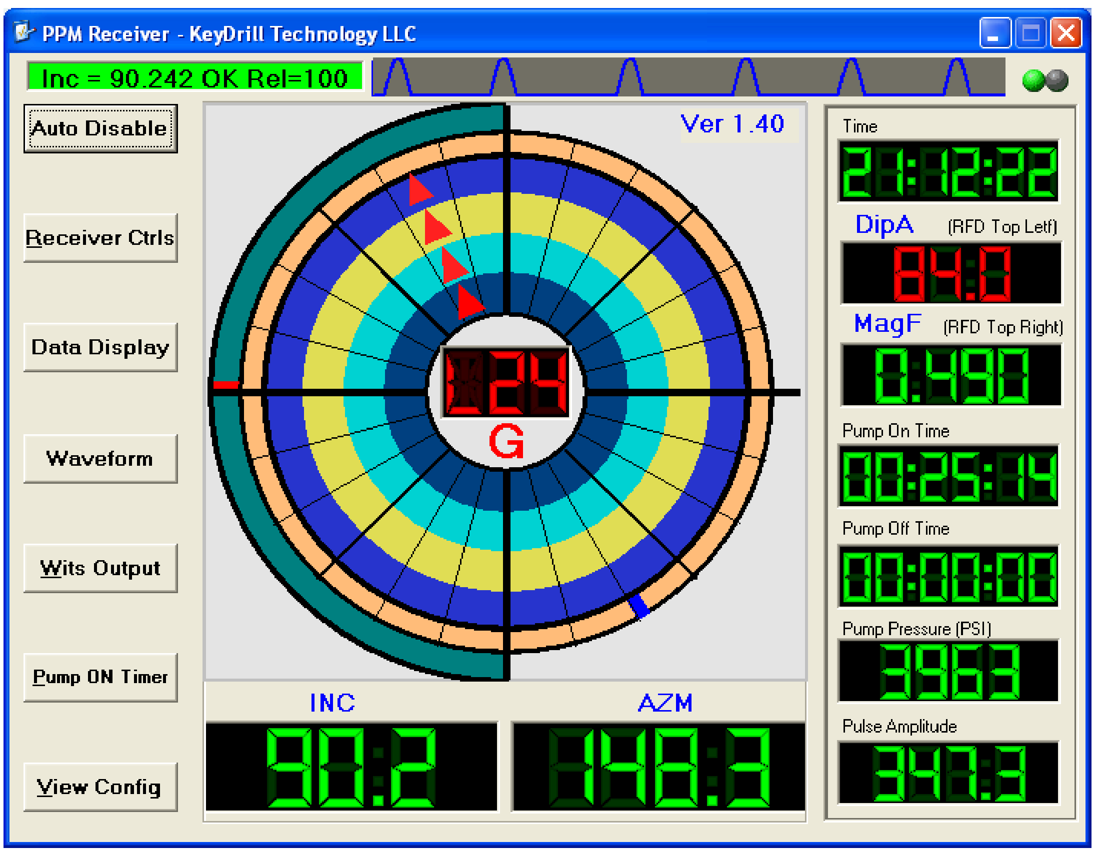
10 Please fill up the following window. The Run # must be between 1 and 99.



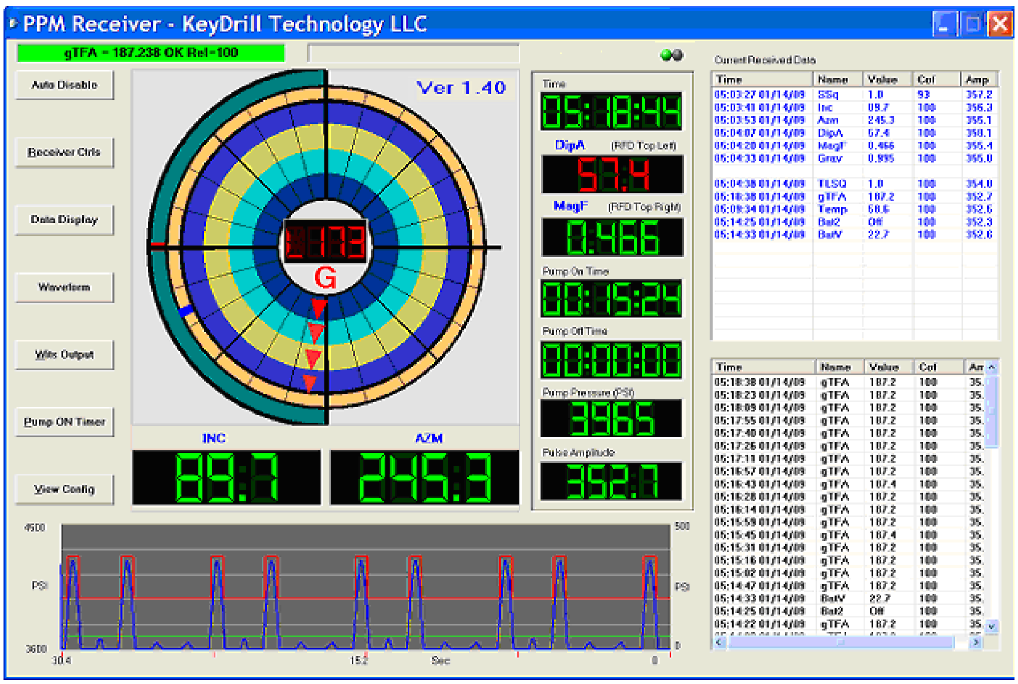
If RUN # is 0 (Zero), it may be a new job. If so, please save or rename the data files from the old job in "C:\Program Files\KeyDrill Technology LLC\KDT\ JobDir\" to other locations first.

Enter the correct DAO number and confirm the RUN #, Click "OK" button to continue.

11 This is a KDT receiver window if the screen resolution is 800 by 600 pixels.

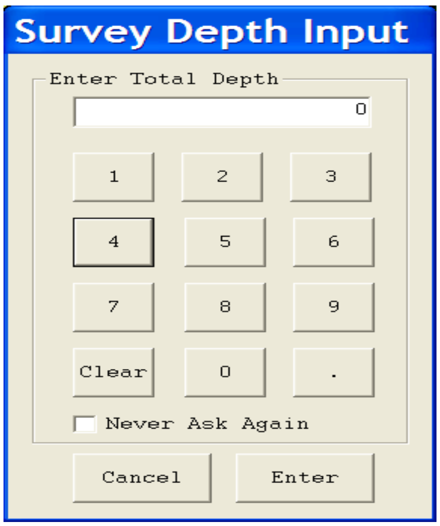


12 If the screen resolution is ***larger than*** 800 by 600 pixels, the receiver window will look like this:



13 1 displays the current received data with its confidence number (also known as reliability). When the area is RED, it means that KDT Receiver is searching for synchronization. When the receiver is synced, its color will change to GREEN.

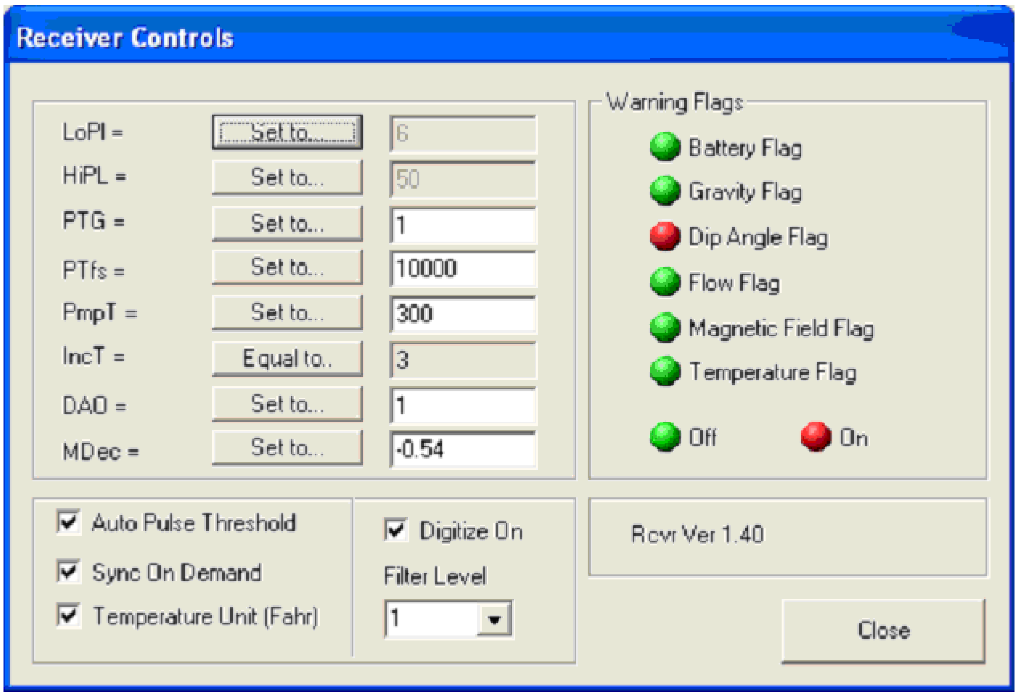
14 When KDT receiver receives survey data, a “Survey Depth Input” dialog box pops up. The depth you input into the box will be saved in the file and can be reloaded and viewed later. If you don’t need it, please check “Never ask again”.



15 The window will display the warning message.

16 3 enables and disables the “Automatic Pulse Threshold” function. When “Automatic Pulse Threshold” is enabled, the receiver will run automatically. LoPL and HiPL do not need to be set.

17 Click 4 will open the following window.



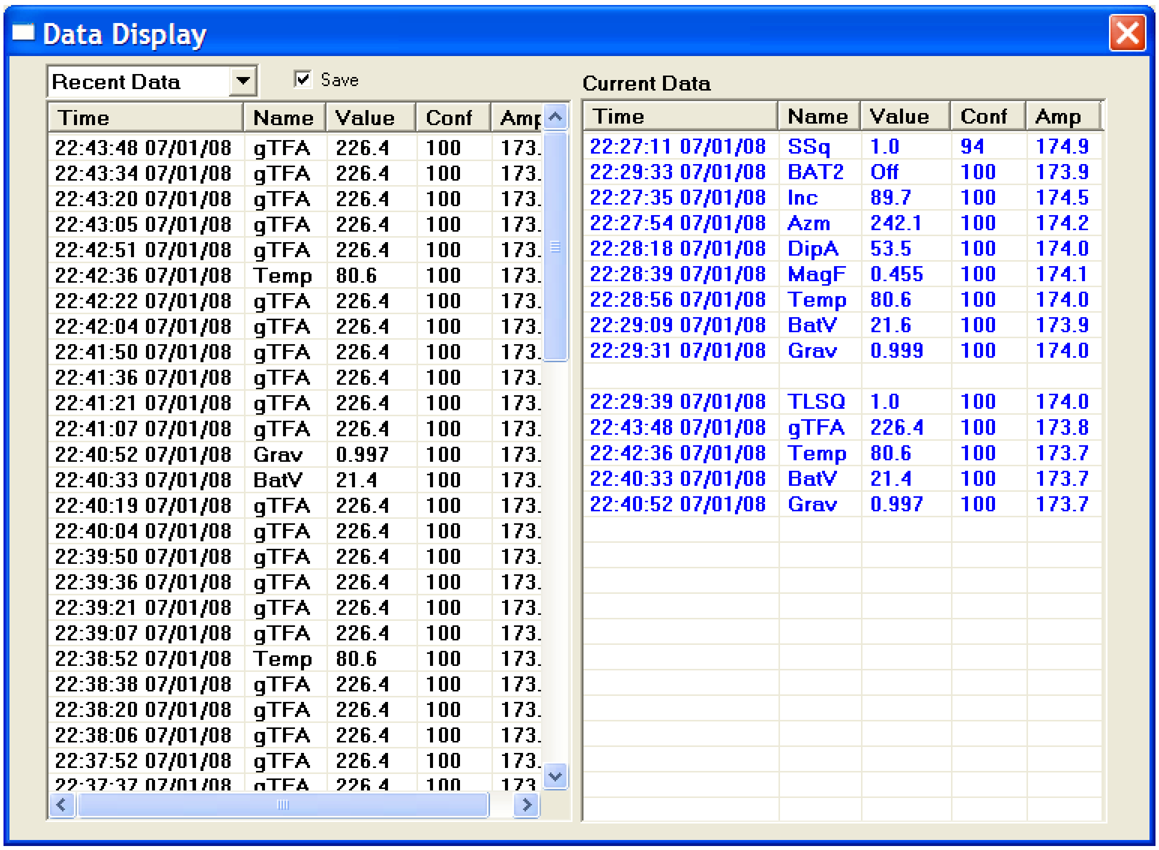
You can change some parameters in the left half to control the receiver behavior. The right half side shows the various flags. “IncT” can only be changed when you program the tools.

IncT is an indicator where Inclination Threshold is set in tool configuration program. You cannot change it in receiver software here.

Digitize On” is used to turn on the pressure waveform record function. It is automatically turned off when your harddisk is less than 1G.

We do NOT recommend changing the “Filter Level”. The KDT Receiver will automatically set it to 1. If the noise is too strong and/or the decoded data is often incorrect, you can increase the “Filter Level” one by one. Do not jump the “Filter level” more than 1 level at a time.

18 will open the following window.



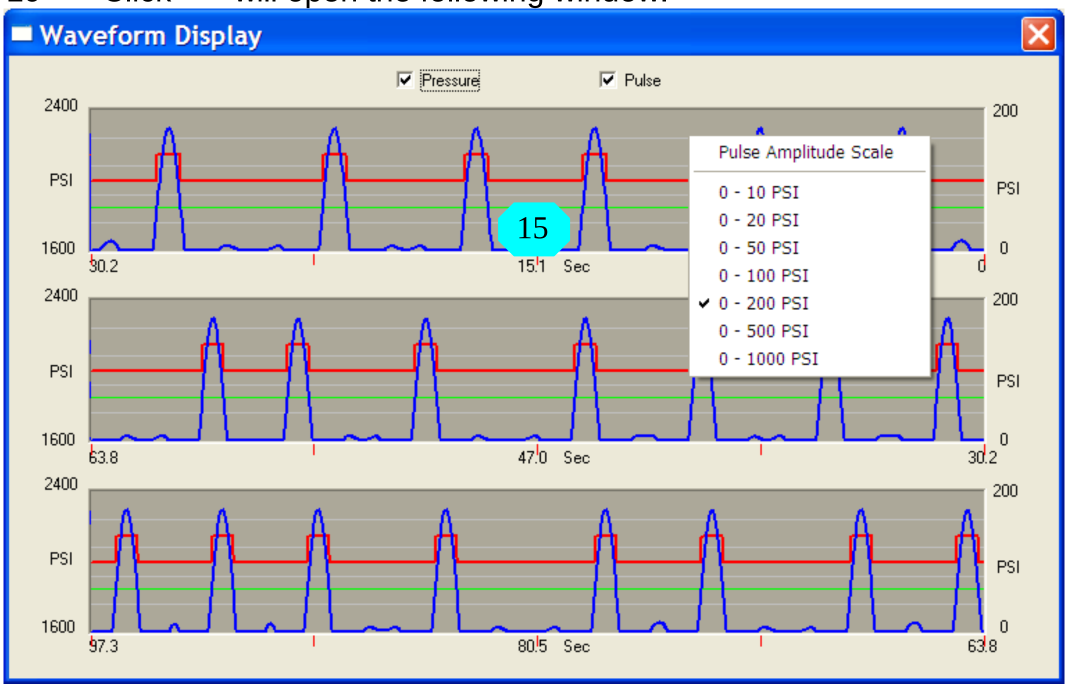
Time	Name	Value	Conf	Amp
22:43:48 07/01/08	gTFA	226.4	100	173.
22:43:34 07/01/08	gTFA	226.4	100	173.
22:43:20 07/01/08	gTFA	226.4	100	173.
22:43:05 07/01/08	gTFA	226.4	100	173.
22:42:51 07/01/08	gTFA	226.4	100	173.
22:42:36 07/01/08	Temp	80.6	100	173.
22:42:22 07/01/08	gTFA	226.4	100	173.
22:42:04 07/01/08	gTFA	226.4	100	173.
22:41:50 07/01/08	gTFA	226.4	100	173.
22:41:36 07/01/08	gTFA	226.4	100	173.
22:41:21 07/01/08	gTFA	226.4	100	173.
22:41:07 07/01/08	gTFA	226.4	100	173.
22:40:52 07/01/08	Grav	0.997	100	173.
22:40:33 07/01/08	BatV	21.4	100	173.
22:40:19 07/01/08	gTFA	226.4	100	173.
22:40:04 07/01/08	gTFA	226.4	100	173.
22:39:50 07/01/08	gTFA	226.4	100	173.
22:39:36 07/01/08	gTFA	226.4	100	173.
22:39:21 07/01/08	gTFA	226.4	100	173.
22:39:07 07/01/08	gTFA	226.4	100	173.
22:38:52 07/01/08	Temp	80.6	100	173.
22:38:38 07/01/08	gTFA	226.4	100	173.
22:38:20 07/01/08	gTFA	226.4	100	173.
22:38:06 07/01/08	gTFA	226.4	100	173.
22:37:52 07/01/08	gTFA	226.4	100	173.
22:37:37 07/01/08	gTFA	226.4	100	173.

Time	Name	Value	Conf	Amp
22:27:11 07/01/08	SSq	1.0	94	174.9
22:29:33 07/01/08	BAT2	Off	100	173.9
22:27:35 07/01/08	Inc	89.7	100	174.5
22:27:54 07/01/08	Azm	242.1	100	174.2
22:28:18 07/01/08	DipA	53.5	100	174.0
22:28:39 07/01/08	MagF	0.455	100	174.1
22:28:56 07/01/08	Temp	80.6	100	174.0
22:29:09 07/01/08	BatV	21.6	100	173.9
22:29:31 07/01/08	Grav	0.999	100	174.0
22:29:39 07/01/08	TLSQ	1.0	100	174.0
22:43:48 07/01/08	gTFA	226.4	100	173.8
22:42:36 07/01/08	Temp	80.6	100	173.7
22:40:33 07/01/08	BatV	21.4	100	173.7
22:40:52 07/01/08	Grav	0.997	100	173.7

12 is a combo box that has 3 selections: “Recent Data”, “History Data”, and “Survey Data”. “Recent Data” displays all data since last Pump is ON, and lists in time sequence 13 wn in . “History Data” lists all history data received since KDT receiver was turned ON or today. “Survey Data” will display all Survey data received since KDT receiver was turned ON or today.

14 lists all current data. The new data will overwrite the old data if the same data is received. It will display the current data with the survey data on top, followed by Telemetry data.

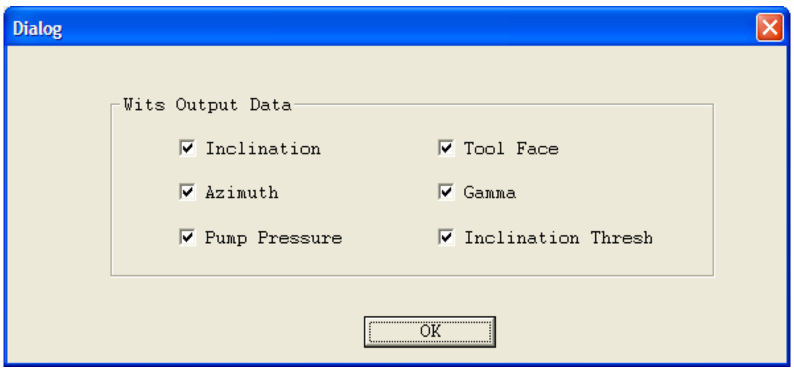
19 Click will open the following window.



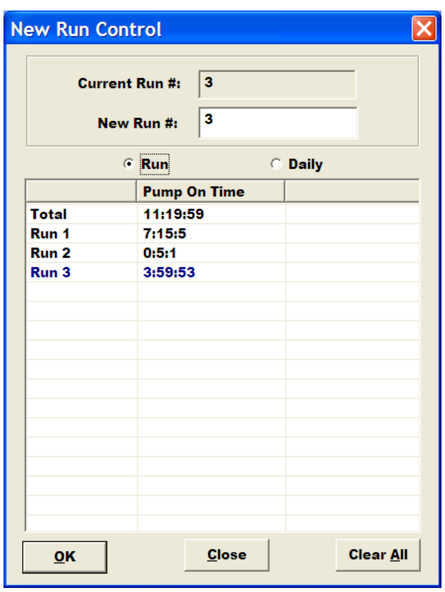
By moving the mouse t 15 , and right-clicking the mouse button, the “Pulse Amplitude Scale” pop-up menu will appear

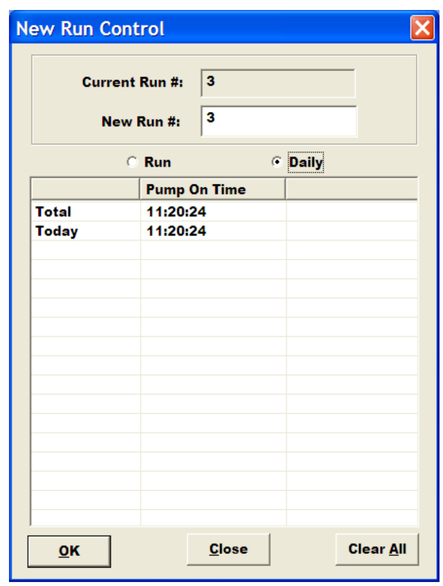
The scale in left-hand side is the pressure scale. The scale in right-hand side is the Pulse amplitude scale. The pressure scale adjusts automatically, and the Pulse amplitude scale is adjusted manually.

20 Clicking 7 will open the following window. Select the parameters you want for your WITS output.



21 Clicking 8 will open the following window.

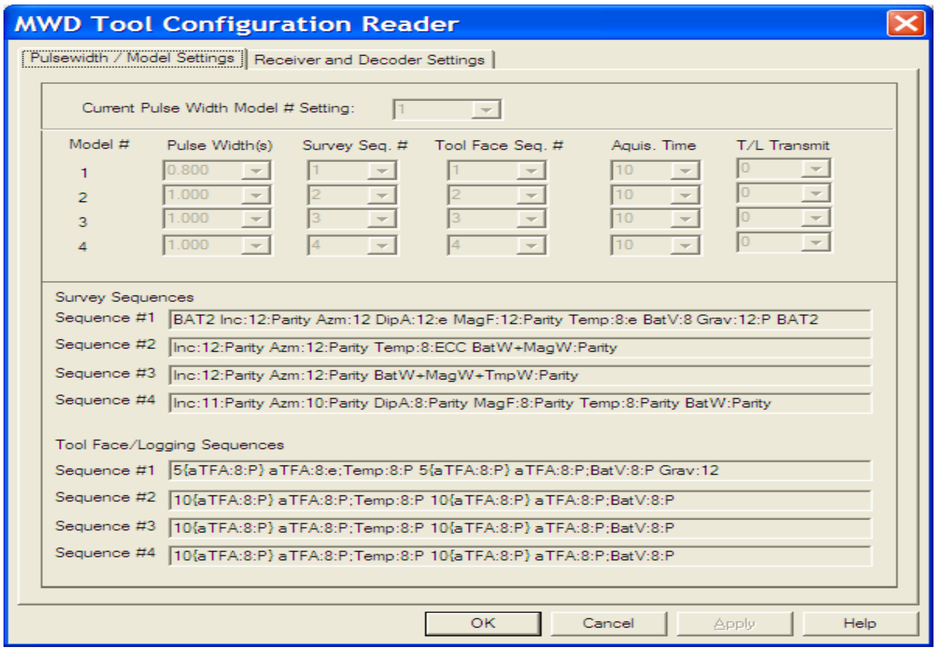




The default will display the Pump On Time on RUN base. If you would like to display the Pump On time in daily base, please click the “Daily” Button.

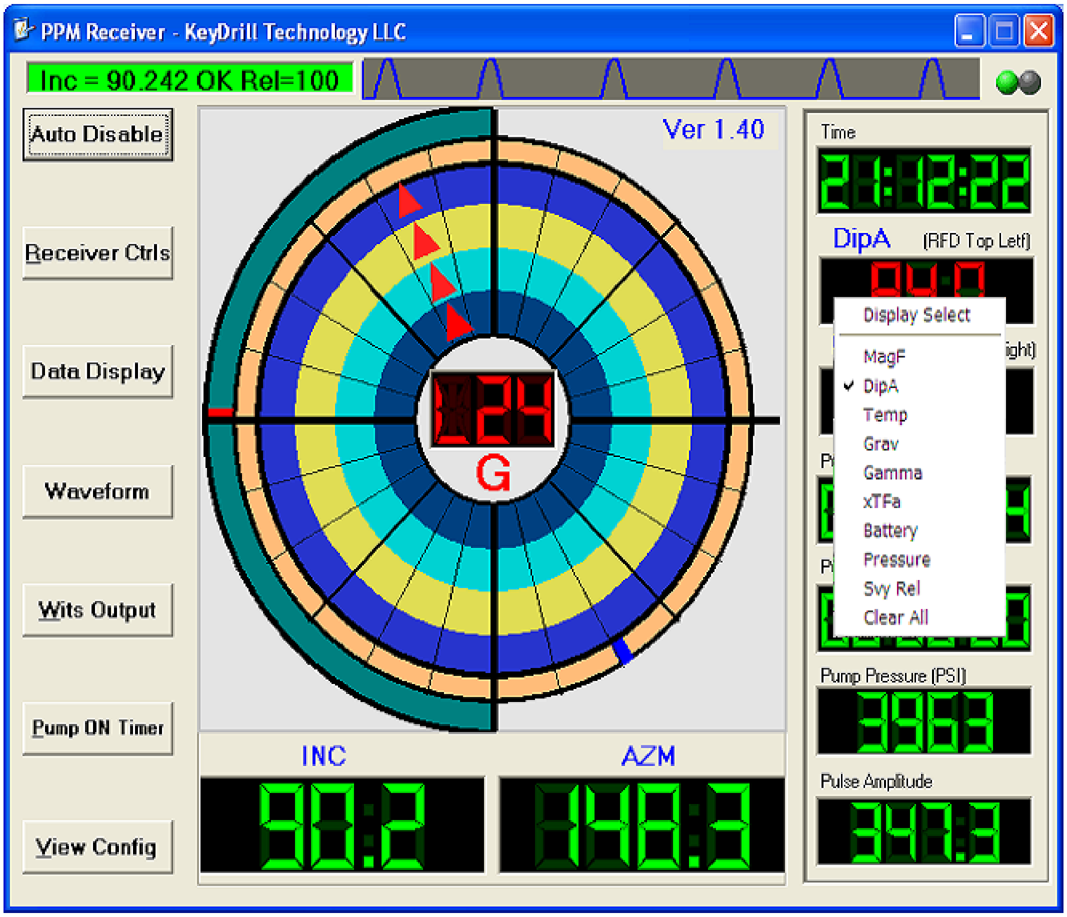
You can also set the “New Run #” here. If the run # is the same as the old Run #, the operator can click “cancel” to exit this dialog box.

22 Clicking 9 will open the following window to display the tool configuration data.



23 By **right clicking** the area 10, the operator can select the parameters to be displayed in KeyDrill's rig floor display.

24 By **right clicking** the are 10 , the operator can select the parameters to be displayed in KeyDrill's rig floor display.



The data color indicates whether the data is inside the presetting range or not. If the data is in the range, it displays in GREEN. Otherwise, it displays in RED as "DipA" shown above.

25 The Pump On time can be found in a 11 .

26 If you have any problem, or you have some troubles to decode, please send your "Config.mwd" file with your recorded waveform files located in the directory "C:\Program Files\KeyDrill Technology LLC\KDT\JobDir**"** to Contact@KeyDrill.com. Then please feel free to contact KeyDrill Technical Support at Contact@KeyDrill.com or call (281)253-2066.

NOTES

D. DIGIDRILL

Digital Drilling Data Systems

DigiDrill Data Logger and Applications

Operator’s Manual

1 Introduction

The applications included in the product are separated into three functional components:
• Data Logger which is responsible for acquiring data from the various tools and other sources and logging this data into the database.
• GeoLogPlot is used to retrieve logged data from the database to generate plots.
• LASBuilder will also retrieve data from the database to generate LAS compatible file for exporting to other applications.

2 Data Logger Operations

The Data Logger application is used to create a database for storage then acquire data and log this data into the database. The Data Logger is designed as a startup wizard-type application that will walk the user through each step in the creation of the database and the configuration of the tool and equipment used.

2.1 Equipment

The equipment supplied is used for depth tracking in conjunction with the Data Logger application. Equipment used for depth tracking operations are:

2.1.1 Depth Tracking Box

The depth tracking box contains the following:
• Depth encoder tracking and display module
• Hookload sensor measurement and display module
• Built-in USB to serial port adapter with 2 ports used for the above devices and 2 serial ports on the back of the box for connecting to external equipment
• Intrinsically safe barriers for the encoder and hookload sensors

The internal USB to serial port adapter is supplied with drivers that automatically assign the 4 ports to be the last 4 ports listed when selecting a port to use in the Data Logger configuration.

Example:

The computer already has a COM1 and a COM3
The driver will add COM4, COM5, COM6 and COM7

If the depth tracking box is replaced then the driver may automatically assign 4 different ports to the list. For instance, if the box in the example above is replaced then the driver will remove COM4, COM5, COM6 and COM7 then assign the replacement box COM ports to COM8, COM9, COM10 and COM11.

Whatever the case always remember that **THE LAST 4 COM PORTS ARE ASSIGNED TO THE USB TO SERIAL PORT ADAPTER**.

The last COM port assigned will **ALWAYS** be for the depth encoder. The second to last COM port assigned will **ALWAYS** be for the hookload sensor. The other 2 COM ports are located on the back of the depth tracing box and can be used for external equipment communications such as WITS or for plugging into the steering tool or MWD receiver.
In the example above, COM7 will be used for the depth encoder and COM6 will be used for the hookload sensor. COM5 and COM4 will be located on the back of the depth tracking box.

2.1.2 Geolograph Line Encoder

The Geolograph encoder has a resolution of 25 counts per foot of block travel and is Atex certified for hazardous area usage. The Geolograph encoder is scaled using the Data Logger 2 step calibration procedure.

2.1.3 Drum Shaft Encoder

The drum shaft encoder is Atex certified and is adaptable to either 1” – 14 UNS or 5/8” – 18 UNF threaded shafts. The resolution of the encoder is 25 counts per revolution and is scaled using the Data Logger 4 step calibration procedure.

2.1.4 Hookload Sensor

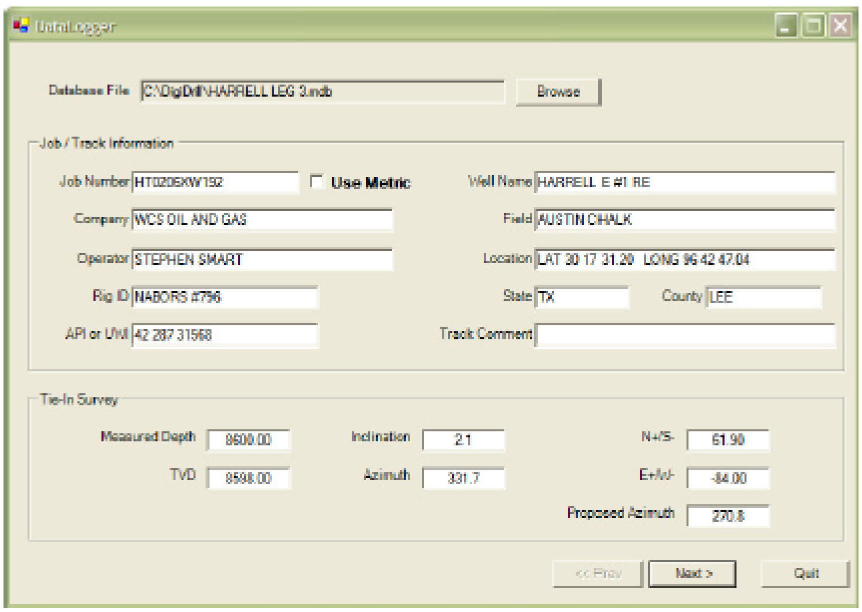
There are 2 hookload sensors available:
• 200 PSI for attaching to a pancake for deadline weight measurement
• 2000 PSI for attaching to the weight indicator at the driller’s station
The hookload sensors are scaled using the Data Logger 2 step calibration procedure.

2.2 Setup

The Data Logger is implemented as a wizard-type startup application that simplifies the steps required for proper operation. Once each step is completed the wizard will automatically configure itself for the next step in the process.

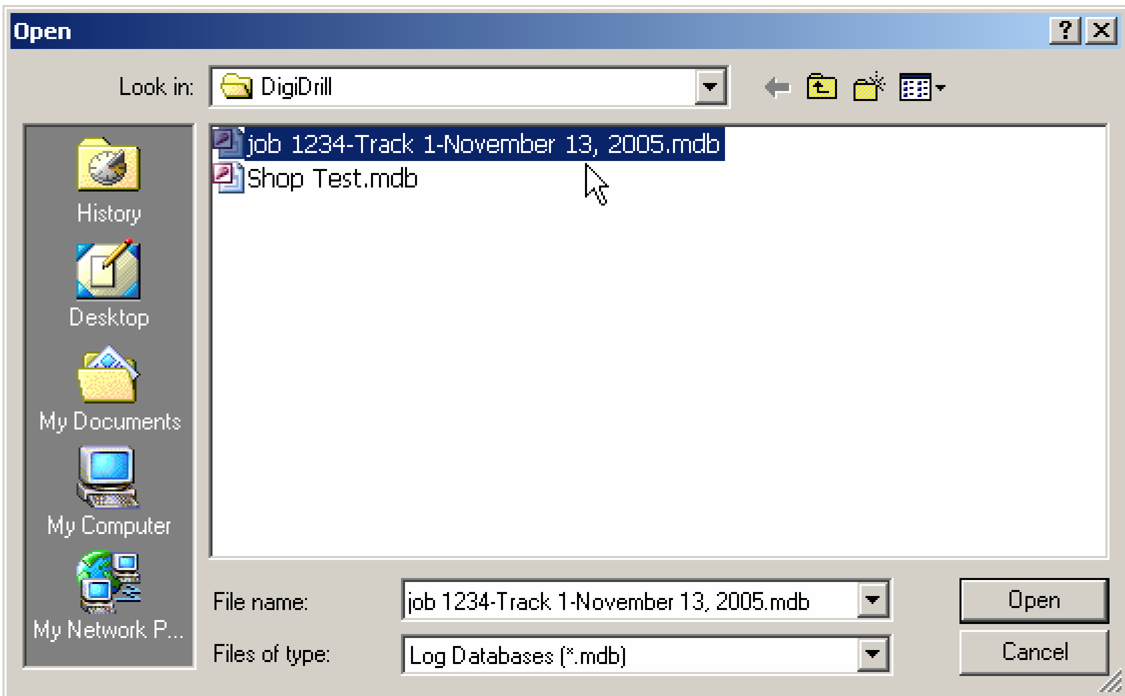
2.2.1 Job Setup

The Data Logger is responsible for creating a master database for all data logged. Every job and track/sidetrack will have its own unique database to work from. The first step in the startup process is to enter all the job information in the first wizard screen. Since each database represents a unique job and track/side track the tie-in survey information will also be included here.



Once all of the information is entered press the ***BROWSE*** button to choose a database name. The Data Logger will prompt the user for a file name to use and will suggest a database name using the ***Job Number, Track Comment*** and the current date and time as illustrated in the figure below.

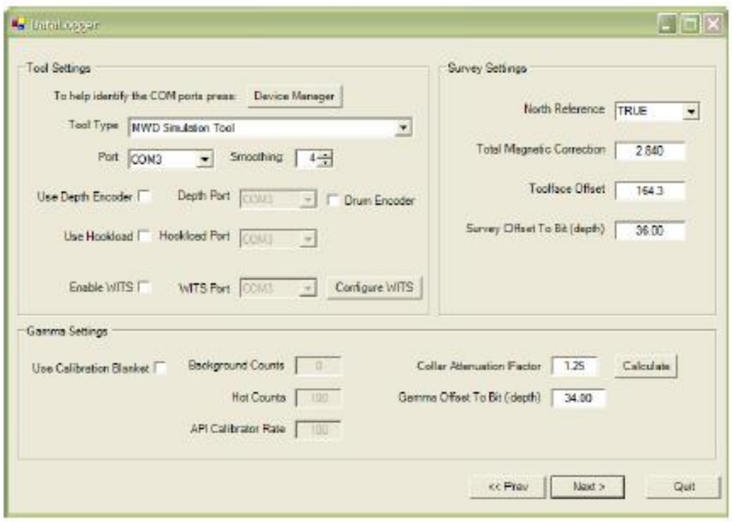
If the database has already been created then the input of the job information is not necessary. Press the ***BROWSE*** button and select an existing database to open and the information fields will be updated.



In this example the ***Job Number*** was entered as “job 1234”. The ***Track Comment*** is “Track 1”. The date and time this database was created is November 13, 2005. As a suggested file name, the Data Logger concatenates this data together to provide a unique name. The user may simply enter another name if the suggested file name is not what they wish to use.

2.2.2 Tool and Equipment Setup

Once the master database is selected then the wizard will proceed to the next page for configuring the equipment setup information. There are 3 groups of information required and will be discussed in the following sub-sections.



2.2.2.1 Tool Settings

- ***Tool Type*** – Select from the list of available tools

- ***Port*** – Choose which COM port the selected tool will be using

- ***Use Depth Encoder*** – Check this box if you will be using the supplied depth encoder for tracking depth then select the COM port that it will be connected to. Check the Drum Encoder box if you will be using the supplied drum encoder. Leave this box unchecked if you will be using a Geolograph encoder.

- ***Use Hookload*** – Check this box if you are using the supplied hookload sensor in conjunction with a depth encoder then choose the COM port that this sensor will be connected to. This will enable the Data Logger to use an intelligent slip in/out detection algorithm for tracking bit and hole depth. If this option is not checked then the user must manually insert and remove the slips for proper depth tracking.

• ***Enable WITS*** – This checkbox will instruct the Data Logger to operate in one of two modes:

If ***Use Depth Encoder*** is **not** checked then the Data Logger will receive depth tracking data from the WITS system using the selected ***WITS Port***. (This is normally the method used fir WITS)

If the ***Use Depth Encoder*** **is** checked then the depth tracking is performed by the Data Logger and depth tracking equipment then transmitted out the selected ***WITS Port*** which can be shared by other applications or service companies. This setup is optional for circumstances where data from the Data Logger is wanted by others at the well site.

In both cases the data received from the tool by the Data Logger is transmitted to the selected ***WITS Port*** for sharing with others.

2.2.2.2 Survey Settings

• ***North Reference*** – This is used to identify what type of north reference is to be used for surveying. This will appear as a label on the ***Survey Report*** printout.
• ***Total Magnetic Correction*** – The total geomagnetic correction added to azimuth and magnetic toolface to either TRUE or GRID north.
• ***Toolface Offset*** – Used for steering tools, this defines the offset of the directional sensors to the high-side of the BHA.
• ***Survey Offset To Bit*** – The distance of the survey sensors to the bit

2.2.2.3 Gamma Settings

• ***Background Counts*** – The count rate of the gamma sensor without any gamma source applied. (See below)
• ***Hot Counts*** – The count rate of the gamma sensor with the calibration blanket wrapped around the tool. (See below)
• ***API Calibrator Rate*** – The API count rate marked on the gamma blanket used for calibration. (See below)
• ***Collar Attenuation Factor*** – The calculated amount of gamma ray attenuation that the drill collar will introduce. This factor may be calculated by pressing the Calculate button then entering the collar O.D. and I.D. or the user may enter their own factor manually.
• ***Gamma Offset To Bit*** – The distance of the gamma ray sensor to the bit.
• ***Data Smoothing*** – The amount of smoothing that will be used to filter the gamma data sent from the tool.

2.2.3 Gamma Calibration

Proper gamma sensor calibration requires that a standard-rate calibration source be used to scale the gamma data to API units. When a new database is created the parameters for the gamma calibration are adjusted so that there will not be any API calibration applied to the gamma data received from the tool. If the user prefers to use a single factor for calibration then this parameter may be entered into the Collar Attenuation Factor. If API calibration is desired then the following steps describe the process required:

• ***Background Counts*** – This is the count rate for the sensor being used and the environment the sensor is exposed to. The background counts will differ due to the following:

- The natural gamma rays emitted from the earth at the current geographical
- Location
- Gamma rays emitted by the sun
- The sensitivity of the gamma sensor used
- Gamma ray attenuation of the tool housing
- Gamma rays emitted by drill pipe or other materials in the immediate area.

The API factor calculation will use this as a baseline count rate. Measure this reading from the tool and record it.

• ***Hot Counts*** – After the background count rate is acquired then wrap the calibration blanket around the tool and record the count rate.
• ***API Calibrator Rate*** – This measurement is recorded on all calibration sources and will differ from one to another.

The API factor is then calculated using the following formula:

$$APIFactor = \frac{APICalibratorRate}{(HotCounts - BackgroundCounts)}$$

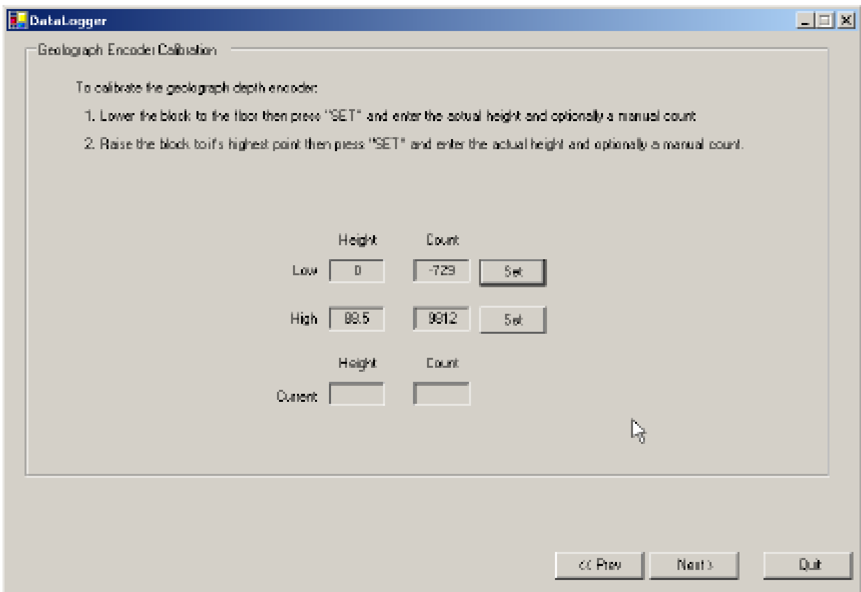
2.2.4 Depth Calibration

Depth tracking using the supplied equipment requires calibration. There are two types of depth encoders supplied and each uses a different calibration method:

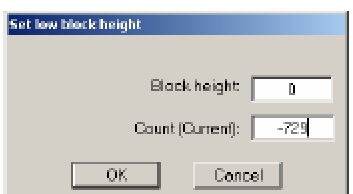
• Geolograph Encoder which attaches to the Geolograph line inside the doghouse
• Drum Encoder that is connected to the shaft of the drawworks drum

2.2.4.1 Geolograph Encoder Calibration

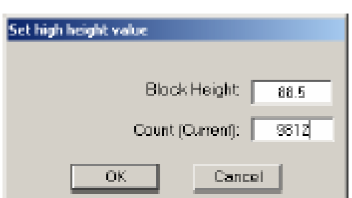
To use the Geolograph encoder, check ***Use Depth Encoder*** but uncheck the ***Drum Encoder***. The next page of the startup wizard will display the Geolograph encoder calibration screen.



To calibrate the Geolograph encoder:



• Lower the block to the drill floor then press the ***Set*** button and enter the block height and the counts read on the depth encoder box in the entry form

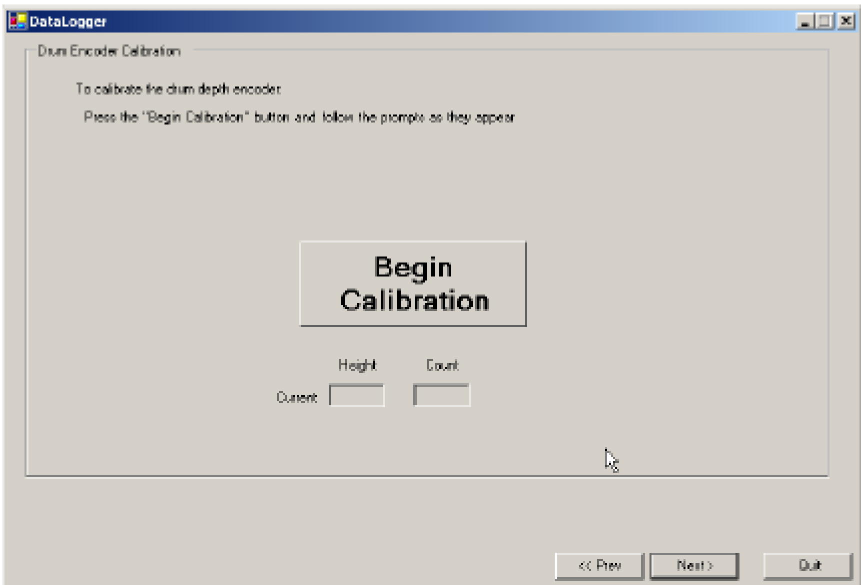


• Raise the block to its highest point then press the ***Set*** button and enter the block height and the counts read on the depth encoder box in the entry form

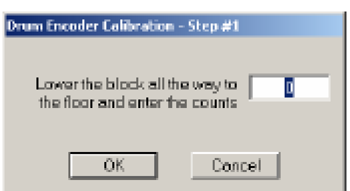
Once calibration is complete the current block height will be displayed on this screenfor verification.

2.2.4.2 Drum Encoder Calibration

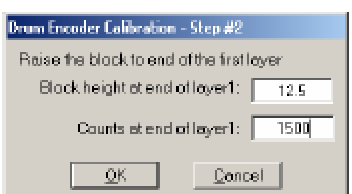
To use the drum encoder, check ***Use Depth Encoder*** and also check the ***Drum Encoder*** box. The next page of the startup wizard will display the drum encoder calibration screen.



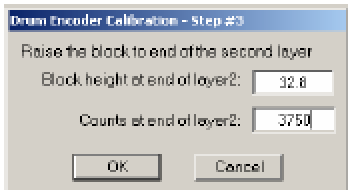
When ready to begin calibration of the drum encoder press the ***Begin Calibration*** button to proceed. The calibration can be canceled at any of the steps following by pressing the ***Cancel*** button.



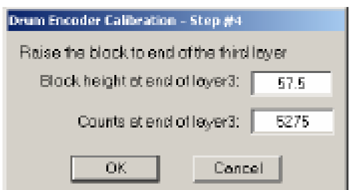
• Lower the block all the way to the drill floor and enter the counts read on the depth tracking box



• Raise the block until the end of the first layer of the drum is reached then enter the block height and the counts read on the encoder box



• Raise the block until the end of the next layer of the drum is reached then enter the block height and the counts read on the encoder box



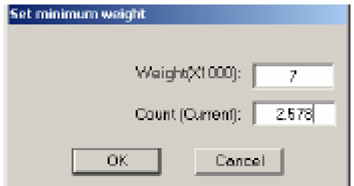
• Raise the block until the end of the next layer of the drum is reached then enter the block height and the counts read on the encoder box

When calibration is complete the current block height is displayed on this screen for verification.

2.2.5 Hookload Calibration

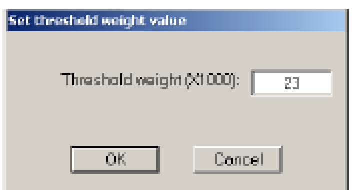
If selected, the hookload sensor can be used to determine whether the slips or in or out at any point in time. **Without this option the user must manually insert and remove the slips in order to track bit and hole depths.** To properly use this method of automatic slips detection the hookload weights must be calibrated.

To calibrate the hookload sensor:



• With the block hanging without any drill string weight press the ***Set*** button and enter the weight measured on the drill floor weight indicator and the counts read on the depth encoder box

• Lift the drill string out of the slips, press the ***Set*** button and enter the weight measured and the counts read on the depth encoder box

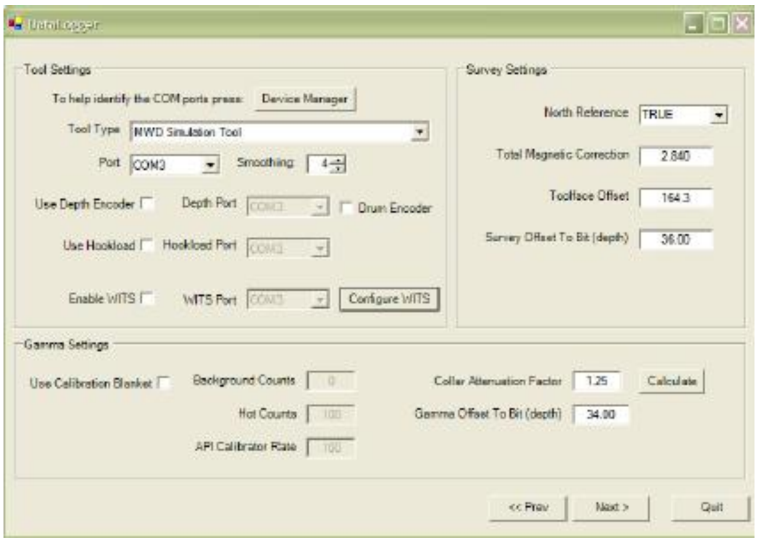


• The threshold weight (the weight at which the Data Logger assumes that the slips have been inserted) is automatically calculated. The user can optionally override this calculation and enter their own

Upon completion of calibration the current hookload is displayed on this screen for verification.

2.2.6 WITS Setup

In order to receive WITS depth data both the ***Use Depth Encoder*** and ***Use Hookload*** check boxes should be unchecked and the ***Enable WITS*** should be checked as illustrated below.

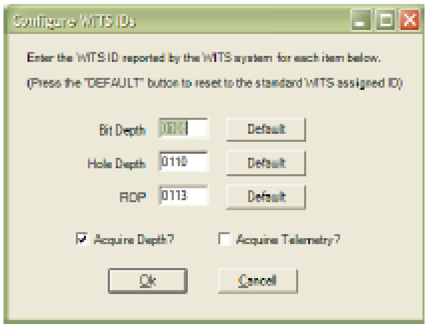


• In the default configuration, depth tracking, and ROP / WOB is performed by the WITS system and is received by the Data Logger.
• The Data Logger application also has the ability to acquire its telemetry data from WITS, or a tool which publishes data via the WITS protocol. By default telemetry is not collected from WITS, but can be turned on via the “Configure WITS” dialog.
• If the Data Logger is receiving telemetry data directly from the tool, and the WITS system is not publishing its own telemetry data, the Data Logger will send telemetry data back to the WITS system for distribution among all other computers and equipment connected to the WITS system

In some cases the WITS system will use non-standard Ids for depth and ROP data. To overcome this press the ***Configure WITS*** button and enter the Ids that the WITS technicians provide into the configuration form.

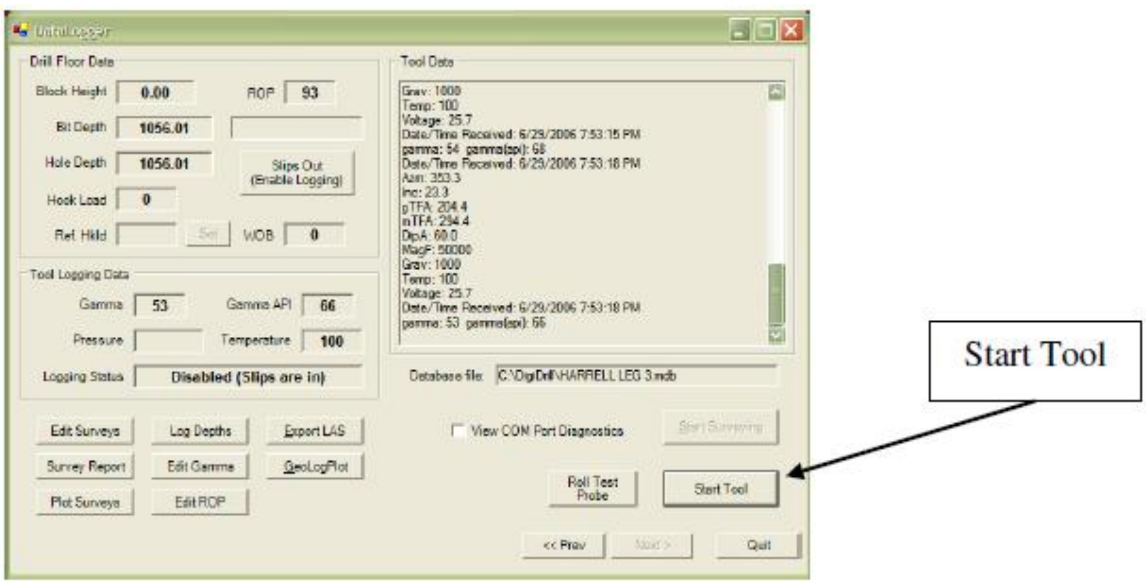
NOTE: These Ids will be permanently stored on the computer and should be rechecked when changing to another WITS system.

To revert back to standard WITS Ids press the ***Default*** button next to each WITS ID.



2.3 Tool Startup and Diagnostics

The last screen of the Data Logger startup wizard displays all data acquired from the various COM ports and functions as a diagnostics display. This screen also contains all the various functions required for tool control, report generation and data editing.



When this screen appears the depth data from the encoder box or WITS will automatically update. The tool, however, must be started in order to begin receiving data by pressing the ***Start Tool*** button.

2.3.1 Starting The Tool

Each tool has a startup procedure as defined below:

• ***Tensor Steering Tool***
Press the ***Start Tool*** button, press ***OK*** on the popup that appears then turn the tool power on.

• ***Applied Physics 750/850 (Net Protocol)***
Press the ***Start Tool*** button, press ***OK*** on the popup that appears then turn the tool power on.

• ***Tensor QDT MWD Tool***
Turn the tool on and let the receiver begin operation then press ***Start Tool*** and the Data Logger will begin listening for data from the tool.

• ***Gyrodata-DMI***
Turn the tool power on then press ***Start Tool*** and the Data Logger will begin listening for data from the tool.

• ***RSS Systems Steering Tool (Not yet completed)***
Press the ***Start Tool*** button, press ***OK*** on the popup that appears then turn the tool power on.

• ***Test Tool***
This is a simulated tool that will generate artificial data internally for testing and demo purposes. It will simulate either a steering tool or MWD tool.

2.3.2 Displays

Descriptions for the data displayed on this screen are:

• ***Block Height*** – Sent via the WITS system or generated internally by using the depth tracking equipment.

• ***Bit Depth*** – Sent via the WITS system or generated internally by using the depth tracking equipment. Bit depth will only change if the slips are out. The Data Logger uses this depth for data logging.When using the supplied depth tracking equipment the display to the right of Bit Depth indicates the bit status as ***On Bottom*** or ***Off Bottom***. This is important when using a hookload sensor for automatic slips detection. If the bit is ***On Bottom*** and the hookload weight falls below the ***Threshold Weight*** defined earlier then the slips will **not** automatically be removed. This is to prevent errors in depth tracking when weight stacks up on long lateral drills.

• ***Hole Depth*** – Sent via WITS or generated internally by using the depth tracking equipment.

• ***ROP*** – Sent via WITS or generated internally by using the depth tracking equipment. This data is also logged into the database for plotting.

• ***Hook Load*** – Sent via WITS or generated internally using the hookload sensor. This data is also logged into the database.

• ***Ref. Hkld*** – Also known as the ***Off Bottom Weight***, this parameter is used to calculate the Weight On Bit (***WOB***) which is logged into the database. This parameter is only used if the hookload sensor is utilized in conjunction with the depth encoder. The Data Logger assigns this value when the slips are automatically removed due to the hookload weight exceeding the threshold weight defined earlier. When the slips are removed the hookload weight will be averaged for 5 seconds then assigned as the ***Reference Hookload***. Once drilling commences any deviation from the ***Reference Hookload*** would be considered ***Weight On Bit***.
• ***WOB*** – Sent via WITS or generated internally by using the hookload sensor and the slips in/out detection algorithms. (See ***Ref. Hkld*** above)
• ***Gamma*** – Received from the tool and logged into the database.
• ***Gamma API*** – Calculated internally by applying the ***API Calibration Factor*** and the Collar ***Attenuation Factor*** to the raw Gamma counts received from the tool. This data is logged into the database for plotting.
• ***Pressure*** – (Not implemented yet)
• ***Temperature*** – Received from the tool and logged into the database for plotting.
• ***Logging Status*** – Displays the status of logging. If the slips are out then logging is enabled. If the slips are in then logging is suspended and data is not written into the database.
• ***Tool Data*** – All data received from the tool.
• ***Database File*** – The database file currently being used for logging and surveying.

2.3.3 Functions

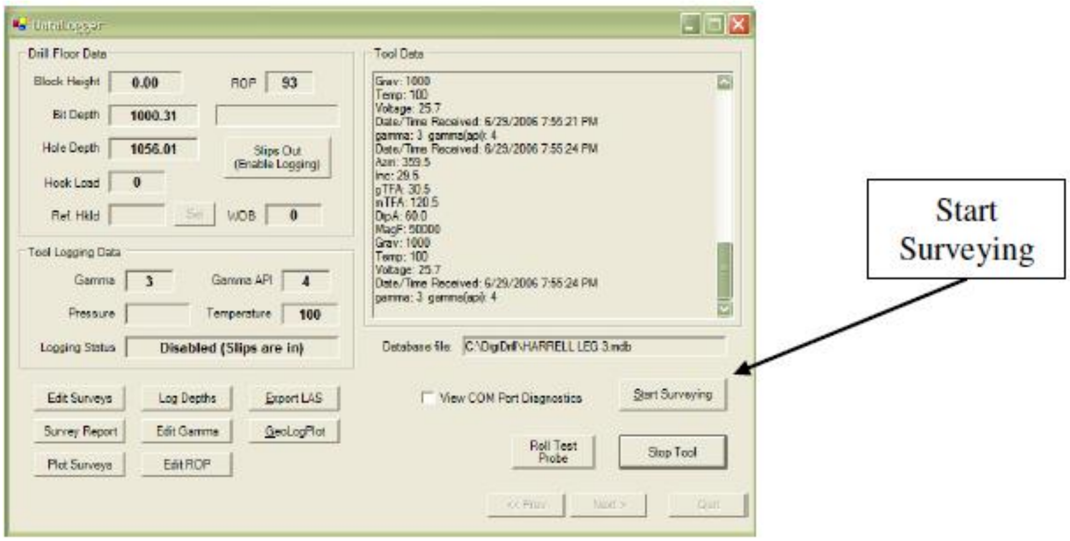
Descriptions for the function buttons are:

• ***Slips Out (Enable Logging)*** – Available only when not using the hookload sensor for automatic slips detection. Pressing this button will enable depth tracking and data will be logged into the database. The button will be re-labeled to ***Slips In (Disable Logging)*** then pressing this button again will disable depth tracking and suspend logging into the database.
• ***Edit Surveys*** – Will bring up the survey editor for adding, deleting or making edits to the surveys that have been entered into the database.
• ***Survey Report*** – Generates a survey report for printing or exporting to PDF.
• ***Plot Surveys*** – Generates horizontal and vertical plots of the survey data entered into the database using standard minimum radius of curvature calculations.
• ***Edit Log*** – Allows the user to adjust the gamma data depths logged into the database.
• ***GeoLogPlot*** – Opens the GeoLogPlot application for plotting the data logged into the database.
• ***Export LAS*** – Opens the LASBuilder application for exporting the data logged into the database to an industry standard LAS file.
• ***Start Surveying*** – Displays the main surveying screen from which all operations are normally performed. (More on this in the next section) This "diagnostics" screen will not be closed and both screens will be accessible to the user. The tool will be automatically started if it has not been done prior to pressing this button.

• ***Start Tool*** – Initializes the COM port for the tool and begins communications.

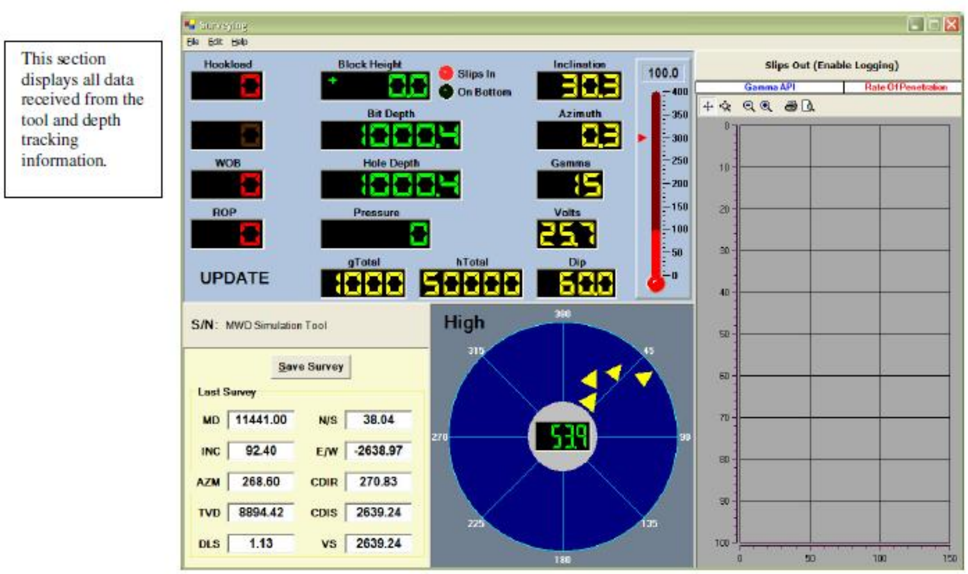
2.4 Surveying and Logging

All surveying and logging functions are performed in the Surveying screen. The diagnostics screen will still be accessible for viewing detailed information however most operations should take place here.



2.4.1 Surveying Screen Description

The various sections of this screen are illustrated below:

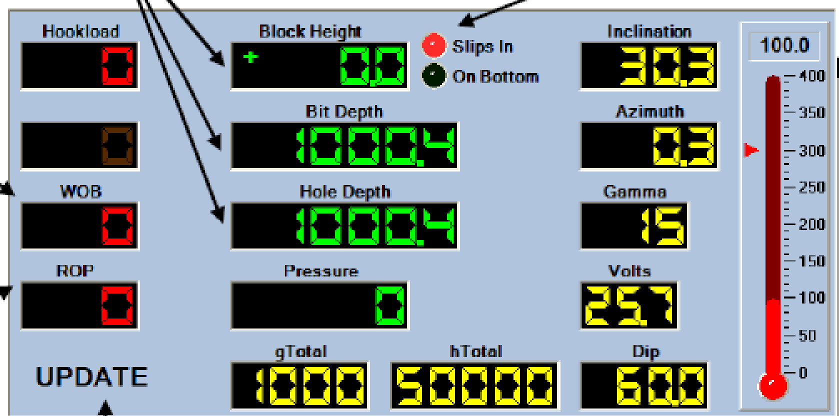


Depth tracking display. Depths can also be reset by clicking on these displays. (Except when using WITS for depth)

Automatic slips detection status indicators.

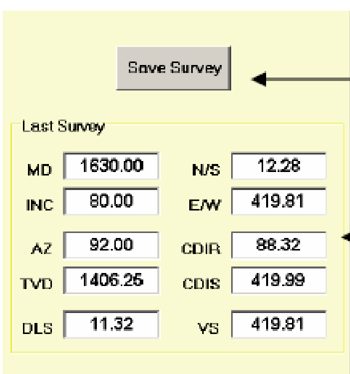
Weight On Bit.

Error!



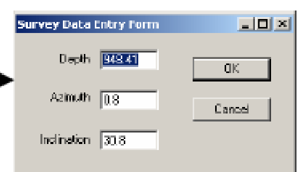
Rate Of Penetration.

"UPDATE" flashes when data from the tool has been received.

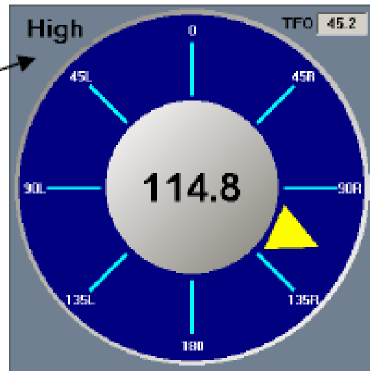


Press this button to in order to enter a new survey into the database. (The survey entry form is shown to the right)

The last survey entered into the database and the calculated closure information is displayed here.



Toolface mode indicator. “High” or gravity toolface and “MTF” or magnetic toolface is displayed.

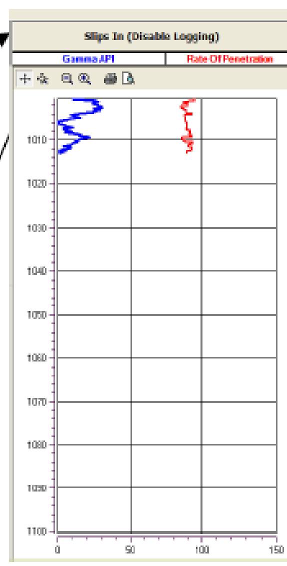


The toolface offset entered in the startup wizard is displayed here for user verification.

Toolface dial. Clicking anywhere on the dial face will switch between toolface modes.

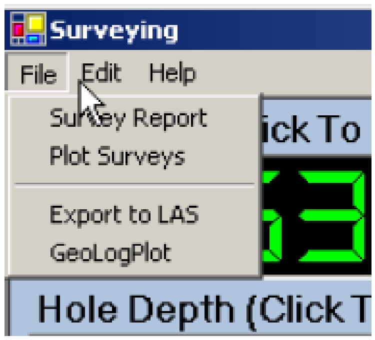
Used to manually insert and remove the slips (enable/diable logging) when a hookload sensor is not used.

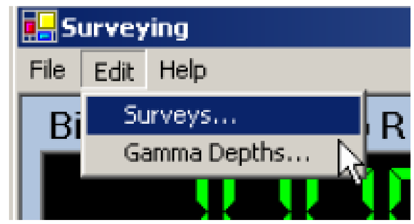
These toolbar buttons are used to scroll, scale, zoom in/out, and print the real-time log display.



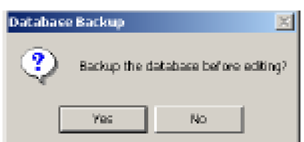
Real-time log display. Currently only gamma is displayed in this graph. The RED line is the raw gamma data scaled to API units. The BLUE line is filtered gamma API data.

All functions on the last screen of the startup wizard (diagnostics screen) are available on the Surveying screen. The illustrations below show the pull-down menu items that reflect their diagnostics screen counterparts.





2.4.2 Editing a Survey



Before the survey editor appears a prompt will appear for backing up the database. If the user chooses to backup the database a copy of the database will be created in a subfolder in the ***C:\DigiDrill*** directory. The name of this folder will be the name of the database with a ***.BAK*** extension appended on to it. The copy of the database file will be created in this directory and the name will be the original database file name with a date and time stamp appended to the end.

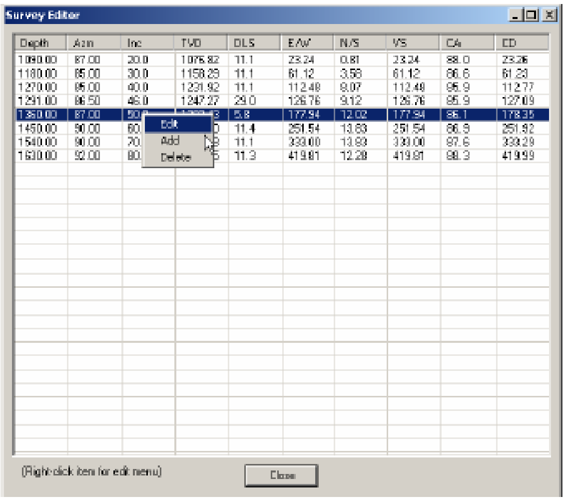
Example:

If the name of the database is entitled:
“Shop Test.MDB”

The name of the backup folder will be:
“Shop Test.bak”

And the name of the database backup in that folder would be:
“Shop Test200601151258.mdb”

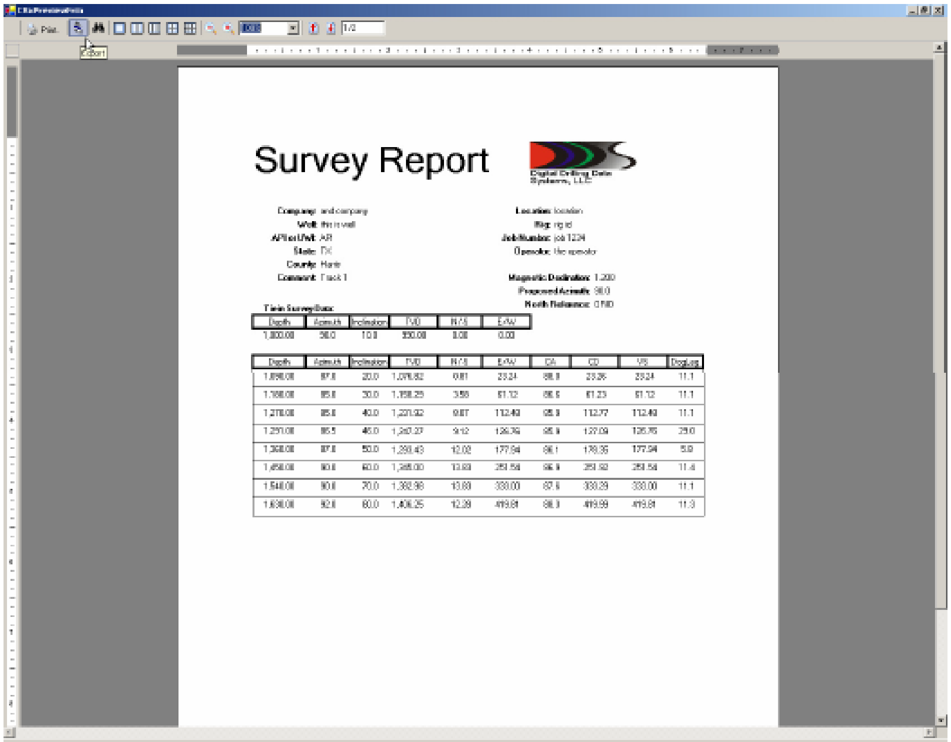
The “200601151258” is in computer recognizable format consisting of the year, month, day, hour and minute. (in that order)



The survey editor is displayed with all the surveys stored in the database along with the calculated closure information. By right-clicking on any survey in the list the user will be presented with a popup menu of functions to select from. Surveys can be added, deleted or edited. After each edit function is completed the curvature calculations will be executed and the closure information displayed will be updated.

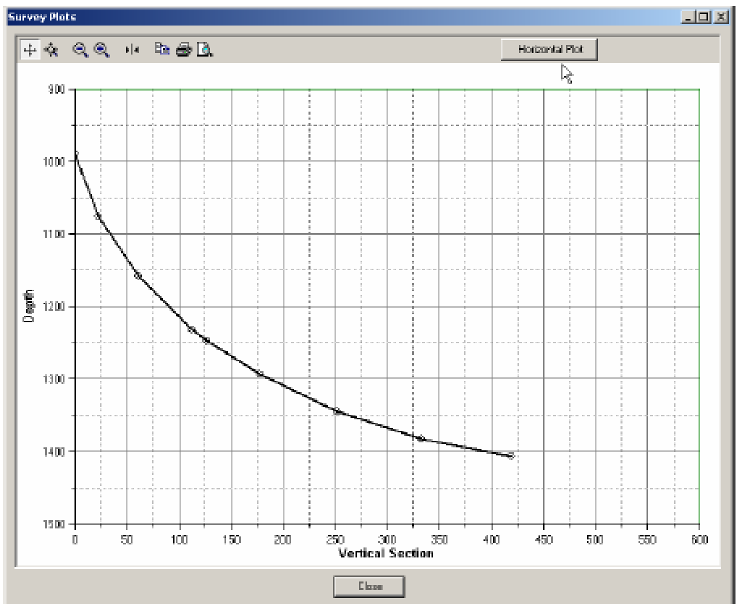
2.4.3 Survey Report

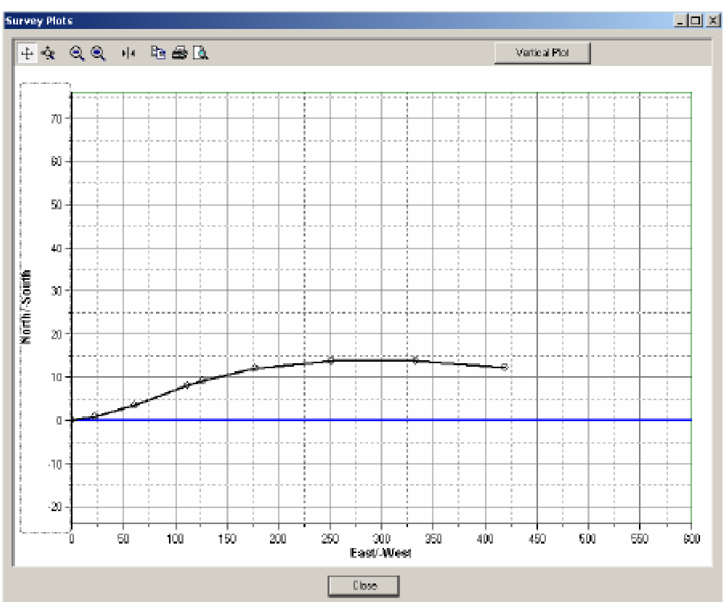
The survey report will appear in a viewer that is capable of either printing the viewed data or exporting the viewed data to a PDF file.



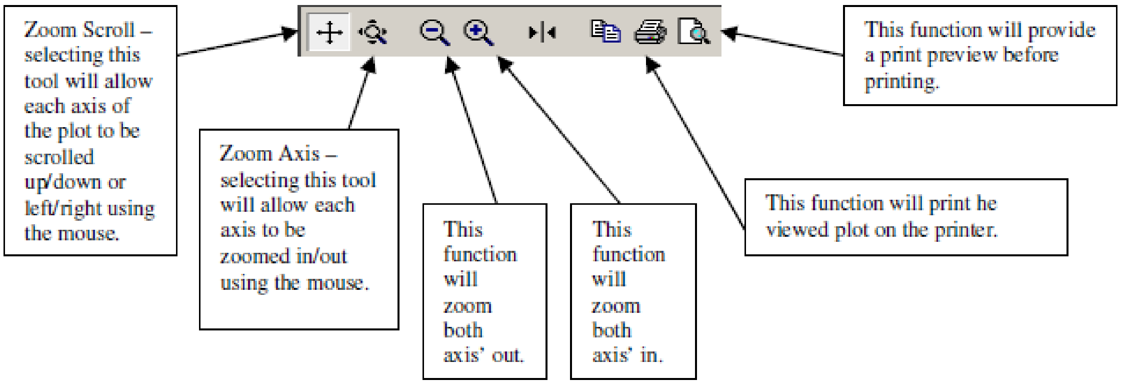
2.4.4 Survey Plots

The survey plot screen will initially display a ***Vertical Plot*** that the user can zoom in, scroll and print from. Pressing the ***Horizontal Plot*** button will present a horizontal plot that can be altered in the same method as the ***Vertical Plot***.



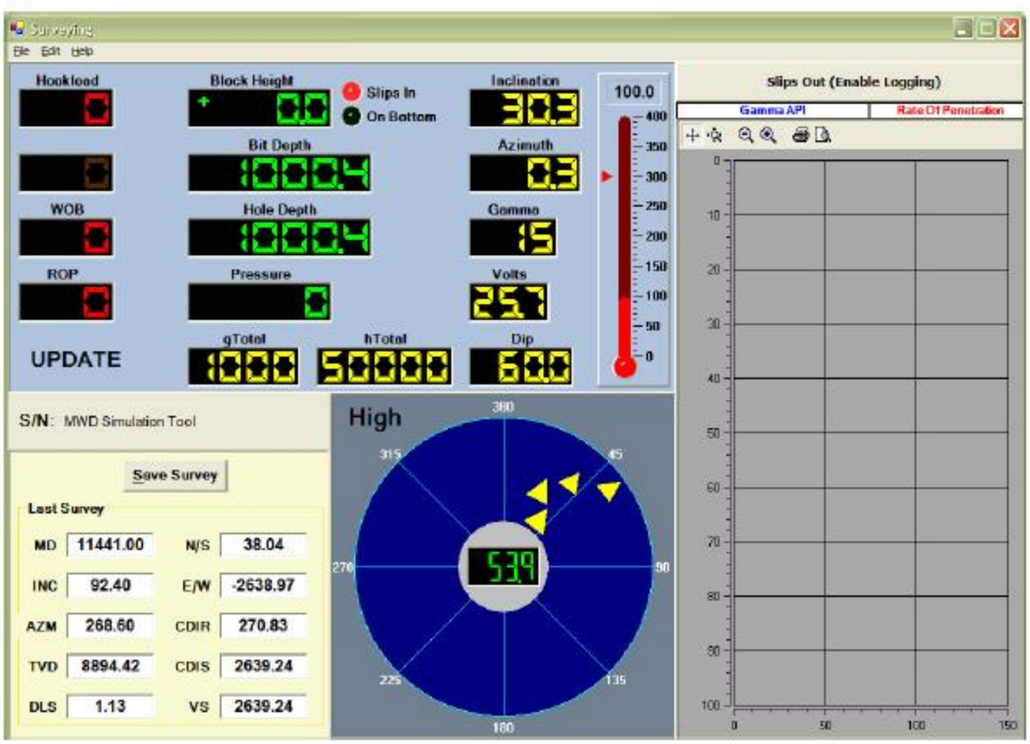


The display has a toolbar in the upper-left corner of the screen that provides the user with the following functions:

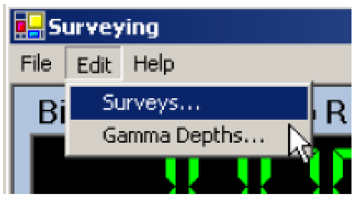


2.4.5 Real-Time Log Display

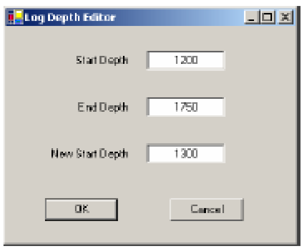
The Real-Time log display can be adjusted without affecting database logging operations.Using the toolbar buttons the display can be zoomed in or out and scrolled up or down and left to right. Once the display is adjusted then right-click on the depth axis on the left of the log then click on ***Tracking Enable***. This enables the log to automatically scroll keeping the most recent data in the view.



2.4.6 Log Depth Editor



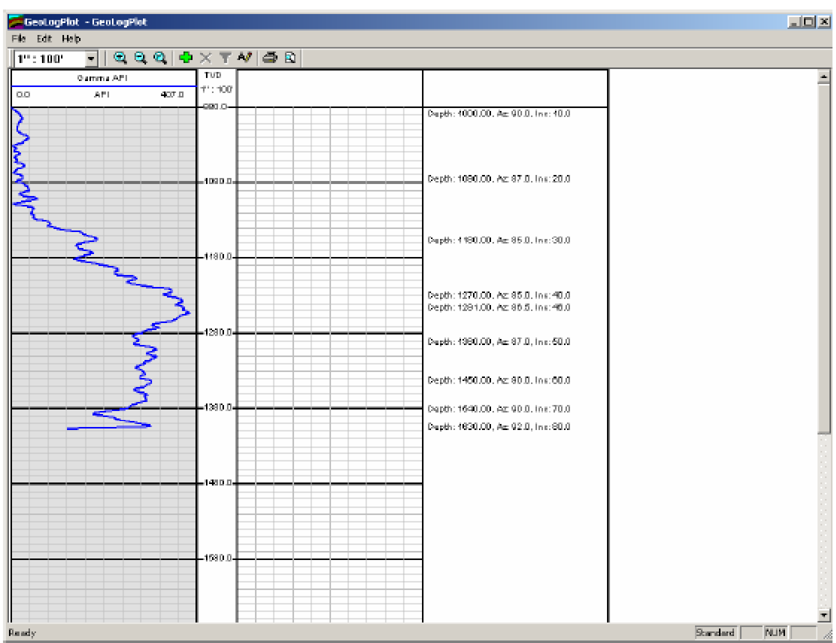
The log data depths can be moved by selecting the pull-down menu ***Edit/Gamma Depths***.



In the editor form enter the start depth and end depth of the data you wish to move then select a new start depth and all data will be shifted to the new starting depth.

3 GeoLogPlot

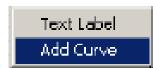
The GeoLogPlot application is used to extract logging data from the database and generate
MWD plots on continuous paper printers. Since this is a separate application from the Data
Logger all logging functions will not be affected during this operation.



3.2 Adding A Curve To A Track

To add a data curve to a track:

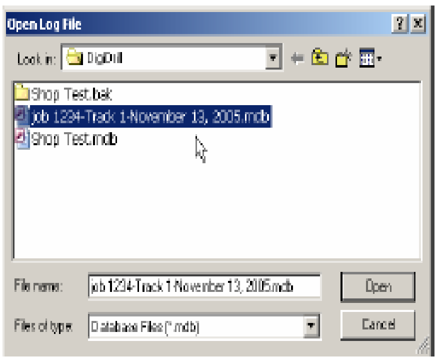
- Click on the track the curve should be added to and the track will be highlighted

- Open the database file selection form by either:
    - Right click in the track area and the popup menu 

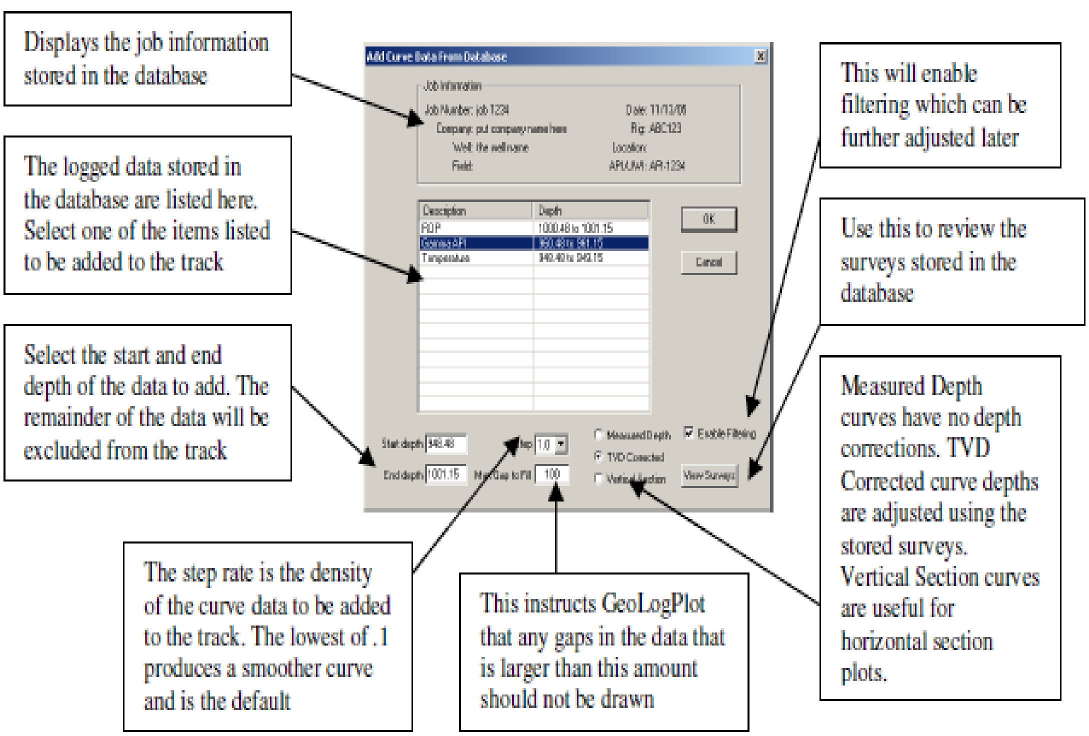
 will appear. Select the ***Add Curve*** item on the popup menu.
    - Click the green **+** button on the toolbar

    - Use the pull-down menu item ***Edit/Curve/Add…***

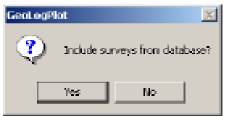
- In the *Open Log File* select the database file to extract data from



- Use the *Add Curve Data From Database* form to select the curve data to add to the track highlighted. The description of each section of this form are:

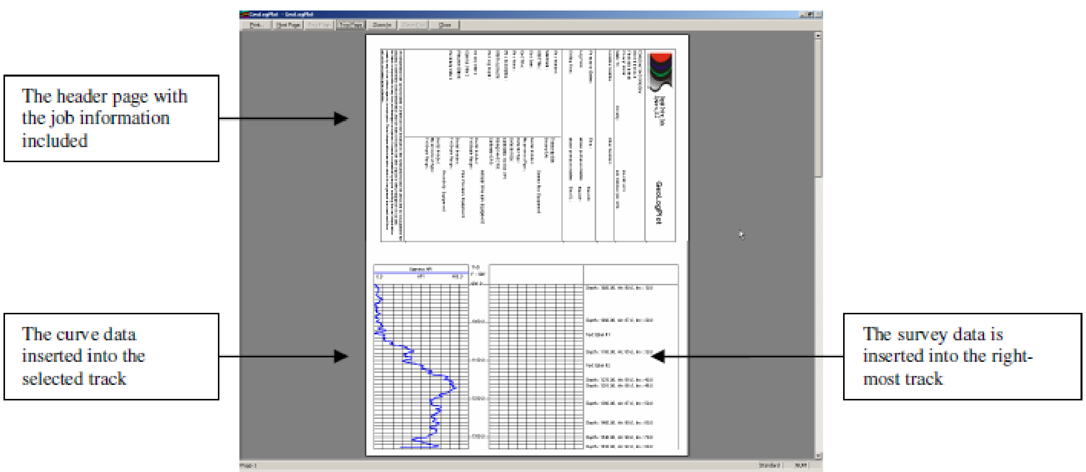


- After a curve is selected GeoLogPlot will inquire whether the surveys from the database should be added. These surveys will be listed in the right-most track.



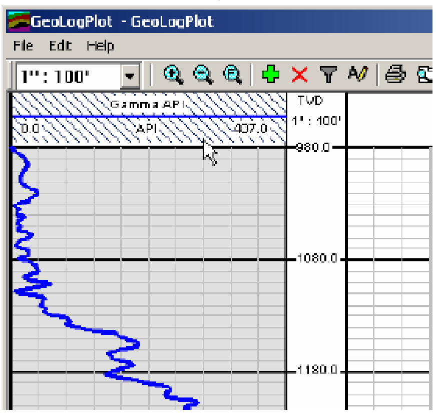
- GeoLogPlot will also inquire if the job information should be included for the data in plot's header page.

The resulting display would look similar to the illustration at the top of this section. A print preview of the plot would produce:

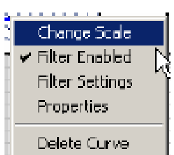


3.2 Editing A Curve

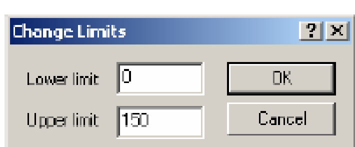
To edit the curve select the curve to modify by clicking on its description in the title block of the track it is in.



3.2.1 Changing The Curve Scale



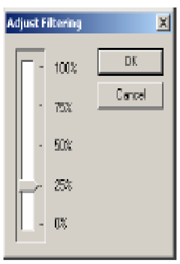
Right-click the curve description in the title block of the track and select ***Change Scale***.



Enter the ***Lower Limit*** (left-side) value and the ***Upper Limit*** (right-side) value and press ***OK***.

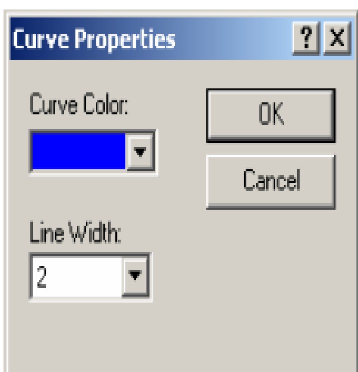
3.2.2 Adjusting The Curve Filtering

To adjust the filtering of the curve either right-click the curve description in the title block of the track and select Filter Settings in the popup menu or click on the funnel icon located in the toolbar above. 



This will produce the filter settings form with a slider to adjust the amount of filtering to apply.

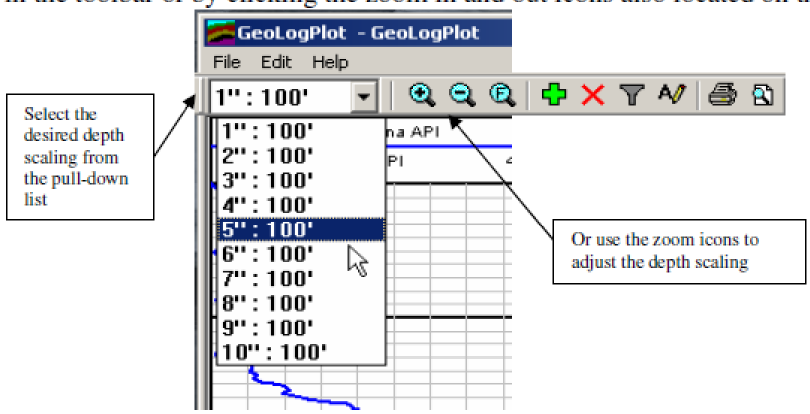
3.2.3 Curve Properties



To adjust the curve color and line width right-click the curve description in the title block of the track and select *Properties* in the popup menu that appears.

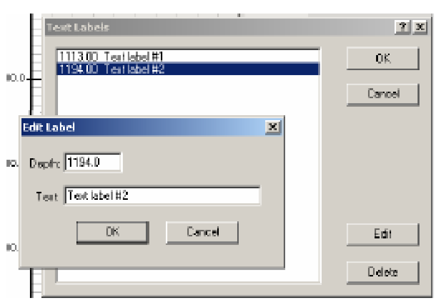
3.2.4 Changing The Plot Scaling

The depth scaling of the entire plot can be adjusted by either using the pull-down selector in the toolbar or by clicking the zoom in and out icons also located on the toolbar.



3.3 Adding Text Markers

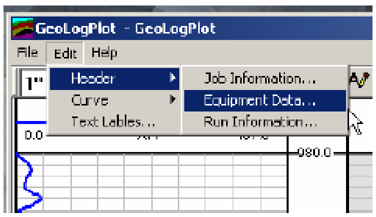
Text markers or comments can be added to the plot by simply right-clicking the depth at which the text should be located and entering the text in the form that appears. The text entered will appear in the right-most track along with the survey data if used.



Text markers can be edited by using the pull-down menu item ***Edit/Text Labels*** at the top of the window.

At this time text markers are not stored and will have to be re-entered for each plot operation.

3.4 Editing The Plot Header



The data on the header page of the plot can be edited by using the pull-down menu item Edit/Header.

There are 3 sections of the header:

- Job Information which can be automatically included when adding a curve and edited afterwards.
- Equipment Data for defining the equipment used for this job and run
- Run Information for data that identifies many aspects of the run

The data entered will not be stored and must be re-entered for each plot.

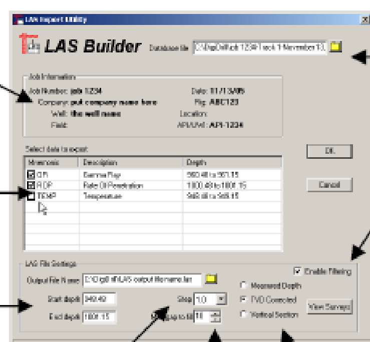
4 LAS Builder

The job information stored in the database is displayed here

Data logged into the database is listed here. Select each data to be included by checking the box on the left of the data

LAS Builder will begin exporting at the start depth defined and stop exporting when the end depth is reached

LAS Builder will step the depths entries by this amount. Typically, the data should be stepped by no more that 1 foot intervals



Select the database to read logging data from

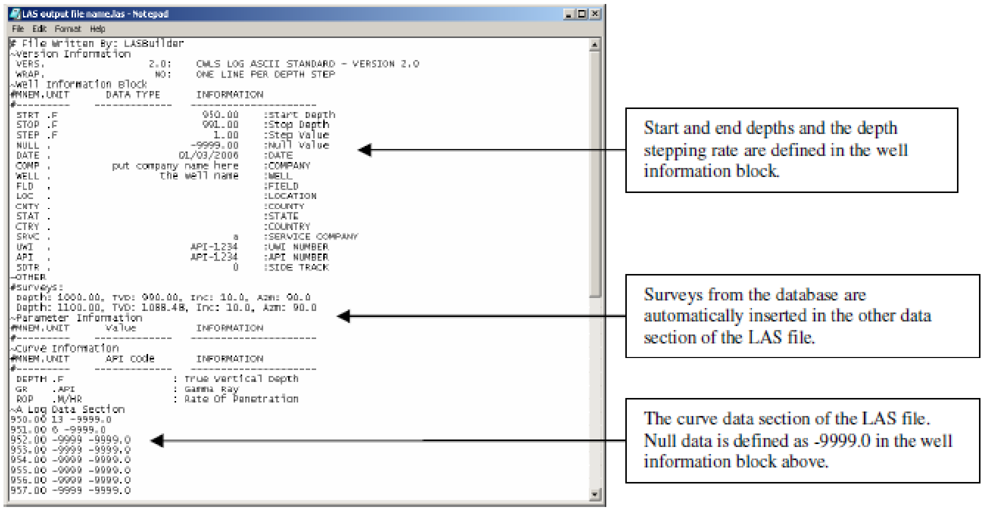
Filtering can be used to smooth the data being exported

The depths of the LAS file can be corrected using the survey data stored in the database. Measured Depth does not correct the depths and outputs the LAS data depths as stored in the database.

This instructs the LAS Builder to produce null values for gaps in data that are larger than this amount. Gaps less than this value are filled in using data interpolation.

4.1 File Contents

The resulting contents of the LAS file generated by LAS Builder:

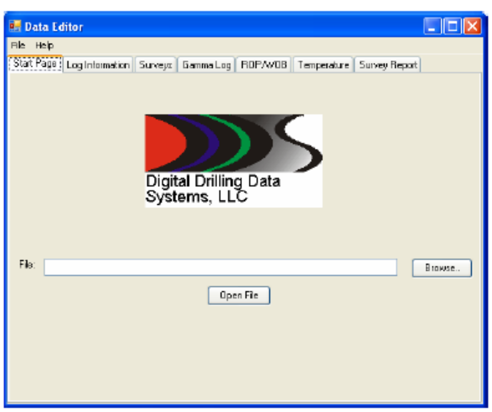


5 Data Editor

The Data Editor application allows for advanced editing of your log files and job information. It tightly integrates the editing of all logs (Gamma, ROP/WOB, Temperature) as well as job/company information and directional surveys. The Data Editor also allows the user to generate survey reports directly from the editor.

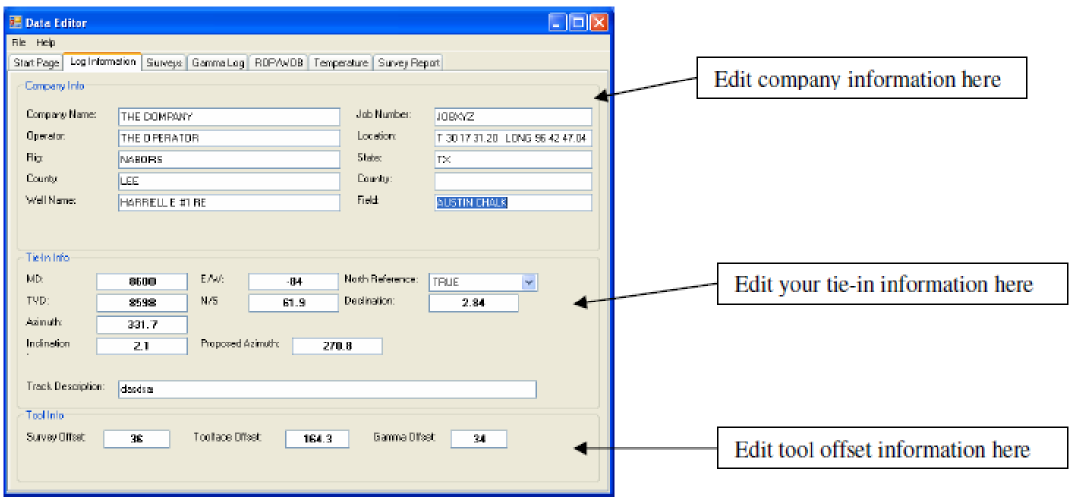
5.1 Start Page

The Data Editor has an interface which is broken down into tabs which separate the data types being edited. When the application is first opened you are typically greeted by the "Start Page". This page simply allows you to choose the database file you wish to edit.



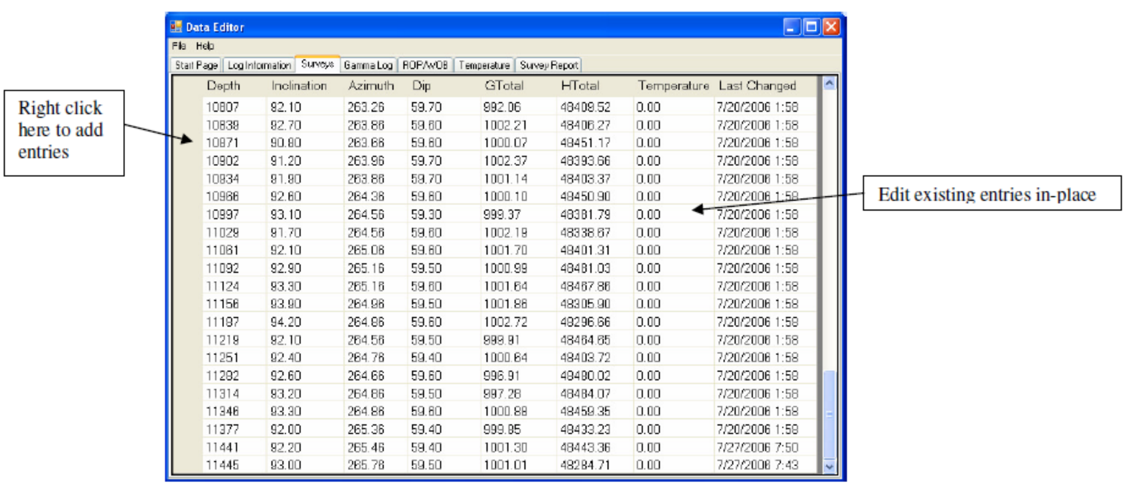
5.2 Log Information

The Log Information tab allows you to edit information such as tie-in, company, and job information.



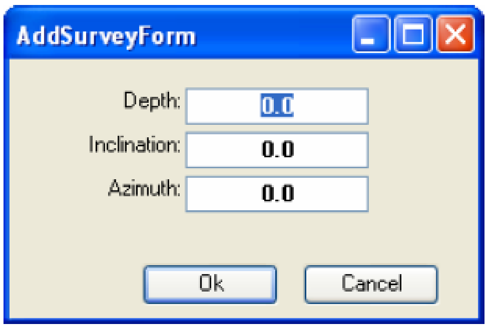
5.3 Survey Log

The survey log editor allows you to modify the surveys stored in the database, including adding new surveys and deleting unwanted surveys. Each time a survey is modified, all the surveys after it are automatically re-calculated.



5.3.1 Adding a new survey

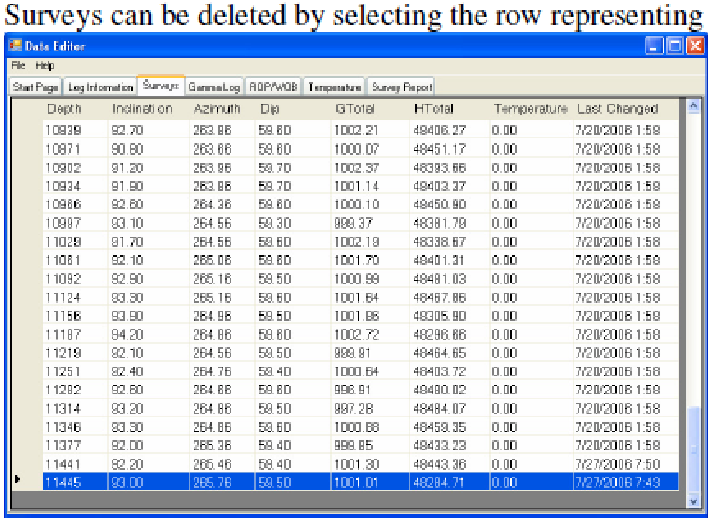
In order to add a new survey, simply **right-click** anywhere on the grid. When the context menu appears, select "Add Survey…". This will bring up the following dialog:



Simply enter the depth, inclination, and azimuth you wish to use for the survey and the new survey will be calculated.

5.3.2 Deleting a survey

Surveys can be deleted by selecting the row representing the survey you wish to delete.

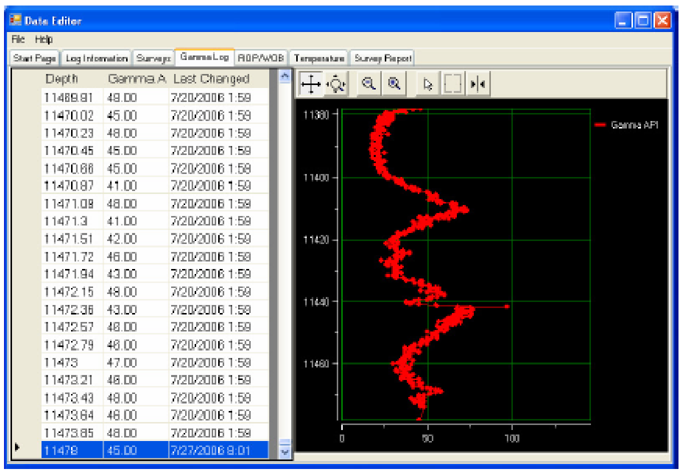


Depth	Inclination	Azimuth	Dip	GTotal	HTotal	Temperature	Last Changed
10839	92.70	263.86	59.60	1002.21	48406.27	0.00	7/20/2006 1:58
10871	90.80	263.66	59.60	1000.07	48451.17	0.00	7/20/2006 1:58
10902	91.20	263.96	59.70	1002.37	48393.66	0.00	7/20/2006 1:58
10934	91.90	263.86	59.70	1001.14	48403.37	0.00	7/20/2006 1:58
10966	92.60	264.36	59.60	1000.10	48450.90	0.00	7/20/2006 1:58
10997	93.10	264.56	59.30	999.37	48381.79	0.00	7/20/2006 1:58
11029	91.70	264.56	59.60	1002.19	48338.67	0.00	7/20/2006 1:58
11061	92.10	265.06	59.60	1001.70	48401.31	0.00	7/20/2006 1:58
11092	92.90	265.16	59.50	1000.99	48481.03	0.00	7/20/2006 1:58
11124	93.30	265.16	59.60	1001.64	48467.86	0.00	7/20/2006 1:58
11156	93.90	264.96	59.50	1001.86	48305.90	0.00	7/20/2006 1:58
11187	94.20	264.86	59.60	1002.72	48296.66	0.00	7/20/2006 1:58
11219	92.10	264.56	59.50	999.91	48464.65	0.00	7/20/2006 1:58
11251	92.40	264.76	59.40	1000.64	48403.72	0.00	7/20/2006 1:58
11282	92.60	264.66	59.60	996.91	48480.02	0.00	7/20/2006 1:58
11314	93.20	264.86	59.50	997.28	48484.07	0.00	7/20/2006 1:58
11346	93.30	264.86	59.60	1000.66	48459.35	0.00	7/20/2006 1:58
11377	92.00	265.36	59.40	999.85	48433.23	0.00	7/20/2006 1:58
11441	92.20	265.46	59.40	1001.30	48443.36	0.00	7/27/2006 7:50
11445	93.00	265.76	59.50	1001.01	48284.71	0.00	7/27/2006 7:43

Then press the "del" key on the keyboard, and the survey will be removed.

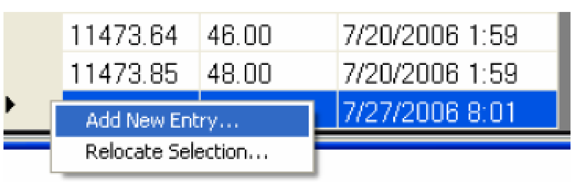
5.4 Real-Time Log Editing

The Gamma, ROP/WOB, and Temperature logs are considered real-time logs. The editors for each of these types of data works the same way and their use has been condensed in this manual. The real-time log editor allows editing of both the curve, and raw tabular data side-by-side. Data can be edited by modifying the data contained in the grid to the left (including adding or removing data points), or by dragging the point to the proper location in the right-side plot.

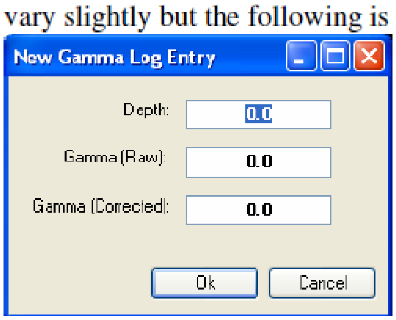


5.4.1 Adding points to a real-time log

To add a new gamma point, right click on the left-hand grid and select "Add new entry..."



You will then prompted to enter the new log entry. Depending on the editor, the prompt will vary slightly but the following is an example of the gamma log entry prompt.



5.4.2 Removing points from a real-time log

Simply select the row you wish to remove, and press the "del" key on the keyboard.

5.4.3 Changing points on a real-time log

Editing points can be done by either "drag"-editing the curve points directly, or by editing the point value in the data grid.

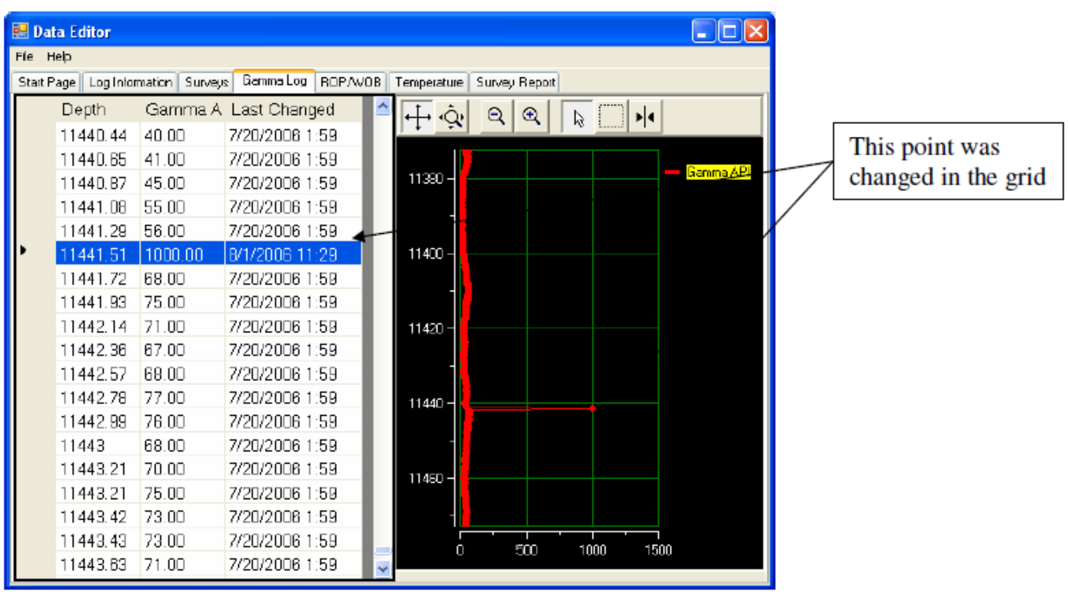
5.4.3.1 "Drag"-editing points

To drag-edit points, you must first enable point dragging on the curve plot. To do so, click on the button that looks like a mouse cursor on the plot toolbar.

Then, click on the point you wish to move, and drag it with the mouse. The modified rov in the grid will be scrolled to and highlighted, and the point on the plot will move to its new position.

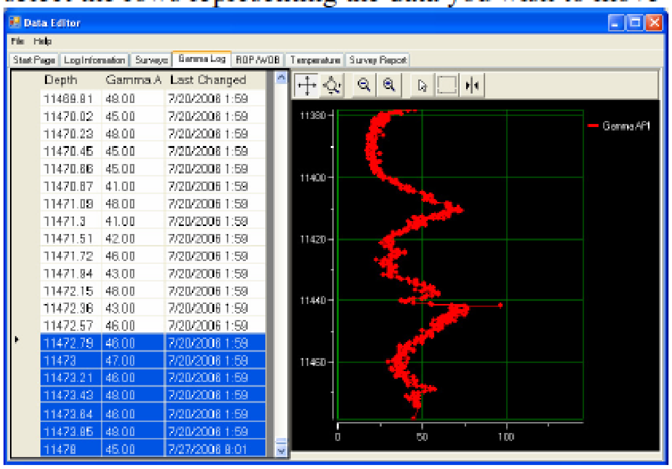
5.4.3.2 Editing points in the data grid

Points can also be easily edited via the data grid. Simply locate the point you wish to change, and edit the data in-place in the grid. The plot will update to reflect the new data in the grid.

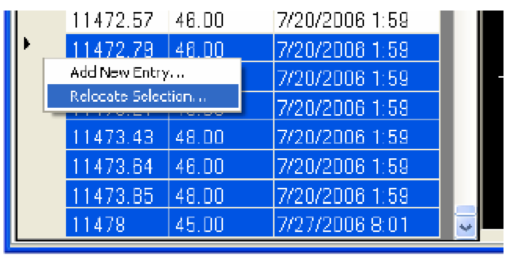


5.4.4 Relocating a section of a real-time log

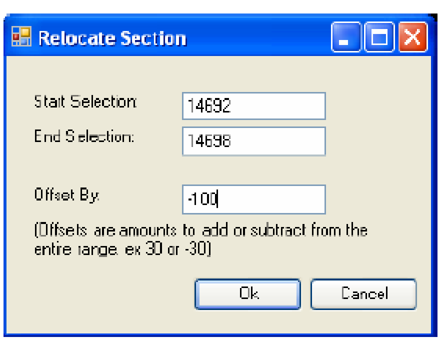
Sections of the real-time logs can easily be relocated. In order to relocate a section, simply select the rows representing the data you wish to move



Right click on the selection, and choose "Relocate Selection…"



This will bring up the "Relocate Selection" dialog.
You only need to fill out the relocation offset field. This allows you to specify how much, and what direction to relocate the log. For example, to relocate the selection down 100 feet simply enter -100. To move it up 100 feet simply enter 100. When you are done, press "Ok".



NOTES

NOTES

CHAPTER 4 – MWD MAINTENANCE MANUAL

SECTION A – NOTES ON ASSEMBLY

A.1 - NOTES ON ASSEMBLY PROCEDURES

NOTES ON ASSEMBLY PROCEDURES

All O-rings must be made of Viton, 70 – 90 durometer [Shore A]. Other, softer elastomers, such as Neoprene will deteriorate rapidly, swell, and extrude under extreme pressures and temperatures.

• Extreme care should be taken when installing O-rings, to avoid over-stretching and cutting. Use only wooden or plastic O-ring picks to guide the O-rings over surfaces when installing or removing O-rings. Metal picks can scratch the sealing surfaces of the O-ring grooves.

• Use extreme caution when applying Loctite 243, or similar thread locking compounds. Avoid applying liberal amounts on small threaded areas around electrical contacts. Doing so may cause shorting problems. It is advisable to apply an adequate amount of Loctite to a piece of paper, allow it to dry to a paste and then apply it with a wooden stick.

• GE Power Systems authorizes only approved GE Silicon SF96-100 (P/N 201253) for use in the oil-fill section of the pulser. Silicon oil is a dimethylpolysiloxane, or a clear (water-white) silicone liquid with a viscosity of 100 centistokes.

This silicone oil was chosen for three reasons:

1. The stable viscosity characteristics at higher temperatures are better-suited for the use than hydrocarbon oils.

2. The clear (water-white) color allows contaminants to be more easily detected.

3. Silicone oil is environmentally safe to handle and is disposable by normal means. Refer to MSDS sheets.

• All silicone oil extracted from a used pulser should be discarded. Silicone oil is an expendable spare part by design and should not be salvaged for reuse. This will prevent potential failures from impurities and oil that may have gone out of spec due to extreme temperature conditions.

• Silicone oil is flammable. Refer to MSDS sheets.

• GE Power Systems only recommends 0.025” to 0.030” diameter, annealed stainless steel lock wire for use in attaching and sealing the compensation membrane and the bellows. The lock wire (tie-wire) is an expendable spare part and not designed for reuse.

• GE Power Systems does not recommend reusing elastomers for module rebuild after the Tensor MWD tool has been exposed to the downhole environment.

• GE Power Systems recommends lubricating all threaded parts and O-rings with a light coat of Dow Corning Compound 4. This compound is compatible with drilling fluids and temperatures to 400°F (204°C).

• Apply Loctite 243 (dried to a paste) and hand-tighten all screws with the proper screwdriver.

• All pressure barrels and housings should be torqued using Petol Gearench or Parmalee wrenches fitted with 1 7/8” jaws. Torque to a range of 65 to 100 ft-lbs. It is advised to use Loctite 243 on the two threaded connections below the screen housing of the pulser.

SECTION A.2 - O-RING LIST / BOM
BOM: Battery Module (Standard)

Asset

Part Number	Size	Product Line	Description
201675	Common	MWD	Battery Housing Module

Serialized Part

Part Number	Size	Product Line	Description
201675S	Common	MWD	Battery Housing Module

Non-Serialized Part

Part Number	Size	Product Line	Description	
201509	1-7/8"	MWD	Housing, Interconnect	2.00
201514	1-7/8"	MWD	Intermodule End	1.00
201635	1-7/8"	MWD	Battery Barrel Housing	1.00
201650	1-7/8"	MWD	Housing, Battery Vent Plug	1.00
201845	1-7/8"	MWD	Thread Protector, Male	2.00
201505	Common	MWD	Bulkhead Retainer, Top (90 Degree)	1.00
201506	Common	MWD	Split Shell	2.00
201521	Common	MWD	Bulkhead Retainer, Bottom (45 Degree)	1.00
201617	Common	MWD	Snubber Assembly, Battery	1.00
201645	Common	MWD	Battery Vent Plug	1.00
201991	Common	MWD	Pigtail, Battery	1.00
AS-011	Common	MWD	AS-011 O-Ring, Viton	1.00
AS-016	Common	MWD	AS-016 O-Ring, Viton	1.00
AS-124	Common	MWD	AS-124 O-Ring, Viton	2.00
AS-127	Common	MWD	AS-127 O-Ring, Viton	2.00
AS-217	Common	MWD	AS-217 O-Ring, Viton	4.00
AS-218	Common	MWD	AS-218 O-Ring, Viton	2.00
AS-220	Common	MWD	AS-220 O-Ring, Viton	4.00
SC-013	Common	MWD	Screw, 6-32 x 1/2" SHCS, SS	4.00
SC-014	Common	MWD	Screw, 6-32 x 3/4" SHCS, SS	4.00

SECTION B – PULSER-SOLENOID STYLE (HOT HOLE)

B.1 MANUFACTURING PROCEDURE & FUNCTIONAL TEST

PULSER OIL FILL ASSEMBLY

1.0 SCOPE
This document describes satisfactory requirements to manufacture Pulser, Oilfilled Assembly, EFS, part number 201133 and identifies inspection points and/or support documentation where required.

2.0 REFERENCE DOCUMENTS

2.1 SOP-290.15.1 - Control of Nonconforming Product

2.2 GE SR QA Manual, Section 13

2.3 SOP-C-5250.3 - Qualification of Inspection and Test Personnel

2.4 SOP-2022 – Pulser Oil Fill Test

2.5 SOP-2060 – Pulser Lever Performance Test (Dry and Wet) Procedure

2.6 SOP-2024 – Pulser Force Test Procedure

2.7 SOP-2087 – Wire Prep for Solder Procedure

2.8 201002 – QDT MWD Maintenance Manual

2.9 Serial Number Log

2.10 Assembly Work Package

3.0 DEFINITIONS

3.1 Assembly Drawing: An engineering drawing with product specifications and tolerances required to fabricate a product.

3.2 EFS: Electronic Flow Switch

3.3 MSDS: Material Safety Data Sheets.

3.4 NCR: A Non-Conformance Report used to process defective materials.

3.5 PPE: Personal Protective Equipment.

3.6 Quality Control (QC) Inspection: An inspection to be completed by a Quality Control Inspector. Results are to be documented when specified on the flow chart or in associated documentation.

3.7 Traveler: A document contained in the Work Package that identifies the manufacturing and inspection steps required for the fabrication, assembly and testing of a product.

3.8 Work Package: A package that may contain the Traveler, Pick List or Bill of Materials, relevant Assembly Drawings and other related documents needed to fabricate a product.

4.0 RESPONSIBILITIES

4.1 It is the responsibility of the Manufacturing Manager to assign individuals to the specified tasks with the proper level of experience and/or training to complete the tasks.

4.1.1 It is the responsibility of the operator completing each process step to follow the requirements of the flow chart or documentation identified on the flow chart.

4.2 It is the responsibility of the person completing each process step to identify deficiencies as they occur in the process. Each individual is to initiate or insure initiation of a Nonconformance Report (NCR) when a defect occurs in the product at any point during the manufacturing process in accordance with SOP-290.15.1.

4.3 It is the responsibility of the Quality Assurance department to ensure the Manufacturing Procedures meet the quality requirements for the product line and to qualify all QC Inspection in Accordance with SOP-C-5250.3.

5.0 SAFETY

5.1 Special attention must be paid around moving parts to prevent pinching, crushing or cutting injuries. All tools and equipment must only be used in accordance with the manufacturer instructions. Operators must be trained on proper operating instructions.

5.2 When soldering, care should be taken to prevent burns from the iron tip. Inspect cord, base and stand before use. Soldering should be performed in well-ventilated area or a fume extractor should be used. Operator must wash hands thoroughly and clean all work surfaces well after completion. If working with lead solder the operator must complete Lead Safety Awareness Training (EHS 470). Rubber, latex or nitrile gloves should be worn.

5.3 All work on energized equipment, including inspection, testing and adjustment requires the following:

5.3.1 Conductive articles of jewelry and clothing (such as watchbands, bracelets, rings and necklaces) shall not be worn while performing electrical work.

5.3.2 Non-conductive (no metal frame) safety glasses with side shields shall be worn at all times when working on, inspecting or testing electrical equipments/components.

5.3.3 Only tools specifically designed for electrical work shall be used.

5.3.4 Power supplies, cords and switches shall be inspected for damage before use.

5.4 When using the wire heat stripper, care should be taken to prevent burns from the hot tip. Inspect cord before use.

5.5 Inspect all cords for nicks or frays before use.

5.6 Whenever you work with chemicals read the MSDS and follow the PPE guidelines.

6.0 TOOLS, EQUIPMENT and MATERIAL

6.1 Tools and Equipment and/or Equivalent

6.1.1 #60 Drill (.04”)

6.1.2 201349 Slave Test Tip

6.1.3 201845 Thread Protector Slaves (x2)

6.1.4 Air Gun

6.1.5 Brass Slave Shaft

6.1.6 Brush

6.1.7 Caliper

6.1.8 Chain Vice

6.1.9 Dental Pick

6.1.10 Feeler Gauge

6.1.11 Flat Narrow Blade Screwdriver

6.1.12 Gauge, 1/10”

6.1.13 Gear Wrench

6.1.14 Hex Head Driver, 1 1/16”

6.1.15 Hex Head Driver, 5/64”

6.1.16 Hex Head Driver, 7/64”

6.1.17 Hook Wrench

6.1.18 Hot Air Gun

6.1.19 Isopropyl alcohol

6.1.20 Multimeter

6.1.21 Needle nose Pliers

6.1.22 Nut Driver, ¼”

6.1.23 Omega Meter

6.1.24 Permanent Marker

6.1.25 Piston Cap Tool Fixture

6.1.26 Pulser Test Box

6.1.27 Pulser Test Cable Slave

6.1.28 Punch (x2)

6.1.29 Ratchet Wrench ½” Drive

6.1.30 Rubber Mallet

6.1.31 Ruler

6.1.32 Safety Wire Pliers

6.1.33 Screwdriver, Flat Blade

6.1.34 Screwdriver, Phillips Drive

6.1.35 Slave Plug

6.1.36 Snubber Shock Pigtail Slave

6.1.37 Solder Iron

6.1.38 Steel Stamp Set, ¼”

6.1.39 Steering Tool Gear Wrench 1 ¾”

6.1.40 Strain Gauge

6.1.41 Syringe, 60cc, with Oil-fill Adapter

6.1.42 System Gauge

6.1.43 Tip Tester Fixture

6.1.44 Torque Wrench

6.1.45 Torsion Spring Clamps

6.1.46 Tweezers

6.1.47 Vacuum Pump

6.1.48 V-Block (x2)

6.1.49 Wire Cutters

6.2 Materials: refer to the bill of materials and assembly drawings.

7.0 PROCEDURE

7.1 Assemble Spring Shaft Assembly

7.1.1 Apply a few small dots of Loctite 243 to the threads of the Bellows Shaft [part number 201142].

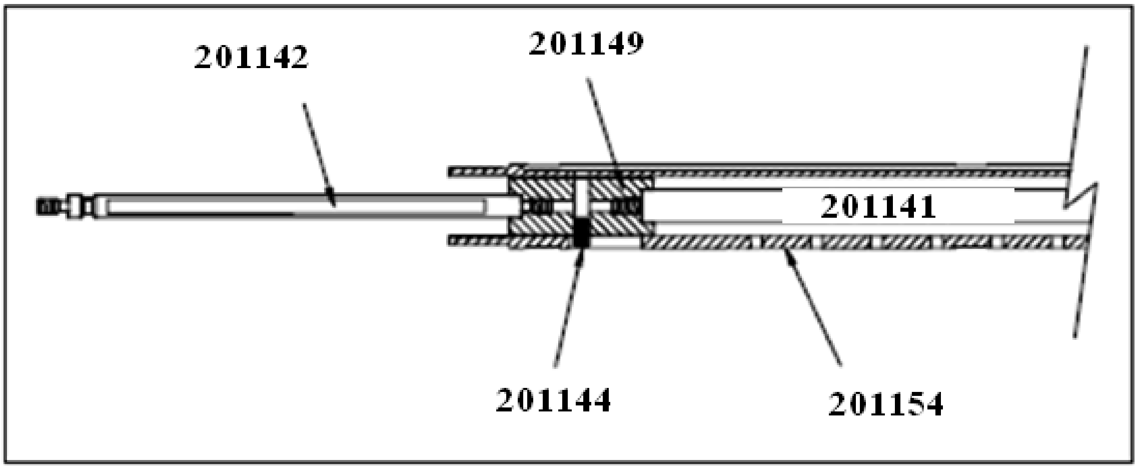
7.1.2 Thread the Bellows Shaft to the Spring Shaft Plug, [201115]. Hand-torque only.

7.1.3 Using Loctite 243, thread the Spring Shaft [201141] to the Spring Shaft Plug [201115]. Assemble carefully and avoid excessive torque to prevent damage to parts.

7.1.4 Inspect the assembly: verify it is not bent.

7.1.5 Apply a coating of Loctite 243 inside the hole for the dowel pin in the spring shaft plug.

7.1.6 Place the shaft assembly in the wire tube [201154] and install the Dowel Pin [201144].



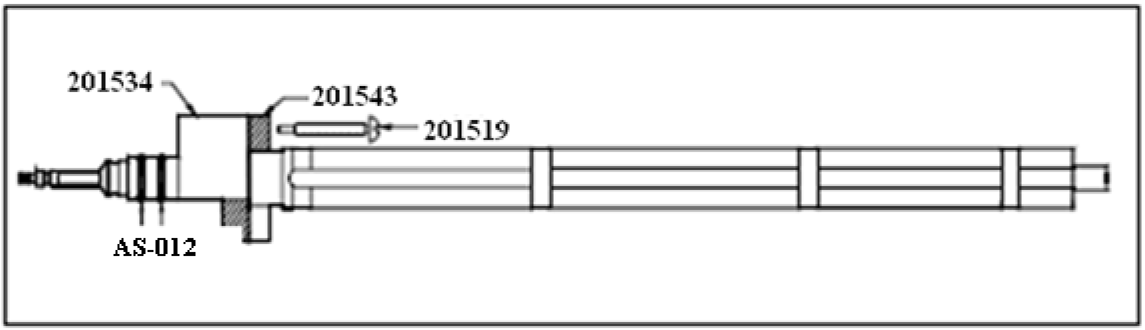
7.1.7 Inspect the shaft: verify that it slides freely.
Note: The Dowel Pin must not protrude outside of the wire tube. Move the shaft sideways against the wire tube to verify that it does not cause the Dowel Pin to protrude.

7.1.8 Fasten the Position Spacer [201534] to the Flow Sensor Plug using Position Screws. See Exhibit 7.2.

7.1.9 Install 2 new O-rings onto the Flow Sensor.

Note: Always install new, unused O-rings. Never put a used O-ring back on an assembly. If you remove an O-ring for any reason, discard it and replace it with a new, unused O-ring.

7.1.10 Insert the Bellows Shaft into the uphole end of the Flow Sensor Plug and thread the wire tube in place using Loctite 243.



7.2 Install Bellows

7.3.2 Apply Loctite 243 to the end of the screws, 8-32, SCS, ¼”.

7.3.3 Install the screws into the pulser screen housing, at the screen mounting holes, over the orifice.

7.3.4 Remove excess Loctite.

7.3.5 Apply silicone lubricant to the O-rings on the wire tube assembly.

7.3.6 Align the dowel pin with the pinhole inside the pulser screen housing.

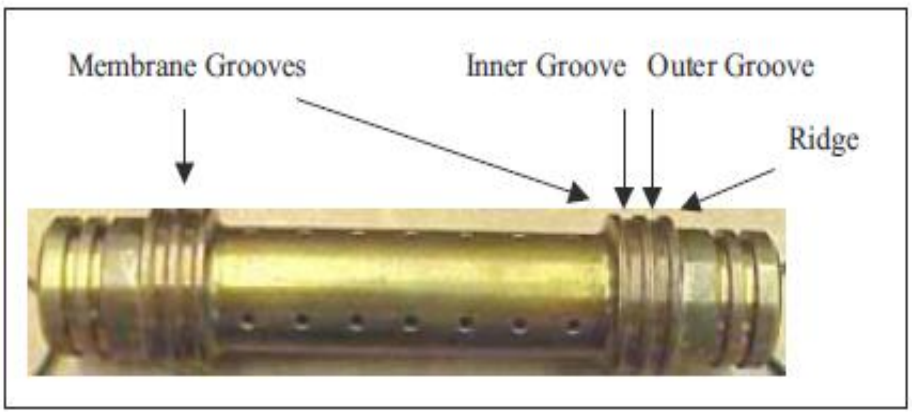
7.3.7 Install the wire tube assembly into the pulser screen housing, until the pin sets into position.

7.3.8 Secure the large end of the bellows with safety wire.

7.3.9 Verify that the wire tube assembly, at the nose, sits evenly and without
rotation, at the 3-web fingers in the pulser screen housing.

7.3.10 Install the shim over the wire tube and onto the wire tube plug, inside the pulser screen housing.

7.3.11 Remove the part label and clean the membrane support with isopropyl alcohol.



7.3.12 Clean inside the membrane support until all visible debris is removed.

7.3.13 Inspect the membrane, PRESS, COMPENS, for nicks or tears. If any nicks or tears are found, replace the membrane and inspect the replacement.

7.3.14 Clean the membrane with isopropyl alcohol.

7.3.15 Slide the membrane over the membrane support. Verify that the membrane extends 1/10” past the outer ridge of the membrane grooves at 1 end of the support.

7.3.16 Apply 2 drops of silicone lubricant, at opposite sides on the membrane, 90 degrees from the release marks.

7.4 Install Safety Wires Over 1 End of Membrane

7.4.1 Coil the safety wire, .025” DIA, .302, into 1” diameter coils.

7.4.2 Verify that the top wire faces counter-clockwise and the bottom wire faces clockwise.

7.4.3 Grip the wire at the cross point with safety wire pliers.

7.4.4 Slip the coil over a cylinder of a diameter similar to the membrane support.

7.4.5 Apply 2 drops of silicone lubricant on the extended end of the membrane.

7.4.6 Slip the coiled safety wire over the extended end of the membrane and it in the inner membrane groove, through the membrane. Verify that the membrane remains extended 1/10” past the outer ridge of the membrane grooves at this end of the support.

7.4.7 Verify that the safety wire coils do not cross each other.

7.4.8 Pull the twister knob on the safety wire pliers until the wire creates a tight crossing at the groove.

7.4.9 Clip the twist at 3/8” length and fold it into the groove.

7.4.10 Repeat the previous 8 steps to install safety wire in the outer membrane groove over the membrane.

7.5 Install Safety Wires Over Other End of Membrane

7.5.1 Hold the other end of the membrane support and extend the membrane past the outer membrane groove by 1/10”.

7.5.2 Repeat the previous section to engage, tighten, clip and fold a pair of safety wires into the 2 membrane grooves on this end of the support.

7.6 Install (1) O-ring, type AS-020, VITON, 75D, into each of the 4 grooves on the ends of the membrane support.

Membrane Support End Grooves

7.7 Install Oil-fill Housing

7.7.1 Inspect all O-rings for nicks or tears. If any nicks or tears are found, replace the O-ring with a new, unused O-ring and inspect the replacement.

7.7.2 Install (1) O-ring, type AS-006, VITON, 75D, onto the oil-fill housing plug.

7.7.3 Apply silicone lubricant to the O-ring.

7.7.4 Inspect the oil-fill housing port for burrs or cross-threading.

7.7.5 Clean the oil-fill housing and port with blasts of air for 15 seconds.

7.7.6 Install the plug to the oil-fill housing port, to finger-tight.

7.7.7 Install (1) O-ring, type AS-127, VITON, 75D, to the inner groove, at 1 end of the oil-fill housing.

7.7.8 Install (1) O-ring, type AS-125, VITON, 75D, to the outer groove at the same end of the oil-fill housing.

7.7.9 Install (1) O-ring, type AS-127, VITON, 75D, to the inner groove, at the other end of the oil-fill housing.

7.7.10 Install (1) O-ring, type AS-125, VITON, 75D, to the outer groove at the same end of the oil-fill housing.

7.7.11 Apply silicone lubricant to the inner and outer O-rings at 1 end of the membrane support.

7.7.12 Install the lubricated end of the membrane support into the down-hole end of the oil-fill housing.

7.8 Install Mud Compensator Housing

7.8.1 Apply silicone lubricant to the entire membrane, liberally.

7.8.2 Fill the 1/10” gap with silicone lubricant at the top and bottom of the membrane, where it extends past the outer ridge of the membrane grooves.

7.8.3 Apply silicone lubricant to the O-rings at the top and bottom of the membrane support.

7.8.4 Clean mud compensator housing with isopropyl alcohol.

7.8.5 Install (1) O-ring, type AS-125, VITON, 75D, to the bottom position on the mud compensator housing.

7.8.6 Install (1) O-ring, type AS-125, VITON, 75D, to the top position on the mud compensator housing.

7.8.7 Apply silicone lubricant to the small radius, inside the mud compensator housing, and to the 2 O-rings just installed.

7.8.8 Twist and push the mud compensator housing over the membrane support assembly, until the assembly reaches the bottom of the housing.

7.8.9 Clean excess lubricant from the mud compensator housin

7.8.10 Clean the coil housing, PLUG END, with isopropyl alcohol.

7.8.11 Install the coil housing on top of the oil-fill housing.

7.8.12 Apply a dot of Loctite 243 to the threads of each of 6 screws, type 6-32, PHL, ¼", FLT.

7.8.13 Install the 6 screws ¾ of the way into the coil housing.

7.8.14 Tighten the 6 screws to finger-tight, in a cross pattern.

7.8.15 Verify that the coil housing sits directly on top of the oil-fill housing.

7.8.16 Tighten the 6 screws in a cross pattern, to hand-tight.

7.9 Install Pressure Bulkhead

7.9.1 Clean the oil-fill plug.

7.9.2 Clean the pressure bulkhead.

7.9.3 Install (1) O-ring, type AS-006, VITON, 70D, to oil-fill plug.

7.9.4 Apply silicone lubricant to the oil-fill plug O-ring.

7.9.5 Install the oil-fill plug into the side of the pressure bulkhead, at the down-hole end.

7.9.6 Install (1) O-ring, type AS-127, VITON, 75D, to the inner groove at 1 end of the pressure bulkhead.

7.9.7 Install (1) O-ring, type AS-125, VITON, 75D, to the outer groove, at same end of the pressure bulkhead.

7.9.8 Install (1) O-ring, type AS-127, VITON, 75D, to the inner groove, at the other end of the pressure bulkhead.

7.9.9 Install (1) O-ring, type AS-125, VITON, 75D, to the outer groove, at the same end of the pressure bulkhead.

7.9.10 Apply silicone lubricant inside the up-hole end of the pressure bulkhead housing, where the M4 connector will seat.

7.9.11 Verify that the M4 connector has a ‘200’ etched into the shoulder, indicating it is for use in high-temperature tools.

7.9.12 Apply silicone lubricant on the area between the brass rings at the top of the M4 connector.

7.9.13 Install the M4 connector, in the down-hole end of the pressure bulkhead housing assembly.

7.9.14 Verify that the 4 slots in the pressure bulkhead assembly are not aligned with the screw holes in the pressure bulkhead housing.

7.9.15 Verify that the 2 oblong holes in the pressure bulkhead assembly are not aligned with the screw holes in the pressure bulkhead housing.

7.9.16 Verify that the distance between the edge of the pressure bulkhead and the edge of the M4 connector is from **.**550” to **.**565”.

7.9.17 Apply Loctite 243 to the nose only, not to the threads, of each of 4 setscrews, type 8-32, SET, 1/8”.

7.9.18 Install the 4 setscrews ¾ of the way into the pressure bulkhead.

7.9.19 Verify that the M4 connector is centered on the pressure bulkhead housing.

7.9.20 Tighten the 4 setscrews in a cross pattern, to hand-tight.

7.10 Install Membrane Screen Housing

7.10.1 Install (1) spring, type SOLENOID RETURN, onto the spring shaft.

7.10.2 Verify that the spring slides down the shaft without resistance.

7.10.3 Install (1) short spring spacer into the spring shaft.

7.10.4 Install a second spring, type SOLENOID RETURN, into the spring shaft.

7.10.5 Install a second short spring spacer into the spring shaft.

7.10.6 Install (1) long spring spacer into the spring shaft.

7.10.7 Verify that the long spring spacer extends 1 7/8”out of the wire tube.

7.10.8 Apply silicone lubricant to the O-ring on the down-hole end of the mud compensator housing.

7.10.9 Connect the mud compensator housing to the membrane screen housing.

7.10.10 Clean the assembly.

7.10.11 Place the assembly in a tabletop chain vice, resting on blocks of wood, with the membrane screen housing under the chain.

7.10.12 Connect a gear wrench to the oil-fill housing, to hold the housing in position.

7.10.13 Connect a second gear wrench to the spring housing, to tighten it into position.

7.10.14 Place the second gear wrench so the handle is below your waist, and then push the handle down to tighten. Torque the connection to a minimum 75 lb-ft.

7.10.15 Insert a flat blade screwdriver into the membrane screen housing to engage the test tip. Rotate the test tip so the screws are visible in 1 of the screen housing windows.

7.10.16 Tighten the screws with a 5/64” hex head driver to hand-tight.

7.10.17 Push the screwdriver against the servo-poppet. Verify that the servopoppet moves and is aligned.

7.10.18 See the serial number log for the next serial number.

7.10.19 Pound the serial number for this tool onto the pressure bulkhead flat area with a mallet and a ¼” steel stamp set.

Note: Verify the direction of each stamp, to avoid stamping any numerals upside-down.

7.10.20 Repeat the 2 steps above to pound the tool serial number into the other side of the pressure bulkhead.

7.10.21 Verify that the thickness of the washer, type FLAT, #6, SS AN960, is between .025” and .030”.

7.10.22 Gently remove the following solenoid wires from the housing:

- Red
- Brown
- Black

7.10.23 Run these 3 solenoid wires along the wire way channel and insert them back into the housing through center entry hole.

7.10.24 Remove the masking tape and clean the tube with isopropyl alcohol.

7.10.25 Apply 1 ½ wraps of ½” wide Kapton tape around the exit groove. Hold the wires in their channel while applying the tape.

7.10.26 Apply 1 ½ wraps of ½” wide Kapton tape around the entry groove.

7.10.27 Remove the shipping nut and washer from the solenoid shaft, and discard.

7.10.28 Apply silicone lubricant to the solenoid spring shaft washer to hold it in position while installing the solenoid.

7.10.29 Install the lubricant side of the washer against the solenoid clapper.

7.10.30 Clean the threads of the solenoid shaft with isopropyl alcohol.

7.10.31 Apply a dot of Loctite 243 on the solenoid shaft threads.

7.10.32 Insert a narrow, flat-blade screwdriver in the plunger hole, in the solenoid retainer.

7.10.33 Match the solenoid wide leg to the wide slot of the coil housing socket.

Note: Be careful to hold the clapper against the solenoid until the assembly is in place.

7.10.34 Support the weight of the solenoid and lower the solenoid shaft into the solenoid retainer.

7.10.35 Rotate the screwdriver clockwise until you feel the solenoid shaft threads engage.

7.10.36 Raise the solenoid assembly and insert a punch above the clapper into the hole in the solenoid shaft.

7.10.37 At the engagement use the punch to tighten the assembly.

7.10.38 Apply a dot of Loctite 243 on the threads of the 3 coil housing screws, type 6-32, PHL, 3/8”, FLT.

7.10.39 Install the 3 screws ¾ of the way into the coil housing socket.

7.10.40 Finish installing the screws in a cross pattern, to hand-tight.

7.10.41 Loosen the 2 mounting screws on the servo-poppet, with a ½ turn.

7.10.42 Engage the test tip with the screwdriver.

7.10.43 Pre-set the up-hole end of the clapper gap to 1/10”, with a 1/10” gauge.

7.10.44 Rotate the screwdriver counter-clockwise, until you feel the clapper grip the gauge.

7.10.45 Slowly rotate the screwdriver counter-clockwise until the servo-poppet screws sit squarely in the nearest window.

7.10.46 Tighten the servo-poppet screws to finger-tight.

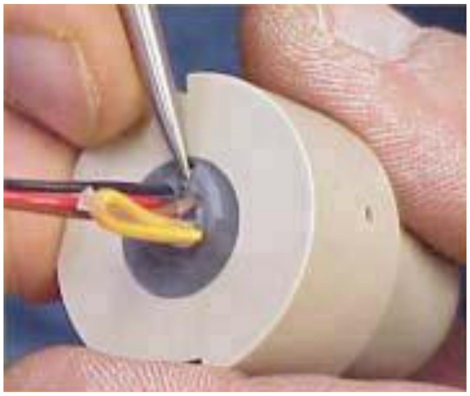
7.10.47 Push the test tip to manually move the clapper.

7.10.48 Power-on the solder iron.

7.10.49 Measure 2” of the orange wire, cut and discard excess.

7.10.50 Bend the orange wire in half.

7.10.51 Slide a 1” section of heat shrink tubing, 3/16” diameter, onto the doubled-over orange wired, completely covering it.



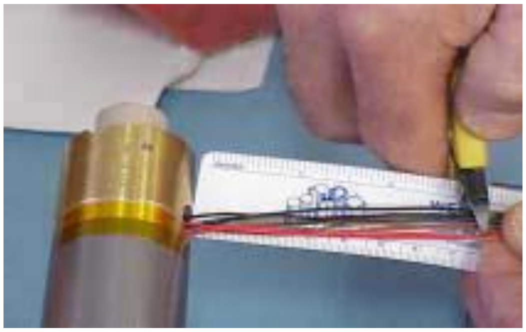
7.10.52 Heat and shrink the tubing evenly with the hot air gun.

7.10.53 Clip the excess heat shrink tubing.

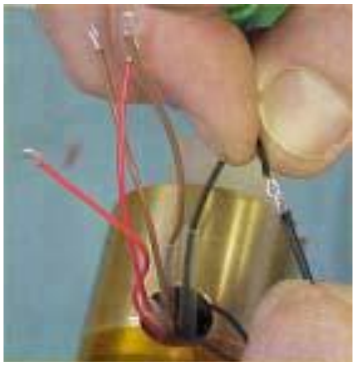
7.10.54 Remove any flakes of potting material from the top of the F4 connector.

7.10.55 Insert the solenoid wires through either window in the solenoid retainer.

7.10.56 Measure 3” of each wire, cut and discard the excess.



7.10.57 Prepare the solenoid wires for soldering with hooked ends.



7.10.58 Group the wires into 3 bundles, according to the 3 colors.

7.10.59 Slide (1) 1” section of heat shrink tubing, 3/32” diameter, Kynar, down the black heavy gauge wire for later use. Do not heat this tubing now.

7.10.60 Slide (1) ¾” section of heat shrink tubing, 3/32” diameter, Kynar, down 1 of the brown wires.

7.10.61 Slide (1) ¾” section of heat shrink tubing, 3/32” diameter, Kynar, down 1 of the red wires.

7.10.62 Lay the 2 light-gauge black wires parallel and connect their hooks to the hooked end of the heavy gauge black wire.

Tensor Pulser - Level 2

To be performed on tools with < 300 hours.

Last Updated Dec 17, 2007

Level 2

Serial Number:	
Circ. Hours:	
Tech. Name:	
Date of Service:	
Customer:	
Kit #	
Job #:	
Operator:	
Well Name:	

INCOMING CHECKS

- ☐ Look at the tool's history; checking for earlier problems and the tool's operating hours.
- ☐ Clean grease, writing, etc. from tool.
- ☐ Connect the pulser to a test box and ensure that the FLOW indicator light is ON.
- ☐ Tap pulser for flow switch function. Flow switch voltage:______
- ☐ Check pull force, hold force, return spring force (RSF).

	Specs	Measured	Setting
INCOMING PULL FORCE	10 - 17 lbs	lbs	1 sec
INCOMING HOLD FORCE	> 14 lbs	lbs	On
RETURN SPRING FORCE	> 3 lbs	lbs	Off

- ☐ Check the oil in the compensation membrane.

INTERNAL CHECKS

- ☐ Loosen all joints on the pulser.
- ☐ Rate the oil condition (1= clean to 10= mud invasion).
- ☐ Clean all parts of mud and soil. Clean solenoid with contact cleaner.
- ☐ Check the outgoing pull and hold Resistance and record below.

Oil Condition:		
Solenoid #:		
Driver #:		
Rev.:		

Pull Resistance:	ohms	**Spec: 13.0 - 14.2 ohms**
Hold Resistance:	ohms	**Spec: 500 - 600 ohms**

- ☐ Inspect the bebro connector for corrosion and damage.
- ☐ Check all wiring that enters the solenoid for nicks/cuts and teflon cold-flow. Check all splices for integrity and rework any bad splices.
- ☐ Check solenoid screw for straightness. Replace if necessary.
- ☐ Check magnetism on clapper. Replace if necessary.
- ☐ Spray contact cleaner into solenoid and stroke. Ensure free travel.
- ☐ Check spring shaft and short spring shaft for any bending and wear. Replace as required.
- ☐ Remove wire tube and sleeve from flow sensor plug. Clean thoroughly and reinstall with 243 blue Loctite.
- ☐ Replace- bellow
- ☐ Check springs for distortion and stretching. **Note: each spring must be ≥ 2.5 inches in length.**
- ☐ Replace compensation membrane.
- ☐ Clean and inspect the orifice. Replace if necessary. Clean threads and reinstall with 243 blue Loctite
- ☐ Inspect poppet and poppet assembly. Replace if necessary.
- ☐ Inspect all remaining parts. Clean all threaded holes and O-ring grooves. Replace all O-rings.

Document #0017

Tensor Pulser - Level 2
To be performed on tools with < 300 hours.

ASSEMBLY

- ☐ Tighten Long spring shaft to Solenoid shaft with 243 Blue Loctite.
- ☐ Measure from the bottom of the solenoid to the top of the clapper and adjust. Clearance: ______ Spec: 0.10-0.12"
- ☐ Replace 006 O-rings in Oil fill ports.
- ☐ Tighten screws in servo poppet using 243 Blue Loctite. Replace screws.

DRIVER CHECK

- ☐ Check connector sockets for retention force using a tester pin. Ensure all pins are straight and undamaged.
- ☐ Check Female Bebro socket for damage.
- ☐ Perform breakout on driver. Check resistance.

	2	3	4	5	6	7	8,9,10 housing
Specs (ohms) 1	O.L.	O.L.	1.5M - 3.5 M	O.L.	43K - 45K	9.5K-58K or O.L.	O.L.

- ☐ Inspect the wires flowing from the kintec to see if the soldering connections are intact. Check for any degradation in the wiring and teflon cold-flow. Re-tape
- ☐ Re-tape with Kapton tape if necessary. Check the guaging and ensure the driver is guaged properly.
- ☐ Ensure set screws on female bebro are tight. Reinstall with 243 blue Loctite if necessary.
- ☐ Inspect snubber for any wear or damage. Ensure bolts are tight. Reinstall with 243 blue Loctite if necessary.

ASSEMBLY

- ☐ Replace all O-rings.
- ☐ Assemble in reverse order of tear-down.
- ☐ **Tighten all joints with barrel wrenches!**

OIL FILL STATION

- ☐ Fill pulser with oil;till air bubbles stop emerging.
- ☐ Check oil in the compensation membrane.
- ☐ Clean off excess oil. Ensure no leaks.

Filled by: ______ **Date:** ______

OUTGOING CHECKS

- ☐ Conduct the Pulser Driver Circuit Test and record results in table below:

Pulser Test Unit +24VDC ±2V	
Idle Current ≤24 mA	
Pull-in Coil Voltage ≥ 65 Volts Peak	
Holding Coil Voltage ≥ 18 V	
Pull-in Coil Duration 85 Ms ± 10 Ms	
Pull-in Coil Current ≥ 4.0 Amps	
Holding Coil Current ≥ 30 mA	

Solenoid #: ______

Driver #: ______

- ☐ Connect the pulser to a test box and ensure that the FLOW indicator light is ON.
- ☐ Tap pulser for flow switch function. Flow switch voltage:______
- ☐ Check for pull force, hold force, and RSF. Record in table below.

	Specs	Measured	Setting
OUTGOING PULL FORCE	10 - 17 lbs	lbs	1sec.
OUTGOING HOLD FORCE	> 14 lbs	lbs	On
RETURN SPRING FORCE	> 3 lbs	lbs	Off

Document #0017

Tensor Pulser - Level 2

To be performed on tools with < 300 hours.

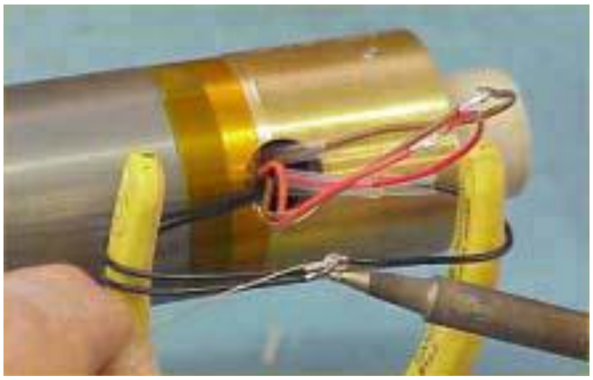
- ☐ Perform a vibration test for 10 minutes.(if vib. table is avail.)
- ☐ Write tool sn on green tag and hrs and tape on pulser.
- ☐ Update the tool tracking system.
- ☐ **Review this checklist to verify that all tests were performed and that all procedures were followed.**

Comments and Faults Found:____

Parts Used

Qty	Description

Document #0017



7.10.63 Crimp and solder these 3 wires together.

7.10.64 Hook, crimp and solder the two brown wires together.

7.10.65 Hook, crimp and solder the two red wires together.

7.10.66 Clean the exposed wire areas.

7.10.67 Set the multimeter to measure Ohms.

7.10.68 Place the multimeter black clip on the black wires connection.

7.10.69 Place the multimeter red clip on the brown wires connection.

7.10.70 Verify that the meter reading is between 13 and 15 Ohms.

7.10.71 Write the reading on the “Tensor Pulser Check List”.

7.10.72 Move the multimeter red clip to the red wires.

7.10.73 Verify that the meter reading is between 500 and 600 Ohms.

7.10.74 Remove the multimeter red clip from the red wires.

7.10.75 Rub the multimeter red clip on the wire channel.

7.10.76 Verify that the meter reading is 0.0 Ohms.

7.10.77 Move the multimeter black clip to the brown wires and repeat the previous 2 steps.

7.10.78 Move the multimeter black clip to the red wires and repeat the same 2 steps.

7.10.79 When all test points are valid, slide the heat shrink tubing over the solder points of each wire.

7.10.80 Heat and shrink the tubing evenly with the hot air gun.

7.10.81 Power-off the solder iron.

7.10.82 Install the wave spring, SSR-0112, on the shoulder of the solenoid retainer, with the wires routed through the center of the spring.

Note: The wave spring has a split, so you can open it and wrap it around the wire.

7.10.83 Start the tapered end of the ring, RET, 1.250”, SPIRAL SS, in one of the alignment pin grooves.

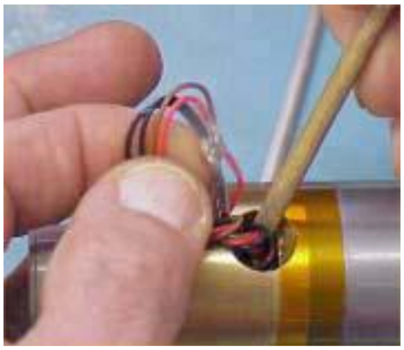
7.10.84 Push down on the F4 connector and insert the remainder of the spring clip into its groove, which is located inside the uphole end of the solenoid.

7.10.85 Release the F4 connector.

7.10.86 Verify that the wave spring resists, by pushing it.

7.10.87 Place the wire circles parallel to each other and twist the group of wires 2 or 3 times.

7.10.88 Ease the wire bundle into the window with a blunt stir stick.



7.10.89 Rotate the tool to verify the wires aren't sticking out of the opposite window.

7.11 Install Solenoid Housing

7.11.1 Clean the solenoid housing using a clean cloth, a long narrow shaft and the air gun.

7.11.2 Apply silicone lubricant to the O-rings on the oil-fill housing.

7.11.3 Place the tool in a vertical position with the oil-fill housing above the screen housing.

7.11.4 Twist the solenoid housing onto the oil-fill housing until they are firmly connected.

Note: At resistance, firmly tap the top of the solenoid housing, and continue to connect the housings together.

7.11.5 Place the assembly in the tabletop chain vice, resting on blocks of wood, with the chain over the mud compensator housing.

7.11.6 Connect a gear wrench to the solenoid, to hold it in position.

7.11.7 Connect a second gear wrench to the screen housing, to tighten it into position.

7.11.8 Place the second torque wrench so its handle is below your waist, then push the handle down to tighten. Torque the connection to 75 lb-ft.

7.11.9 Apply silicone lubricant to the pressure bulkhead O-rings.

7.11.10 Twist the bulkhead onto the solenoid housing to hand-tight.

7.11.11 Mark the oil-fill plug and the solenoid housing, with a permanent marker, to identify the hand-tight alignment position.

7.12 Re-check Clapper gap with 3-turn procedure.

7.12.1 Lay the partially assembled unit on the test bench next to the Pulser Driver Assembly [201137] with the Driver Snubber Shock Assembly [201528] attached.

7.12.2 Plug the male, 4-pole connector assembly [201598] into the female, 4- pole connector assembly [201599].

7.12.3 Connect the 4-pin / 6-socket connector on the driver snubber to its mate in the female connector assembly.

7.12.4 Connect Pulser Test Unit [203100] to the other end of the driver. The HOLD position on the Pulser Test Unit will energize the solenoid for further procedures.

Note: At this point screws should be just loose enough to allow the base to turn on the shaft threads for position adjustment.

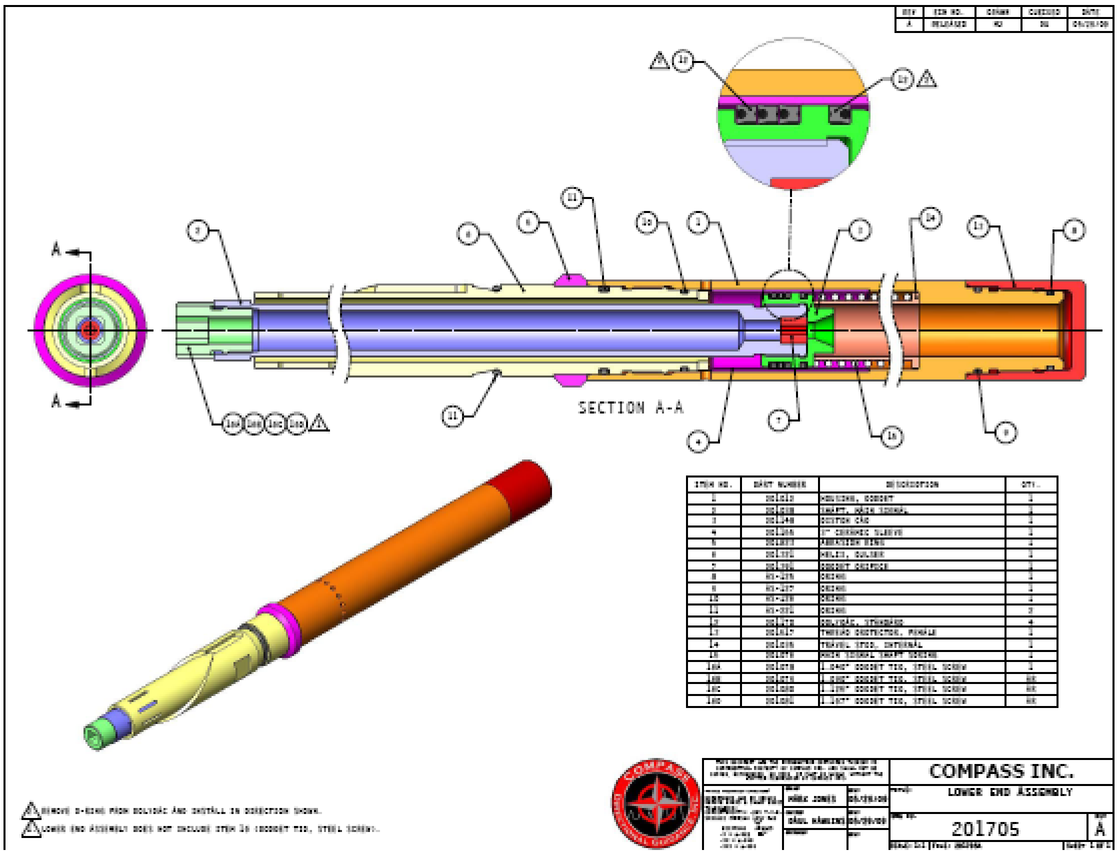
7.12.5 Thread the base onto the shaft until it bottoms.

7.12.6 Energize the solenoid. If necessary, use a small screwdriver to push the shaft up until the Clapper touches the solenoid housing.

7.12.7 Unthread the assembly until the Poppet Tip bottoms out against the Servo Orifice. Then re-thread the assembly 3 turns plus an additional, partial turn if needed, to position the screw heads in the nearest window.

7.13 Perform Pulser Oil-fill Procedure

B.2 LOWER END



7.14 Install Helix End Assembly

7.14.1 Apply clear RTV to the orifice, CERAMIC POPPET, sidewalls.

7.14.2 Install the orifice, CERAMIC POPPET, in the up-hole end of the signal valve shaft, with beveled end facing uphole.

7.14.3 Clean the excess clear RTV from the signal valve shaft.

7.14.4 Install O-ring, AS-127, VITON, 75D, on the bottom position of the poppet housing.

7.14.5 Install O-ring, AS-125, VITON, 75D, on the top position of the poppet housing.

7.14.6 Install O-ring, AS-221, VITON, 75D, on the bottom position of the helix end, PULSER/HELIX END, down-hole position.

7.14.7 Install the abrasion ring to its stop position above this O-ring.

7.14.8 Verify that the chamfer on the abrasion ring is positioned down-hole.

7.14.9 Install O-ring, AS-221, VITON, 75D, on the middle position of the helix end.

7.14.10 Install O-ring, AS-126, VITON, 75D, on the top position of the helix end.

7.14.11 Install the signal shaft into the down-hole end of the helix shaft.

7.14.12 Place the assembly in a tabletop chain vice, with the chain connected to the mid-section.

7.14.13 Rotate the tool until the slot is underneath, and the chain lies on a smooth surface.

7.14.14 Put the seal, STD, POLYPAK, in the groove on the down-hole end of the piston cap. Make sure the installed O-ring in the polypak is facing downhole.

7.14.15 Verify that the seal is squarely seated in the groove.

7.14.16 Apply 4 dots of Loctite 243 to the Signal Shaft threads at 90-degree intervals, for both low temp and high temp tools.

7.14.17 Install the poppet end, #1 (1.122” outer diameter), threading it into the signal shaft, at the down-hole end, to hand-tight.

7.14.18 Repeat the 2 steps above for the up-hole end of the signal shaft and the piston cap.

7.14.19 Place the mounting fixture on the piston cap.

7.14.20 Tighten the slave screws onto the piston cap mounting holes, to fingertight.

7.14.21 Connect a ½” drive ratchet wrench to the poppet end, to hold it in position.

7.14.22 Set a torque wrench to 75 lb-ft.

7.14.23 Connect the torque wrench to the installation tool with the torque wrench handle below your waist.

7.14.24 Pull the handle upward until you hear the double click.

7.14.25 Remove the O-ring from the polypak.

7.14.26 Install the wiper to the outside or uphole groove of the piston cap, with the wiper channel facing up-hole.

7.14.27 Apply silicone lubricant to the polypak and wiper, liberally.

7.14.28 Verify that the wear sleeve, SIGNAL PISTON, slides completely and smoothly over the main spring.

7.14.29 Apply silicone lubricant to the inside of the wear sleeve, liberally.

7.14.30 Gently slide the wear sleeve over the wiper and the polypak.

7.14.31 Apply Loctite 620 to the outside of the wear sleeve, liberally.

7.14.32 Apply silicone lubricant to the inside of the housing, at the seat of the wear sleeve.

7.14.33 Apply silicone lubricant to the O-rings on the helix end.

7.14.34 Install the main spring into the housing.

7.14.35 Push and rotate the assembly into the housing until it is fully connected.

7.14.36 Place the assembly in a tabletop chain vice with the chain over the middle section.

7.14.37 Connect a gear wrench to the poppet housing, to hold it in position.

7.14.38 Connect a steering tool gear wrench to the helix end, to tighten it into position.

7.14.39 With the steering tool gear wrench below your waist, push the wrench down to tighten. Torque this connection to 75 lb-ft.

7.14.40 Push the helix end to actuate the spring in and out.

7.14.41 Release the setting on the torque wrench to minimum value.

7.15 Perform Pulser Force Test (Vacuum)

7.16 Install Ceramic Tip

7.16.1 Install the pigtail to the solenoid housing.

7.16.2 Connect the pulser test cable to the MDM connector on the pigtail.

7.16.3 Turn the poppet screws ¼ of a turn to release the torque of the hand-tight procedure.

7.16.4 Power-on the pulser test box.

7.16.5 Set the "on-time" knob to the "on" position, to keep the pulser in the hold position.

7.16.6 Verify that the poppet has backed-off from the orifice.

7.16.7 Remove the 2 screws holding the servo-poppet.

7.16.8 Loosen the 2 clamp screws on the servo-poppet for a 1/8" gap at the clamp.

7.16.9 Apply a dot of Loctite 243 to each of the visible screw threads.

7.16.10 Apply a dot of Loctite 243 to the servo-poppet shaft threads.

7.16.11 Tighten the clamp screws to the end of the shaft, to finger-tight.

7.16.12 Power-off the pulser test box.

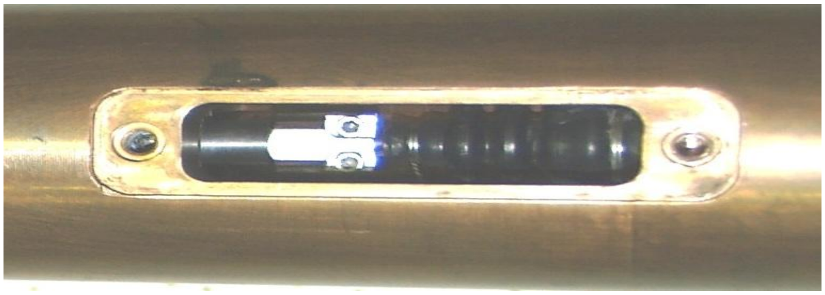
7.16.13 Power-on the pulser test box.

7.16.14 Set the “on-time” knob to 1.

7.16.15 Set the “off-time” knob to 2.

7.16.16 Allow it to actuate for 2 minutes.

7.16.17 Verify that the tip is flush against the orifice. Rotate the tool to view the tip from each window.



7.16.18 Verify that the shaft pulses while in alignment.

7.16.19 Power-off the pulser test box.

7.16.20 Remove excess lubricant.

7.21 Send to QC for inspection.

7.22 Send the assembly to inventory or to the next assembly. Refer to the manufacturing flow map or procedure.

7.23 In case of conflicting instructions, give precedence to documentation in the following order:

(1) Product Specification and Drawings and manufacturing instructions contained on them.
(2) Manufacturing Flow Chart
(3) Manufacturing Procedures (MPs)
(4) Process Instructions, such as welding procedures (Ps, P.I.s and P.P.I.s)
(5) Standard Operating Procedures (SOPs)

1.0 SCOPE

This procedure describes the functional testing, at room temperature, required to verify proper function under the vacuum test conditions for the Assy, Pulser Oilfilled 175C

MWD, PN 201126.

2.0 REFERENCE DOCUMENTS

2.1 GE RS QA Manual, Section 13

2.1 2 SOP-C-5250.3 - Qualification of Inspection and Test Personnel

2.1 3 SOP-290.15.1- Nonconformance Report (NCR) Procedure

2.1 4 Assembly Work Package

3.0 DEFINITIONS

3.1 Operator or Assembler: The individual who performs a specific, or several, manufacturing steps.

3.1 2 Documentation Point: A step in a procedure requiring the operator to record information from an inspection, test or process to a specified location such as in a Traveler, Work Package or database.

3.1 3 Work Package: A package that may contain the Traveler, Pick List or Bill of Materials, relevant Assembly Drawings and other related documents needed to fabricate a product.

3 1 4 Traveler: A document contained in the Work Package that identifies the manufacturing and inspection steps required for the fabrication, assembly and testing of a product.

3.1 5 Pick List: A list of piece parts required to fabricate a product. The Pick List will not include standard commodities such as solder.

3.1 6 Bill of Materials: A list of all parts and materials required to fabricate a product. The Bill of Materials will include standard commodities such as solder.

3.1 7 Assembly Drawing: An engineering drawing with product specifications and tolerances required to fabricate a product.

3.1 8 NCR: A Non-Conformance Report used to process defective material.

3.1 9 In-process Inspection: An inspection completed during the manufacturing process, often completed by the assembler. This inspection requires documentation of the results when identified in the manufacturing procedure.

3.1 10 Quality Control (QC) Inspection: An inspection to be completed by a Quality Control Inspector. Results are to be documented when specified on the flow chart or on associated documentation.

3.1 11 MSDS: Material Safety Data Sheets

3.1 12 PPE: Personal Protective Equipment

4.0 RESPONSIBILITIES

4.1 It is the responsibility of the Manufacturing Manager to assign individuals to the specified tasks with the proper level of experience and/or training to complete the tasks.

4 1 2 It is the responsibility of the operator completing each process step to follow the requirements of the flow chart or documentation identified on the flow chart.

4.1 3 It is the responsibility of the person completing each process step to identify deficiencies as they occur in the process. Each individual is to initiate or insure initiation of a Nonconformance Report (NCR) when a defect occurs in the product at any point during the manufacturing process in accordance with SOP-290.15.1.

4.1 4 It is the responsibility of the Quality Assurance department to ensure the Manufacturing Procedures meet the quality requirements for the product line and to qualify all QC Inspection in Accordance with SOP-C-5250.3.

4 1 5 Where a measurement is taken for product acceptance and for the control of quality related activities, the IM & TE (inspection, measuring, and test equipment) device shall be subject to calibration. The Operator shall check the calibration sticker to ensure the calibration of the device has not passed its expiration date.

5.0 SAFETY

5.1 Special attention must be paid around moving parts to prevent pinching, crushing or cutting injuries. All tools and equipment must only be used in accordance with the manufacturer instructions. Operators must be trained on proper operating instructions.

5.1 2 All work on energized equipment, including inspection, testing and adjustment requires the following:

5.1 3. Conductive articles of jewelry and clothing (such as watchbands, bracelets, rings and necklaces) shall not be worn while performing electrical work.

5 1 4 Non-conductive (no metal frame) safety glasses with side shields shall be worn at all times when working on, inspecting or testing electrical equipments/components.

5 1 5 Only tools specifically designed for electrical work shall be used.

5 1 6 Power supplies, cords and switches shall be inspected for damage before use.

5.1 7 When using the wire heat stripper, care should be taken to prevent burns from the hot tip. Inspect cord before use.

5.1 8 Inspect all cords for nicks or frays before use.

5.1 9 Whenever you work with chemicals read the MSDS and follow the PPE guidelines.

Oil Fill Procedure

6.0 TOOLS, EQUIPMENT and MATERIAL

6.1 Tools and Equipment and/or Equivalent

6.1.1 Snubber Shock Pigtail Connector

6.1.2 Vacuum Pump

6.1.3 Flat Blade Screwdriver

6.1.4 Pulser Test Box

6.1.5 System Gauge

6.1.6 Rubber Mallet

6.1.7 Permanent Marker

6.1.8 60cc Syringe with Oil Fill Adapter

6.1.9 Slave Plug

6.1.10 Table Top Chain Vice

6.1.11 Small Blocks of Wood

6.1.12 Slave Nut, Washer and O-Ring

6.1.13 Thread Protector Slaves (x2)

6.1.14 Air Pressure Main with Hose

6.2 Materials

6.2.1 Alcohol

6.2.2 Cloth/Large Rags

7.0 PROCEDURE

7.1 Perform the Pulser Oil Fill Vacuum Test

7.1.1 Verify valve positions at the start of the test are as follows
• Valve A: Closed
• Valve B: Closed
• Valve C: Open
• Valve D: Closed

7.1.2 Connect the slave cable to the MDM connector head on the assembly.

7.1.3 Power-on the vacuum pump.

7.1.4 Open vacuum valve A.

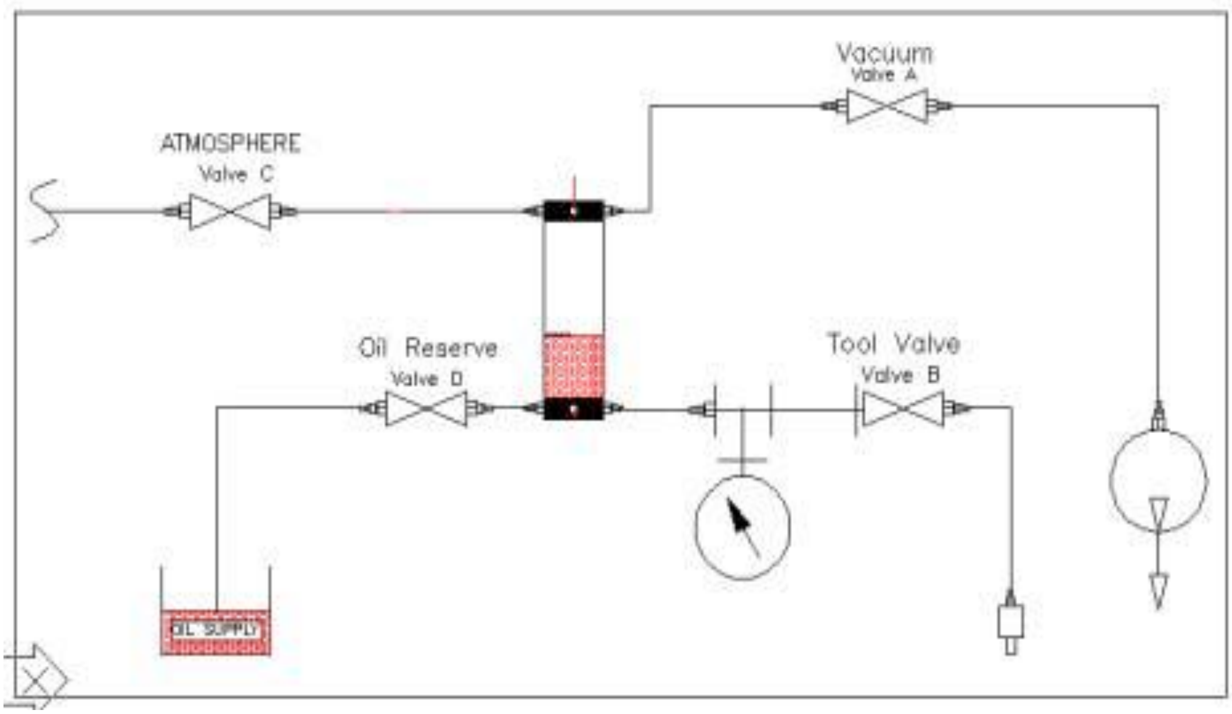


Exhibit 1- Oil Fill Stand

7.1.5 Partially close atmosphere valve C, 1/8 turn. This valve is open at beginning of test.

7.1.6 After 3 seconds, power-off the vacuum pump.

7.1.7 Open the oil, SILICONE, 50CS, reserve valve D and watch the reservoir fill until you reach the top mark.

7.1.8 Close valve D.

7.1.9 Remove the oil fill plug.

7.1.10 Connect the oil fill adapter; to the pressure bulkhead at the oil fill port.

7.1.11 Power-on the pulser test box.

7.1.12 Set the “on-time” knob to 1.

7.1.13 Set the “off-time” knob to 2.

7.1.14 Verify that valve D is closed.

7.1.15 Verify that valve A is open.

7.1.16 Power-on the vacuum pump.

7.1.17 Partially open tool valve B, 1/8 turn, to allow air in pulser to move into the oil reservoir.

7.1.18 When the bubbles slow, completely open valve B.

7.1.19 With all connections in place, hold the tool in a vertical position and raise it above your shoulders for 10 seconds.

7.1.20 Rotate the tool 180 degrees and raise it above your head for 10 seconds.

7.1.21 Lower the tool to table level and tap it for 1 minute with a rubber mallet.

7.1.22 Raise the tool above your shoulders for 10 seconds.

7.1.23 Rotate the tool 180 degrees and hold it above your head for 10 seconds.

7.1.24 Place the tool in its stand and verify that the MDM and oil fill connections are in place.

7.1.25 Completely close valves A and C.

7.1.26 Power-off the vacuum pump.

7.1.27 Verify that valve B is completely open.

7.1.28 Allow the tool to pulse, to release the air for 5 minutes. Note: if a constant stream of air bubbles is present, refer to the lead tech for troubleshooting.

7.1.29 When the supply lines are full and no bubbles are visible, mark the current oil level on the reservoir with a permanent marker.

7.1.30 Verify that valve C is closed.

7.1.31 Open valve A.

7.1.32 Power-on the vacuum pump for 3 seconds, then power-off the vacuum pump.

7.1.33 See the oil volume rise 2 inches, for 30 minutes.

7.1.34 Partially open valve C to 1/8 turn; allow oil to move into the tool for 5 minutes.

7.1.35 Close valve A.

7.1.36 Watch the supply line for air bubbles as you hold the tool above your shoulders in a vertical position.

7.1.37 When no more bubbles are visible, rotate the tool 180 degrees and return it to above your shoulders.

7.1.38 Move the tool to table level and tap it 5 to 10 times with a rubber mallet.

7.1.39 Return the tool to its stand and verify that the connections are still in place.

7.1.40 Allow the tool to pulse until you no longer see bubbles.

7.1.41 Close valve C.

7.1.42 Open valve A.

7.1.43 Power-on the vacuum pump until the gauge shows 28.5 inches of mercury.

7.1.44 Close valve A.

7.1.45 Power-off the vacuum pump.

7.1.46 Allow the tool to pulse until you no longer see bubbles.

7.1.47 Fully open valve C and watch the oil drop to the first, and/or lower mark.

7.1.48 Switch-off the “on-time” knob and power-off the pulser test box.

7.1.49 Disconnect the slave cable from the MDM connector.

7.1.50 Close valve B.

7.1.51 Lay the tool in the horizontal position.

7.1.52 Remove the plunger from the syringe.

7.1.53 Remove the oil fill adapter from the oil fill plughole and replace it with the oil fill adapter on the syringe.

7.1.54 Plug the adapter on oil fill supply line.

7.1.55 Wipe excess oil off the assembly and the plug area.

7.1.56 Place the pulser in a tabletop chain vice, resting on blocks of wood, in the horizontal position with the syringe in the vertical position.

7.1.57 Connect the chain over the solenoid housing, near the syringe.

7.1.58 Verify that the mud compensator holes are open.

7.1.59 Remove the end caps from both sides of the pressure apparatus.

7.1.60 Slide the nut, washer and o-ring past the window on the screen housing and the mud compensator holes.

7.1.61 Slide the pressure apparatus into the nut and loosely tighten.

7.1.62 Install the o-ring, washer and nut onto the outside end of the pressure apparatus, to hand-tight.

7.1.63 Install thread protectors to the screen housing, to hand-tight.

7.1.64 Power-on the air pressure source to 60 lbs.

7.1.65 Turn the air pressure regulator knob counter-clockwise to the “off” position.

7.1.66 Turn the air source line to the pressure apparatus plug.

7.1.67 Gradually increase the air pressure to 40 lbs by turning the air pressure regulator knob clockwise. At 40 lbs of air pressure the level of oil in the syringe should be from 20 to 24cc. Note the number.

7.1.68 Verify that the oil is not discolored and there are no bubbles.

7.1.69 Release the air pressure completely, by turning the air pressure regulator knob counter-clockwise.

7.1.70 Increase the air pressure by turning the air pressure regulator knob clockwise, until you reach 10cc less than the number noted above.

7.1.71 Write the resulting amount of oil on line 6 of the data sheet.

7.1.72 Remove the syringe, and discard the oil in an approved container.

7.1.73 Verify that the oil in the tool is at the top of the hole.

7.1.74 Plug the oil fill.

7.1.75 Wipe the excess oil off the assembly and the plug area.

7.1.76 Remove the threaded protector.

7.1.77 Remove the air supply hose, and reduce the air pressure to zero psi.

7.1.78 Loosen the nuts on the pressure apparatus.

7.1.79 Move the assembly to the next assembly queue.

7.2 When there is a conflict of information in the instructions the order of precedence of documentation is listed below:

(1) Product Specification and Drawings and manufacturing instructions contained on them.
(2) Manufacturing Flow Chart
(3) Manufacturing Procedures (MPs)
(4) Process Instructions, such as welding procedures (Ps, P.I.s and P.P.I.s)
(5) Standard Operating Procedures (SOPs)

8.0 EXHIBITS

8.1 Pulser Force Test Valve Positions
ASSY, PULSER OIL FILLED 175C MWD

PULSER FORCE TEST (aka) VACUUM TEST

	Valve A (vacuum)	Valve B (tool valve)	Valve C (atmosphere)	Valve D (oil reserve)
Procedure Number				
7.1.1	CLOSED	CLOSED	OPEN	CLOSED
7.1.4	open	*	*	*
7.1.5	*	*	close 1/8 turn	*
7.1.7	*	*	*	open
7.1.8	*	*	*	close
7.1.14	*	*	*	verify close
7.1.15	verify open	*	*	*
7.1.17	*	open 1/8 turn	*	*
7.1.18	*	open	*	*
7.1.25	close	*	close	*
7.1.27	*	verify open	*	*
7.1.30	*	*	verify close	*
7.1.31	open	*	*	*

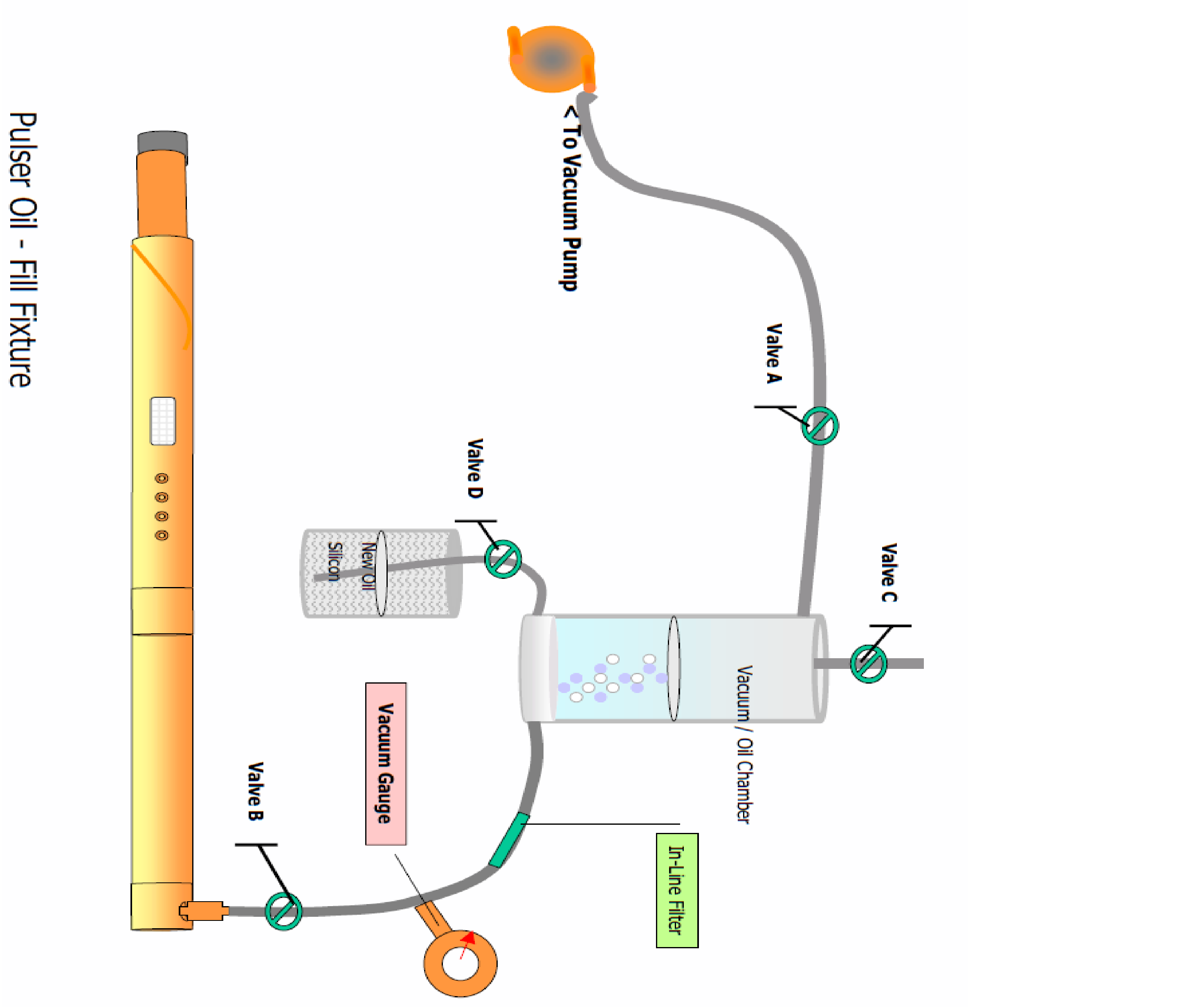
ASSY, PULSER OIL FILLED 175C MWD

PULSER FORCE TEST (aka) VACUUM TEST

	Valve A (vacuum)	Valve B (tool valve)	Valve C (atmosphere)	Valve D (oil reserve)
Procedure Number				
7.1.34	*	*	open 1/8 turn	*
7.1.35	close	*	*	*
7.1.41	*	*	close	*
7.1.42	open	*	*	*
7.1.44	close	*	*	*
7.1.47	*	*	open	*
7.1.50	*	close	*	*
Valve Status at End of Test	VERIFY CLOSED	VERIFY CLOSED	VERIFY OPEN	VERIFY CLOSED

Chart Notes: * - See Previous Step for Valve Position.

B.3 PULSER OIL-FILL FIXTURE COLOR DIAGRAM



B.5 BOM

BOM: Pulser Assembly (Tensor)

Asset

Part Number	Size	Product Line	Description
201125	1-7/8"	MWD	Pulser System, w/Driver 175° C

Serialized Part

Part Number	Size	Product Line	Description
201125S	1-7/8"	MWD	Pulser System, w/Driver 175° C
201128	1-7/8"	MWD	Driver, Pulser 175° C
201135	Common	MWD	Solenoid

Non-Serialized Part

Part Number	Size	Product Line	Description	Quantity
201157	1-7/8"	MWD	Compensation Membrane Housing	1.00
201195	1-7/8"	MWD	Housing, Solenoid	1.00
201203	1-7/8"	MWD	Pulser Screen Housing w/Oil Fill Hole	1.00
201509	1-7/8"	MWD	Housing, Interconnect	1.00
201511	1-7/8"	MWD	Housing, Lower Oil Fill	1.00
201513	1-7/8"	MWD	Housing, Upper Oil Fill	1.00
201514	1-7/8"	MWD	Intermodule End	1.00
201532	1-7/8"	MWD	Housing, Pulser Driver	1.00
201845	1-7/8"	MWD	Thread Protector, Male	1.00
120001	Common	MWD	Temp Tab "B"	1.00
120002	Common	MWD	Temp Tab "C"	1.00
201141	Common	MWD	Spring Shaft Assembly w/ Plug	1.00
201142	Common	MWD	Bellows Shaft	1.00
201143	Common	MWD	Solenoid Wave Spring	1.00
201152	Common	MWD	Shim, Pulser	1.00
201154	Common	MWD	Wire Tube	1.00
201155	Common	MWD	Compensation Membrane Support	1.00
201160	Common	MWD	Short Spring Spacer	2.00

Non-Serialized Part

Part Number	Size	Product Line	Description	Quantity
201169	Common	MWD	Plug, Oil Fill	3.00
201189	Common	MWD	Long Spring Spacer	1.00
201190	Common	MWD	Compensation Membrane	1.00
201205	Common	MWD	Pulser Screen	3.00
201233	Common	MWD	Bellows, High Temp	1.00
201348	Common	MWD	Servo Poppet Tip Assembly	1.00
201392	Common	MWD	Servo Orifice	1.00
201419	Common	MWD	Spring, Solenoid Return	2.00
201505	Common	MWD	Bulkhead Retainer, Top (90 Degree)	1.00
201506	Common	MWD	Split Shell	2.00
201518	Common	MWD	Flow Sensor Plug	1.00
201529	Common	MWD	Snubber Assembly, Pulser Driver	1.00
201543	Common	MWD	Solenoid Spacer	1.00
201598	Common	MWD	Rotary Connector, Female	1.00
201599	Common	MWD	Rotary Connector, Male	1.00
201961	Common	MWD	Retaining Ring, Solenoid	1.00
201990	Common	MWD	Pigtail, Pulser Driver	1.00
AS-006	Common	MWD	AS-006 O-Ring, Viton	3.00
AS-012	Common	MWD	AS-012 O-Ring, Viton	2.00
AS-020	Common	MWD	AS-020 O-Ring, Viton	4.00
AS-124	Common	MWD	AS-124 O-Ring, Viton	3.00
AS-125	Common	MWD	AS-125 O-Ring, Viton	5.00
AS-127	Common	MWD	AS-127 O-Ring, Viton	6.00
AS-217	Common	MWD	AS-217 O-Ring, Viton	1.00
AS-218	Common	MWD	AS-218 O-Ring, Viton	1.00
AS-220	Common	MWD	AS-220 O-Ring, Viton	2.00
SC-006	Common	MWD	Screw, Servo Poppet Tip	1.00
SC-011	Common	MWD	Screw, 8-32 x 5/16 Phil/Flat, SS	6.00
SC-013	Common	MWD	Screw, 6-32 x 1/2" SHCS, SS	4.00
SC-014	Common	MWD	Screw, 6-32 x 3/4" SHCS, SS	4.00

Non-Serialized Part

Part Number	Size	Product Line	Description	Quantity
SC-015	Common	MWD	Screw, 4-40 x 1/4" SHCS, SS	2.00
SC-026	Common	MWD	Screw, 8-32 x 1/4" SHCS, SS	3.00
SC-028	Common	MWD	Screw, 8-32 x 1/8" SHCS, SS	4.00
SC-035	Common	MWD	Screw, 2-56 x 1/4" SHCS, SS	2.00
SC-037	Common	MWD	Screw, 6-32 X 3/8" Phil/Flat, SS	3.00
SC-058	Common	MWD	Screw, Set/Hole for Flow Sensor Plug	1.00
SC-059	Common	MWD	Screw, 2-56 x 1/4" Pan Head, SS	2.00

B.7 PULSER MAINTENANCE

PULSER MAINTENANCE

The following has been prepared as a guide in the event that it has been a while since the last Pulser was serviced. This guide is not meant to be used by someone not familiar with the QDT Pulser.

Prior to starting to work on a tool a Pulser Inspection report should be available and a physical inspection of the tool should be done.

This would include:

1. Note the condition of the outer tubes noting any damage or erosion to the tool.
2. Check the compensator membrane with a ball driver to see if there is still a good oil fill. If the membrane is hard not swollen or collapsed on the carrier.
3. Remove the screens from the screen housing and note the condition of the bellows and
4. Put the Pulser on the Pulser Test Box and check the activation of the EFS and if the tool is pulsing.
5. Check on the job report and note the hours on the tool and any reports of a failure. If there was a failure there should be a failure report.

Once the preliminary inspection has been completed the Pulser can be disassembled.

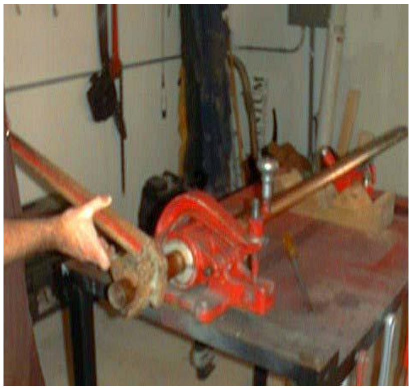
DISASSEMBLY OF PULSER

Step #1

Remove the lower end of the Pulser including the Helix End and the Poppet Housing. Note any cuttings alongside the shaft in the Poppet Housing. Note the condition of the Polypaks on the Piston Cap. Note any wear on the Piston Cap itself and inspect the erosion sleeve for wear.

Step #2

With all of the modules in the MWD**, it is imperative that the tool be disassembled from the top end.** Remove the Interconnect Housing using your Gearwrenchs. This will expose the Bulkhead which is held in place with two socket cap screws.



Step #3

Remove the screws and set the castle effects on top of each other. This will give you the desired space to free the 10 pin connector from the bulkhead. With the castles on top of each other, a large ball driver can be used to apply pressure to the 10 pin connector. Make sure the pressure is applied to the socket portion of the connector and not the pins to avoid damage to the pins. Once removed set the Bulkhead aside and remove the Split Shells and set these aside.

Step #4

Again using the Gearwrenches remove the Interhousing Module and set aside.

Step #5

Using the Gearwrenches break and remove the Driver Barrel and set aside. At this point the Pulser Driver will be exposed.

Step #6

Remove the four socket cap screws holding the Pulser Driver on the Snubber Shock and set the Driver aside. Inspect the Snubber Shock for any wear. The Snubber Shock is critical as this is the component that protects the Pulser Driver from vibration. The molding should be such that the brass pin does not make contact with the body of the Snubber Shock.

Step #7

Using the Gearwrench break the rest of the connections on the tool. Once this is done the oil fill portion of the tool will be ready for disassembly. Before taking the oil fill portion of the tool into the Tech Shop remove the Top Oil Fill plug and drain the oil. The Top Oil fill plug consists of the housing, pigtail, female Bebro and the snubber shock.

Step #8

Remove the Solenoid Housing and again drain any remaining oil. At this point the solenoid will be exposed. Wipe any remaining oil off of the tool and remove any loose Kapton Tape.

Step #9

Stand the Pulser up on the bench and remove the retaining ring that is holding the Male Bebro in place. This will free up the Male Bebro and it can be pulled loose. Be cautious that the wires are not stretched excessively. You may have to untwist the Solenoid wires in order to loosen the Male Bebro. Leave the Male Bebro hanging on the wires attached to the Solenoid.

Step #10

It will now be necessary to remove the Solenoid. Prior to doing this it will be necessary to remove the Servo Poppet Assembly. This will allow the Solenoid Shaft to drop down and expose a hole in the Shaft that is used to break the Solenoid Shaft free from the Spring Shaft.
Lay the Pulser down on tool stands to remove the Servo Poppet Assembly. The assembly can be removed most easily by removing the top two screws in the Poppet Assembly. This will allow the back shell of the Poppet Assembly to drop off. Pushing the Clapper on the Solenoid back or inserting a screw driver will allow the Servo Poppet Assembly to be easily removed and set aside.

Step #11

Set the Pulser in the upright position again and use a small Ball Driver in the hole in the Solenoid Shaft to break the connection between the Solenoid Shaft and the Spring Shaft.

Step #12

Once the above connection has been broken a small bladed screwdriver can be inserted into the center hole in the top of the Solenoid and the Solenoid Shaft unscrewed from the Spring Shaft.

Step #13

With the Pulser in the upright position remove the 3 screws in the legs of the Solenoid that screw into the Solenoid Cap. Remove the Solenoid and set is aside. Inspect the solder joints on the wires in the top of the solenoid that attach to the Male Bebro and the wire for any flattened or abraded areas.

Step #14

Remove the 5 screws holding the Solenoid Cap in place. The Cap should be held in place when the last screw is removed as there are springs that will push it off. Set aside.

Remove the 2 springs and 3 spacers from the Spring Housing and Wire Tube.

Step #15

Remove the Bottom Oil Fill Housing and set aside

Step #16

Remove the Compensator Housing. Invert the Compensator Housing and using the ¾" brass punch, remove the Compensator Carrier with the Membrane attached. Inspect the Membrane for any marks or cracks. Personally I usually only replace the Membrane every second time the tool is serviced unless the tool has been flooded or the wires are broken or badly worn.

Step #17

You should now have the Screen Housing along with the Wire Tube sticking up. Simply pulling on the Wire Tube should enable this assembly to be removed from the Screen Housing.

Step #18

You will now have the Screen Housing by itself. The only thing left would be to remove the Servo Orifice. There are set screws at the bottom of the lower holes that hold the Screens in place. Once the set screws have been removed the orifice can be knocked out using the 3/8" ball driver from the lower end. Inspect the seat for the Orifice for any erosion.

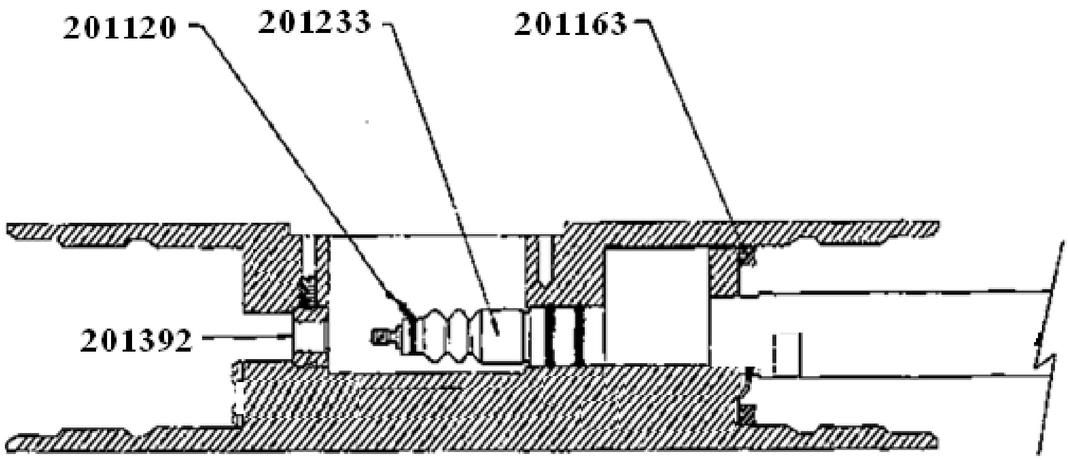
Step #19

Clean up all parts in preparation for re-assembling the Pulser.

ASSEMBLY OF PULSER

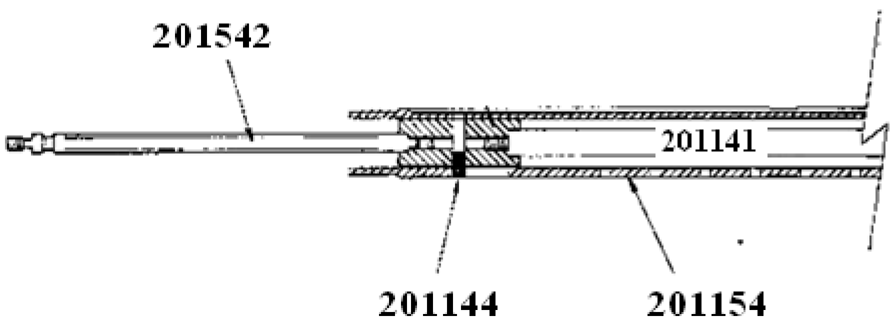
Step #1

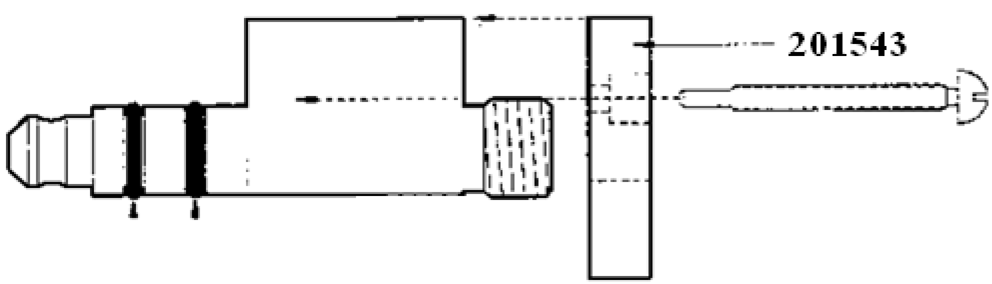
Re-install the Servo Orifice (201392) and hold in place with the Set Screws inserted into the lower holes that hold the Screens on the Screen Housing.



Step #2

Wire Tube (201154) and Spring Tube Assembly (201141, & 201542). Make sure that the Alignment Screws (201543) are seated into the holes in the Screen Housing.





Step #3

Install the Spacer (201163). This is normally simply dropped in place with the Screen Housing in the upright position.

Step #4

The next part to be attached is the Compensator Housing. This includes the Carrier and the Compensation Membrane. The Compensator Membrane is held in place by Tie Wire with two bands with a double wrap on each end.


Step #5

The Oil Fill Housing is attached next and is simply screwed into the Compensator Housing.

Step #6

The next step is to insert the springs and Spacers into the Wire Tube. The normal configuration is to drop in a Short Spacer in followed by a spring, the Long Spacer, a spring and then a Short Spacer. The last Short Spacer will be protruding from the Wire Tube.

Step #7

The Coil Housing is next attached. This is held in place with five Phillips screws and the Coil Housing must be held in place depressing the springs while the Phillips screws are put in place. Loctite should be applied to the screws before they are put in place.

Step #8

The Solenoid is next attached. This is done using three Phillips Screws and again Loctite should be applied to the screws. This is done with the Pulser in the upright position and the wide leg must fit into the wide slot in the Coil Housing.

Step #9

With the Pulser still in the upright position the fine bladed screw driver is inserted into the center hole in the top of the Solenoid and the Solenoid Shaft is screwed into the Spring Shaft.

Step #10

The next step would be to tighten the Solenoid Shaft to the Spring Tube. This is done using a small Ball Driver that is inserted into the hole in the Solenoid Shaft. Tighten until you get a good flex in the Ball Driver when it is held at the end.
Once tightened you should check for a gap between the shoulder on the Solenoid Shaft and the Clapper. If there is a space you will hear a double click effect when the tool is pulsing. Very often this can be reduced through the use of a Belleville Washer on top of the Spring Shaft.

Step #11

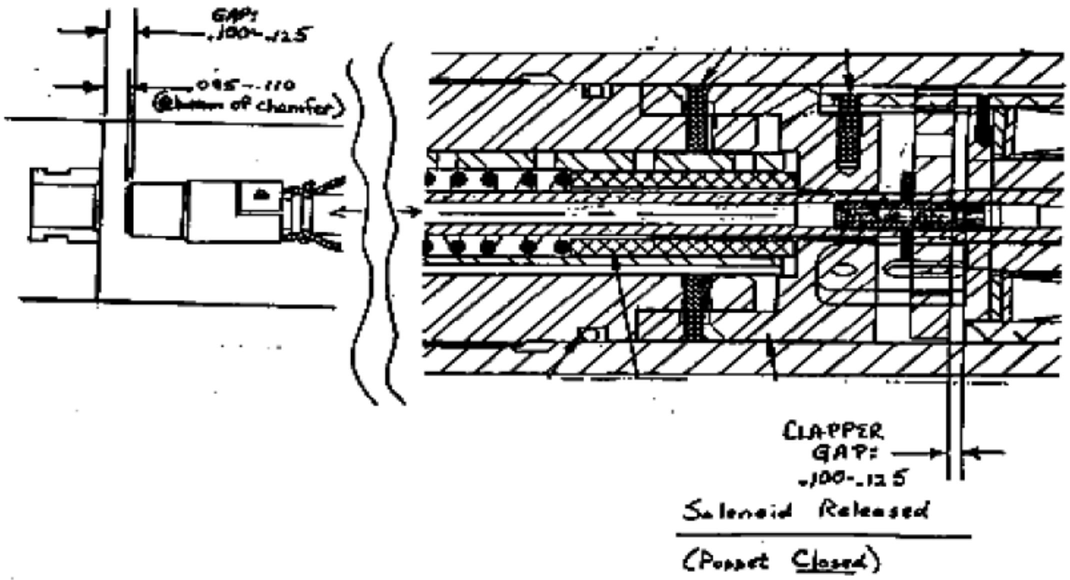
Lay the Pulser down on a couple of tool blocks for the next couple of steps. Installing the bellows is the next step. Install the Tie Wire on the upper end of the Bellows using Tie Wire Pliers.

Step #12

Installing the Tie Wire on the lower or small end of the Bellows is the next step. This should be done with the Bellows Shaft retracted. The easiest way to do this is by inserting a screwdriver between the Clapper and the Coil Housing. This should position the Bellows Shaft such that the end of the bellows matches the shoulder on the lower end of the Bellows Shaft. Install Tie Wire using the Tie Wire Pliers.

Step #13

The next step is to install the Servo Poppet Assembly. By backing off the two upper screws as much as possible the Servo Poppet Assembly can normally be installed as a single unit. Once in place remove the screwdriver between the Coil Housing and the Clapper. This will align the Servo Poppet Assembly and hold it in place. The gap has to be set so only lightly tighten the two screws.



Step #14

The next step is to adjust the gap between the Servo Orifice and the Servo Poppet. The best way to do this is to insert the appropriate size of Ball Driver (0.100 – 0.110") between the Clapper and the Solenoid body and then screw the Servo Poppet Assembly down until the Ball Driver is held tight between the Clapper and the Solenoid body.

Step #15

Once the gap has been set the screws should be tightened to maintain the setting. The next step would be to remove each of the screws in the Servo Poppet Assembly, one at a time, put Loctite on them, re-install them and tighten well.
At this point the connections on the Bebro should be checked using your Multimeter. Instructions on doing this inspection or quality control check are in the next section.

Step #16

With the Pulser in the upright position, insert the Male Bebro into the top of the Solenoid. It has to be aligned so that the slot in the housing of the Male Bebro matches the Dowel Pin. In order to avoid damage to the wires the three wires should be pulled out of one of the holes in the side of the Solenoid. With the wires pulled out the Bebro should seat well and the Retaining Ring can be installed holding everything in place. There is a Split Spring that fits below the Bebro and which holds the Bebro tight against the Retaining Ring.

Be cautious when pulling the wires out of the holes in the side of the Solenoid to avoid pulling them out of the Solenoid or damaging the solder connections. Once the Bebro is in place and held there by the Retaining Ring the wires can be pushed back inside of the Solenoid.
Again check the connections to the Bebro to ensure that no damage to the solder connections has occurred while stuffing the wires back into the Solenoid.

Step #17

The Oil Fill Housing can now be attached. Normally this will screw on without a problem. Once in a while it will seem tight which is the result of the solenoid being a little miss-aligned. By simply knocking the side of the Oil Fill Housing the Housing should be able to screw into the Lower Oil Fill Plug without a problem.

Step #18

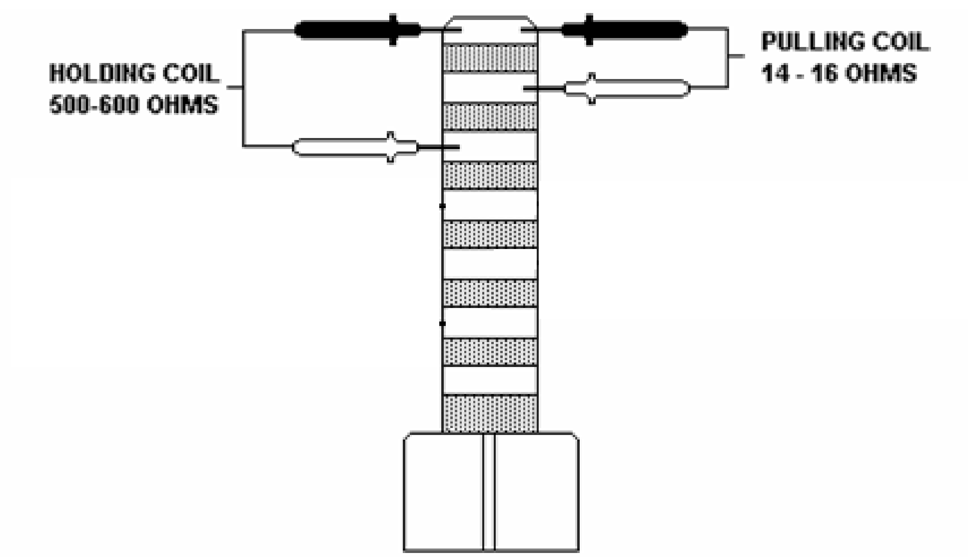
Install the Top Oil Fill Housing on the Assembly and tighten all of the connections. Again check the connections in the assembly at the MDM. the EFS should also be checked at this point. The instructions for doing this are in the next section.
You are now ready to do an oil fill on the assembly.

PULSER WIRING FLOW SWITCH CHECKS

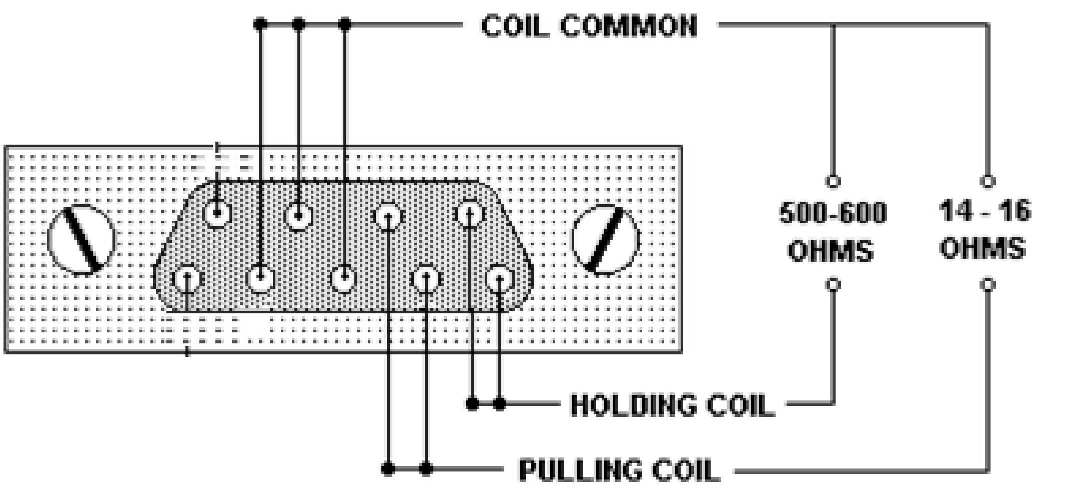
1. Solder, clean with alcohol then shrink wrap wires between the Male Bebro and the Solenoid using the following as a guide.

	BEBRO	SOLENOID	COMPONET
1	Black	Black (2)	Coil Common
2	Brown	Top White	Pulling Coil (Top/Center)
3	Red	Red	Holding Coil (Bottom/Side)
4	Orange	N/A	Not Used
5	Yellow	N/A	Not Used
6	Green	N/A	Not Used
7	Blue	N/A	Not Used

2. After soldering and assembling the Bebro to the Solenoid it is important to check for the proper readings.
3. Use the Ohm Meter set on ohms to check the Bebro contacts as shown below.



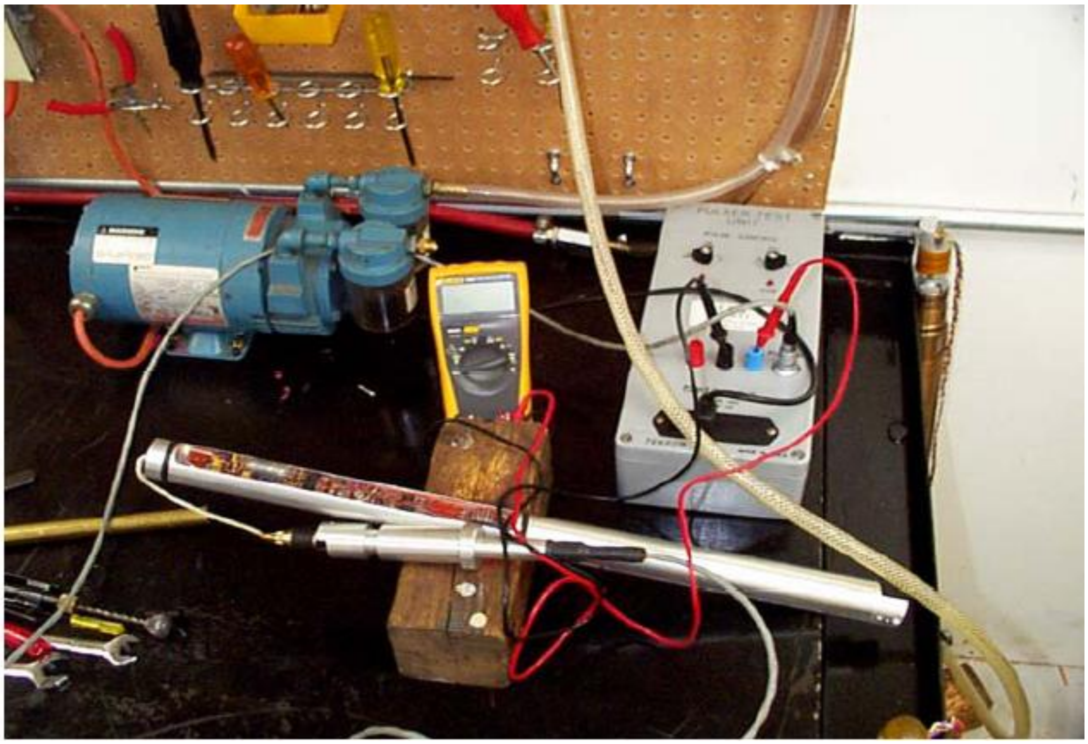
4. The coil readings may vary slightly.
5. Complete the assemblies of the oil fill section.
6. Prior to taking the time to do an oil fill it is recommended that the following test also be done. This may save having to redo the oil fill if the pigtail and bulkhead happened to be bad.
7. Use the alligator jumpers along with a little tie wire to test the connections on the MDM.
8. Readings should be as below.



Electronic Flow Switch (EFS)

Once a tool has been built up prior to doing the oil fill our using an EFS Pulser driver the activation of the switch needs to be checked. The procedure for checking the EFS is as follows:

1. Plug the Pulser Test Box into the top of the assembled Pulser. Note on the photo below we are connecting to the driver by itself but this is accomplishing exactly the same thing.
2. Turn the main power supply switch on the Pulser Test Box to “on”.
3. Turn the Pulser rate switch (upper left) to “off”.
4. Using an ohm meter, attach the black contact to the ground line – see the picture below.
5. Set the ohm meter to read volts DC.
6. A reading of 0.25 v should be observed. This means the switch is turned off.



7. Tap on the Pulser or driver (if referring to the picture above) and the voltage reading should change to about 5 volts. This means the switch is turning on.

8. When you stop tapping or inducing vibration the voltage reading should return to about 0.25 volts.

IMPORTANCE OF THE OIL FILL

OIL FILL PROCEDURES

Important

I cannot overstress the importance of the oil fill to the performance of this MWD. The only people who have been successful with the tool are those who have taken the time to understand the importance of the oil fill, why it's important and how it can best be done.

History:

When this MWD came onto the market the first place it was run was in Canada with Ryan. Canada has some of the most MWD friendly drilling conditions that exist in the world. The holes; especially those that the tool was used in, are shallow, the muds close to water or at least have very low solids and are not hot. The tool worked in Canada fairly well for a number of years once the problems with tolerances and the settings on the vacuum switch were somewhat resolved.

In areas with deeper drilling, high temperatures and high solids muds, getting the tool to work was a hit and miss situation. The old vacuum switch got blamed for most of the problems and with the introduction of the EFS the manufacturer thought they had solved the problem. Unfortunately this did not turn out to be the case although at shallower depths the failure rate did drop significantly.

However, with depth the tool continues to experience failures. These failures and those with the Vacuum switch can almost all be attributed to a bad oil fill. Those who have not identified the problem with the oil fill; including the manufacturer, continue to have problems with reliability.

The following procedure is the basics and is based on using the kit that I normally send out with a new purchase or lease. The kit is fully assembled on a peg board to speed up the process of getting started. This pre-assembly is done to minimize the time from receipt of tools till you have an operating Tech Facility.

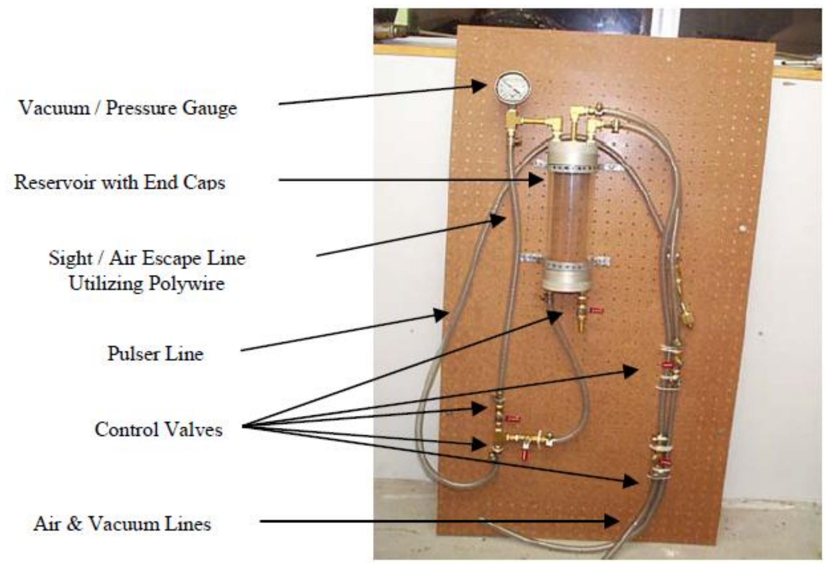
Shown below and to the right is an Oil Fill kit typical of what is shipped to the field. Not shown are the vacuum pump and a means of pressuring the system. It should be noted that there are operators out there doing very well without the pressure part of the package. If set up properly a gravity feed is sufficient to get good oil fill.

Features

1. **Pre-assembled**
2. **Polywire Tubing**
3. **Large (3/8") ID Tubing**
4. **Large Reservoir**
5. **All Brass Valves**
6. **All Brass Fittings**

Notes

There are a large number of oil fill units currently in use that use a small ID tubing that will collapse with vacuum. This makes a good oil fill difficult.



EQUIPMENT & PROCEDURES

The system shown on the bottom of the previous page is, as was mentioned, not complete. On this page is the Oil Fill System as set up in Compass' Tech Shop. On the picture below I have indicated those items that are required in addition to the basic kit.

Included are:

1. The vacuum pump
2. A Pulser test box complete with cables
3. A communications to go from the oil fill portion of the Pulser to the driver. The driver used in this case can be either EFS or Mechanical (vacuum).
4. A block of wood on which to tap the Oil Fill portion of the Pulser.
5. Ground supports or "V" blocks on which to rest the tool.

The oil fill system remounted on a larger peg board. This is a shop set-up that accomodates the needed tools

This is the vacuum pump. This one is mounted on the bench and above and left is a switch to turn the pump on and off - recommended

This is the Pulser Test Box. The Test Box is hooked to the Pulser via the driver and communications cable

Though hard to see, this is the braided communications cable. This is essential as the pulser needs to be pulsing during the oil fill process.

Oil Fill portion of Pulser

Though unimpressive the "Tapping Block is almost essential for a good oil fill. You will go through a few.

Some important pointers when setting your system up in the shop or elsewhere are as follows:

1. The sight tube that goes from the main valves to the top of the reservoir is more important than one would first think. This tube will allow the air coming out of the Pulser to go to the top of the reservoir without having to go through the oil. As you will see from experience when a bottle is newly filled it can take a few hours to get the air out of the reservoir and oil it contains. By routing the air out of the Pulser to the top of the bottle we are minimizing the aeration of the oil.

2. The tubing that is used is called Polywire and will not collapse with vacuum. This 3/8” tubing is used throughout the system. The exception is right at the oil fill plug where the design dictates the use of ¼” tubing. Here we usually use very heavy walled clear tubing that again will not collapse with the vacuum. This short portion of clear tubing also lets us more easily see the bubbles as they come out of the Pulser.

3. The height of the oil reservoir is also critical. During the oil fill process the Technician must be able to raise the Pulser to a level equal to or above the top of the reservoir. This process greatly facilitates removal of air from the system.

4. Ideally the height of the system or the length of the Pulser line will be such that the Pulser can be rested in a horizontal position on ground supports of some kind.

5. The system should also be designed such that the Pulser can be stood up in a corner; both in the upright and inverted position. If this is done it should also allow the Technician to bounce the Pulser on the “Tapping Block” on the floor.

6. As mentioned a pressure system is not crucial to a good oil fill. However, I do use air, other systems have been rigged up with a simple foot pump, others utilize a pump and some rely on strictly gravity.

Getting Started:

The steps involved in getting started, once the system has been set up as outlined in the previous section are as follows:

1. With all of the valves in the closed position start up the vacuum pump. Once running open the valve for the vacuum line going from the pump up to the top of the bottle. Your gauge should register about 24 – 28 PSI of vacuum. This is dependent on your elevation. Close the valve and shut off the pump.

    1. Hopefully your system will hold the desired PSI of vacuum. If not try to locate the leak and tighten the connection as needed. Sometimes these leaks are easier to locate when the
    system has oil in it.

3. Filling the reservoir can be accomplished with either the Pulser line or a line coming off the bottom of the reservoir can be used. Insert either line into your oil bottle. When the line is in the oil slowly open the appropriate valve. The valve will be dependent on the line being used. If coming off the line in the bottom of the reservoir this would be the valve to open. If using the Pulser line, open the valve going from this line to the bottom of the reservoir. You should barely have to crack the valve. Regardless how careful you are I expect that you will end up with a lot of bubbles.

4. Keep the valve open until the reservoir is about ½ - 2/3rds full of oil. When at this level close the valve, drain the hose in your oil bottle and recap and put the oil away.

5. Start the vacuum pump again, open the vacuum line and ensure that you have a good vacuum. Close the valve again and shut off the pump. Observe the system for any leaks and repair as needed. As mentioned you may get a lot of bubbles out of the reservoir for the first half hour or more. This is a function of the aerated oil plus the surface tension of the oil that we discussed earlier.

6. Once you have gotten the air out of the system and fixed any leaks so that the system will hold a vacuum; without losing any vacuum for an hour or so at a minimum, you are ready to start working on the oil fill of a Pulser. It should be noted that normally getting the air out of the system is only needed after filling the reservoir. The first time will take a while due to the surface tension between the oil and the reservoir.

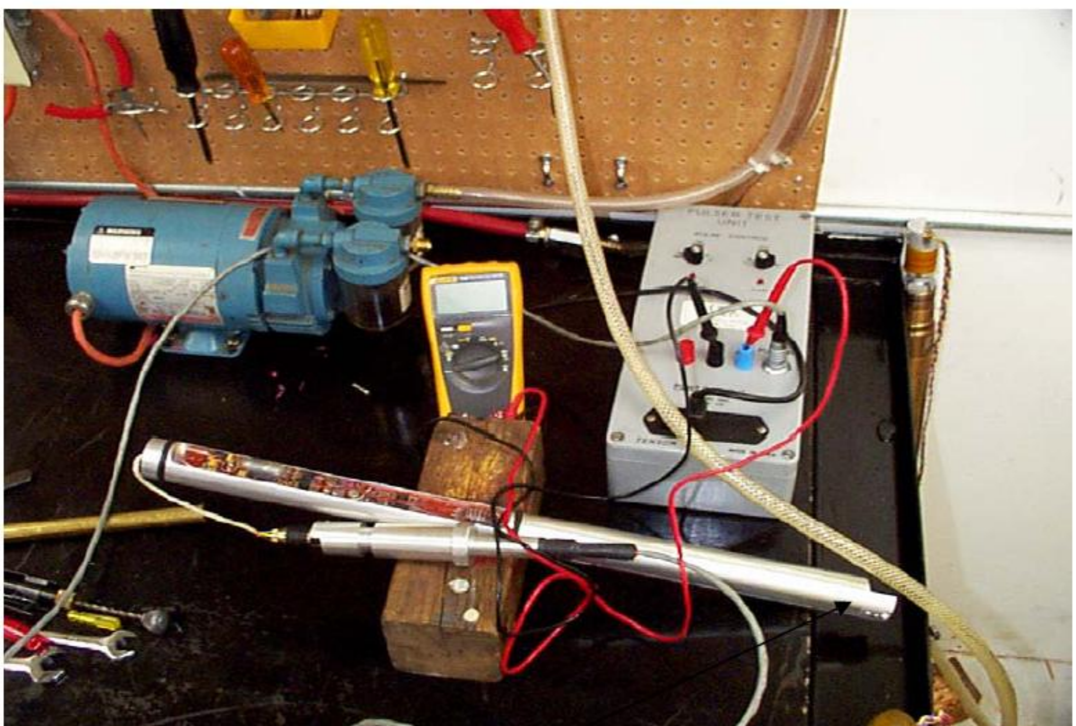
Performing an Oil Fill

Setting Up

1. I have found that the oil fill is more easily done using the oil fill port on the bottom of the tool versus using the oil fill port on the top of the tool.

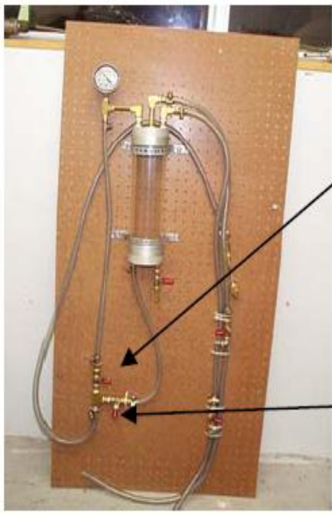
2. With all of the valves closed, attach the Pulser line to the lower port of the oil fill section of the Pulser. This connection should be tightened by hand.

3. Connect the communications cable to the Pulser and the Pulser driver as is done when checking the activation of the EFS. The picture on the next page shows the basic configuration with the exception of the communications cable going from the Pulser Driver to the Oil Fill portion of the Pulser.



Attach the Communications Cable here and to the top of the Pulser

4. With all of the valves closed turn on the vacuum pump, open the vacuum line and build up a vacuum in the system. Once you have a vacuum the valve for the line to the sight tube can be opened. Open it slowly and very little at first to get the first bunch of air out of the system without aerating the system too much.



This is the valve that should be opened only a little and very slowly. You can expect to initially see a lot of air coming out of the lines and pulser. This should settle down after a few minutes.

This is the valve that is to be opened in Step #6 on the following page. This will allow the lines to fill and put the oil down to the pulser where it will be drawn in.

5. Some people recommend keeping the vacuum on for about 15 minutes before starting the fill. I have not found this to be that beneficial. Once the initial vacuum has been taken, the pump can however be run on a continuous basis for the first 15 minutes while getting the first bunch of air out of the system. At this point the Pulser would normally be on ground supports in the horizontal position. This way any oil in the lines should be pulled into the Pulser.

6. Open the valve between the Pulser line and the bottom of the reservoir. When opened the lines down to the Pulser on the ground stands should fill up with the air in the line going up the sight line. This valve is shown on the picture on the bottom of the previous page.

7. When you think there isn't really any air coming out of the Pulser pick it up and raise it above the reservoir as shown in the picture below. You should see all kinds of air come bubbling out. When doing this, try to hold a loop in the lines as indicated. When the Pulser is lowered; and the air bubbles kept in the loop, this will prevent the air from going back into the Pulser.

8. Raising and lowering the Pulser for the first 15 – 30 minutes should get you to the point where it is harder to get bubbles to come out of the Pulser. During this time the vacuum pump can be started then the valve opened to maintain a good vacuum. The pump should not have to be run on a continuous basis if you don't have any leaks. Do however maintain a good vacuum.

This is the loop that needs to be maintained when the pulser is raised

9. If not mentioned earlier, the Pulser should be pulsing almost continuously while trying to get the air out of the system. This together with the air being expanded and contracted via the raising and lower of the tool helps to get the air to move by some of the tight tolerances and out of the Pulser.

10. Normally it will get more difficult to get the air out after a few hours. There are a number of things that can be done to encourage the air to move by the tight tolerances. Included would be the following:

a) Stand the Pulser up in a corner while pulsing. In the picture below the Pulser is setting on the "Tapping Block". After letting it sit for a while, hopefully to let air migrate toward the top, the Pulser can be tapped and then raised.

b) The next time I needed a break I may set it up the other way; bottom up. Do not tap the tool on the up hole end as you may damage the snubber shock

Communications Cable

The pulser in the upright position with the communications cable attached to the top and the oil fill plug in the lower port.

The “Tapping Block” is used on a regular basis. Note the damage to the block. This is an indication that the tapping is rigorous.

c) You may want to rig up a shelf to set the Pulser on when in the raised position. It is typical for the air to start to come out just when you don’t think your arms or shoulders will allow you to hold the Pulser in the raised position a second longer.

d) As was mentioned the deeper the well that the tools will be used in the more diligent you must be in getting all of the air out of the tool.

e) The tool can be considered done when after sitting in the upright position, being “Tapped” vigorously, then raised and held in the raised position for a number of minutes and you don’t get any bubbles.

f) I did not mention earlier that once or twice during the process I will release the vacuum and let the tool pulse in the up right or inverted position. My reasoning for this is that air may be trapped below the compensator membrane; which is fully compressed when on vacuum, and this may let some air migrate upward.

g) Another thing not previously mentioned is that early in the evacuation process I normally pressure the system up to about 30 PSI and hold it for a few seconds. This is to ensure all of my tie wires are sealing the system and I have no holes in the diaphragm, compensator membrane or bellows.

Finishing Up

When I cease to get any air out of the system I have another procedure for finishing off the oil fill. Although some people do not like to have positive pressure in the system, I personally like a little pressure.

My process is as follows:

a) When done with the oil fill I put the Pulser on the ground supports, pressure the system up to 30 PSI again and hold it for a few seconds.

b) I then release the pressure and let it bleed back down to “0” PSI.

c) The next step is to remove the oil fill plug.

d) Within about 5 seconds of removing the plug; during which I hang up the Pulser fill line, I like to have the plug in place. You will get a little leakage during this time.

e) The last step is to use a ball driver (dull point) and feel the tautness of the compensator membrane. I like to be able to feel a nice spongy resistance when it is pressed on gently.

f) Attach the driver to the oil fill section; install the pressure barrel, bulkhead, etc.

g) Perform a test of the activation on the flow switch as previously explained.

h) Mark on the outer tube the date the fill was done.

i) Complete the Maintenance Report for that particular Pulser and file by asset number.

j) Green tag the Pulser and put on the “Ready” rack or into the appropriate Kit.

Hopefully you have been able to stay with me through this long dialog. I think that if you took the time to read this once and you have done a few oil fills on your own, you will appreciate the time spent on this important aspect of servicing the tool.
If this process or your version that accomplishes the same, results in a few good runs you will be a believer. Good Luck!!

Compass Stepper Positive Pulser

The tool is fully retrievable and replaceable, which saves rig time by eliminating pipe trips for directional equipment.

Compass Positive Pulser generates a sequence of pressure increment pulses in the circulating system enabling the transmission of MWD data recorded downhole to surface.

Description

The Pulser Module consists of 3 main sections: Pulser Drive, and Oil Fill Section and a helix end.

The Pulser allows mud flow to be restricted creating a pressure differential by way of a main orifice poppet/orifice assembly. The movement of the main poppet in and out of the orifice creates an increase in pressure. The two factors that greatly affect poppet movement are the operation of the electrical section of the module and the fluid pressure on the compensation membrane.

Features

- Temperature option up to 350°F °(175°C)
- Simple to operate under a wide range of flow rates from 35 to 1100 gal/min
- Operable in lost circulation material concentrations of 50 lbm/bbl medium nut plug
- Servo technology for faster data rates, stronger signal and superior ant jamming capabilities for reliable data transmission in difficult drilling

Specifications

UBHO Sub O.D.	3.5 To 9.5in, (larger on request)	89 to 241mm
UBHO Sub Length	40in (longer on request)	914mm
Minimum Flow Rate	35 US gals/min in water	8 l/sec
Maximum Flow Rate	1100 US gals/min in water	67 l/sec
Temperature	175ºC	350ºF
Hydrostatic Pressure	Maximum 20,000 psi	137.9MPa
Operating Voltage	20-29V	
Nominal Current	12mA	
Shock	1000g/0.5millisecond	
Vibration	25g RMS 30-500 Hz Random, 30g 50-300 Hz Sine	
Mud Sand Content	Less than 1% recommended	
Lost Circulation Material	Up to 50 lb/bbl premixed Medium Nut Plug or Cedar Fiber	

C. - PULSER STEPPER MOTOR STYLE

C.1 MANUFACTURING PROCEDURE

PULSER MODULE (COMPASS STEPPER)

C.1 MANUFACTURING PROCEDURE

PULSER MODULE (COMPASS STEPPER)

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OVERVIEW

The Pulser Module allows mud flow to be restricted creating a pressure differential by way of a main poppet/orifice assembly. The movement of the main poppet in and out of the orifice creates an increase in pressure. These pressure changes translate into pressure pulses. There is a series of events that controls the movement of the main poppet in and out of the orifice. The two factors that greatly affect poppet movement are the operation of the electrical section of the module and the fluid pressure on the compensation membrane.

The Pulser Module consists of 3 main sections: a Pulser Driver, an Oil Fill Section and a helix end.

PULSER DRIVER

The Pulser driver contains a capacitor bank and a control circuit. In its simplest form, a capacitor bank is a battery that can charge and discharge quickly. The 28 volt battery in the tool string supplies the electrical energy required to charge the capacitor bank. The capacitor bank in turn discharges the electrical energy required to energize the stepper motor. The second component of the Pulser driver is the control circuit. It is responsible for the encoding of the data from the directional module and the power from the capacitor bank and transferring it to the stepper motor. As a result, the control circuit can be considered to have a series of logic; however, it is not a computer.

A picture of the Pulser motor driver is shown below. It is a combination of a Pulser control board and a capacitor bank, which are placed inside a chassis carrier and encapsulated with sylgard. One end has a 15 socket MDM, which attaches to the motor section; the other has a 6 pin Kintech style connector.

OIL FILL SECTION

The oil fill section contains a stepper motor. The motor is attached to a shaft that, in turn, is connected to the servo poppet. Fixed to the shaft is the compensation membrane.

Initially, the directional module creates an electrical signal that is transmitted to the control circuit. The control circuit sends a message to the stepper motor. The capacitor bank then energizes the motor. The motor pulls the shaft attached to the servo poppet The servo poppet is now in an open position. The pull force requires a large energizing charge, supplied by the capacitors in the Pulser driver. The capacitors discharge to the stepper motor. When the stepper motor is de-energized, the return springs drive the shaft and servo poppet back to the closed position.

MECHANICAL ASSEMBLY

NOTE:

In the following it should be noted that the single biggest difference between the standard (Tensor style) and the latest version of the Compass Pulser is that the disassembly of the oil fill section is done from the bottom rather than the top.

Significant changes that have been incorporated include:

1. The poppet tip on the end of the servo assembly has been a headache from day one. This component has gone through a number of changes from the original version. Included were:
    a. The original tip was subject to erosion and if this was not a failure mode the screw was soldered in and this would either fall out or break off.
    b. We then went to a high grade carbide tip with a shoulder on the ID. We used a 6-32 screw to attach the tip to the ball screw shaft. The head of the screw tended to erode so we moved it further back. This helped but then there were still issues with the screw breaking off.
    a. We then went to the current design with a shrink fit carbide tip inside a steel body. The first version used a high carbon steel that was subject to corrosion in certain muds. Short term we went to a nickel coating that solved most of the problems.
    b. The latest batch of tips we went with a BeCu body that hopefully should eliminate all of the problems seen in the past. We did however reduce the body length to open up the area around the orifice.

2. On the old shaft mild steel was used. A fairly common failure mode was for the shafts to bend at the polypac groove. On the new shaft we have shortened the shaft and used a high grade steel as a sort of saver sub. Typically this is a retrofit item implemented when a shaft comes in bent.

In the original tools we had a single bearing. We found that the bearing being used could not handle the loads and was also a mode of failure. The first retrofit was to add a second bearing. After an engineering review it was discovered that this did not make the improvement desired. The new design goes back to a single bearing but one that is larger and easily able to handle the loads.

Look at tool's history, checking for earlier problems and the tool's operating hours. Also, connect the pulser to a test box and ensure that the FLOW indicator light is "ON". Tap pulser for flow switch function.

Check Force.

Loosen all joints on pulser. Remove screen housing.

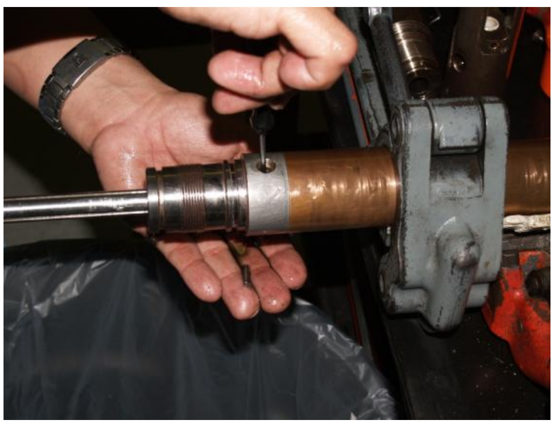
Then remove the next housing, the compensator housing.

Remove the compression spring from the pulser shaft.

Remove the compression spring from the pulser shaft.

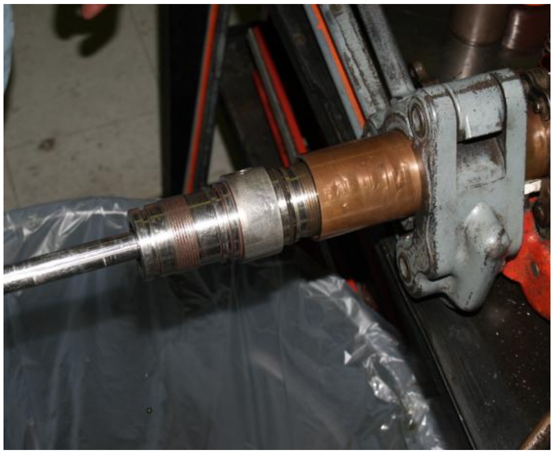
Remove the loctite from the set screws with a punch or chisel.

Remove the set screws.



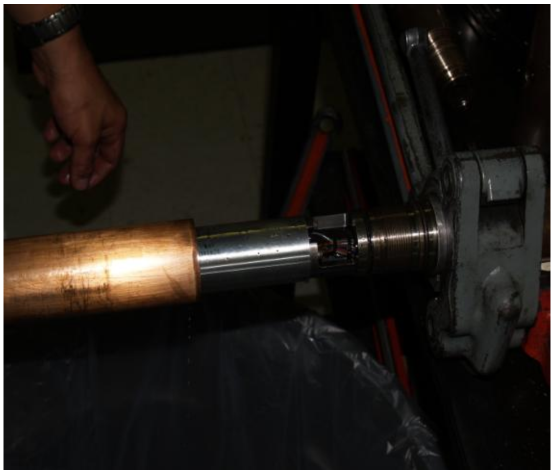
Remove the Locking Pin.

Using the Gearwrenchs to loosen the connection.



Remove the Ball screw housing and set aside.

Using the Gearwrenchs break the Stepper Motor Housing.



Remove and set the Motor Housing aside.

At this point the Stepper Motor will be exposed.

Use a small Allen wrench. Remove the four socket cap screws holding the bearing mount.

Set the Ball Screw Pulser Shaft Assembly aside.

The gear housing

Inspection.

Remove the screws in the legs of the gear housing that screw into the stepper motor.

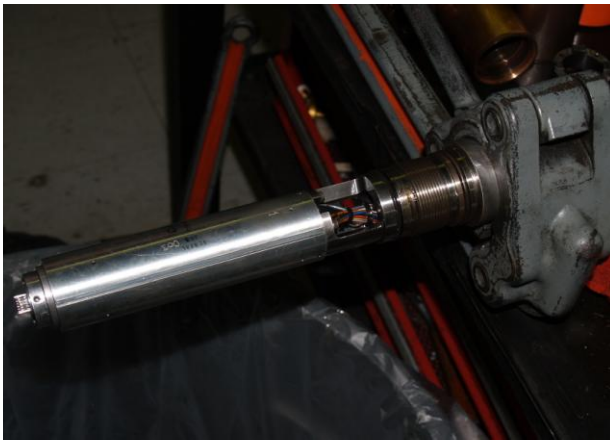
The set screw in the Lock Nut will need to be loosened using an Allen Wrench. The screws on the shaft nut are loosened so it can be removed.

Use a screwdriver to gently pry off the Cap

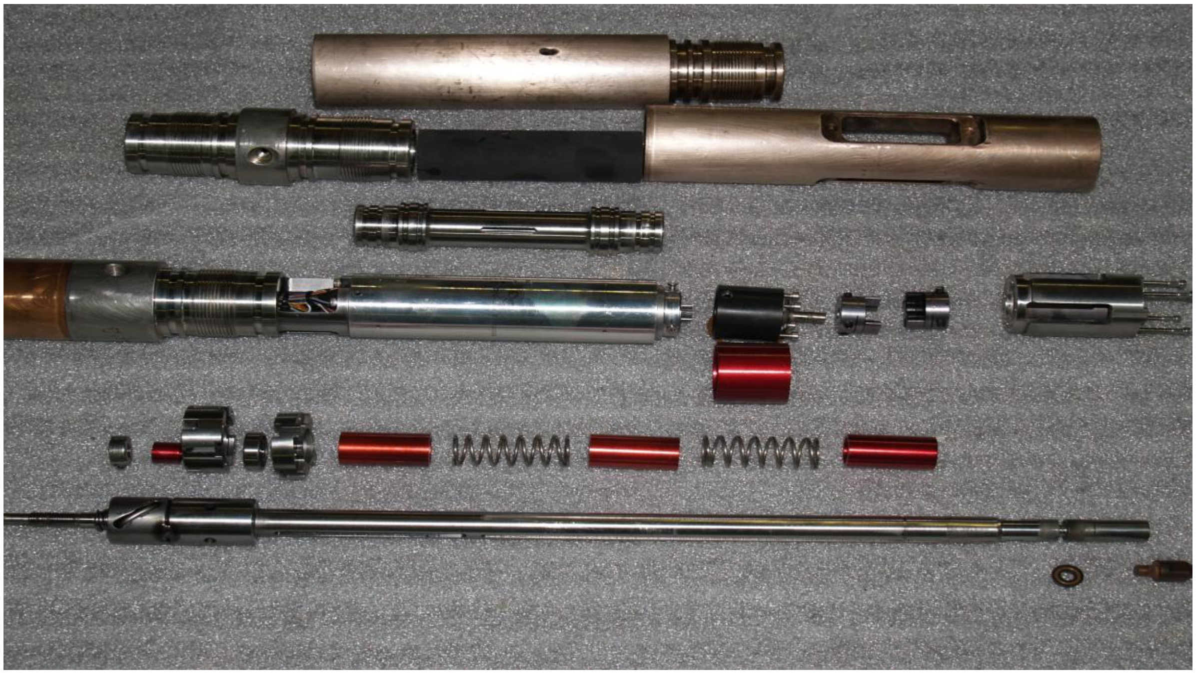
You can now access the gear box.

Carefully remove the gear box.

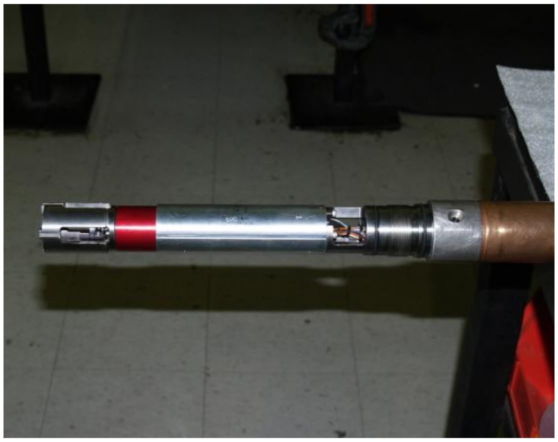
Inspect the gear box for damaged gears.



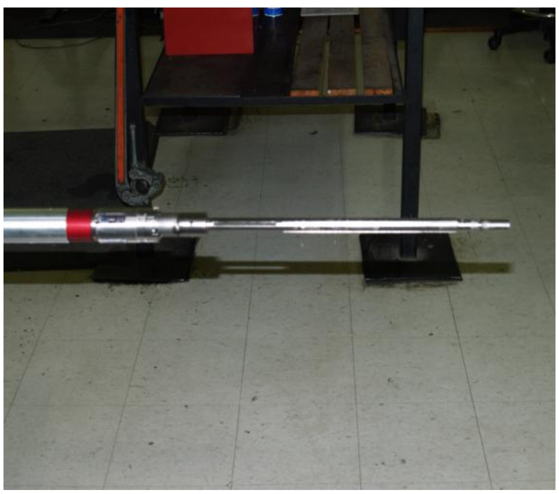
This is the Stepper motor.



These pictures illustrate all the current components of a Compass Pulser.



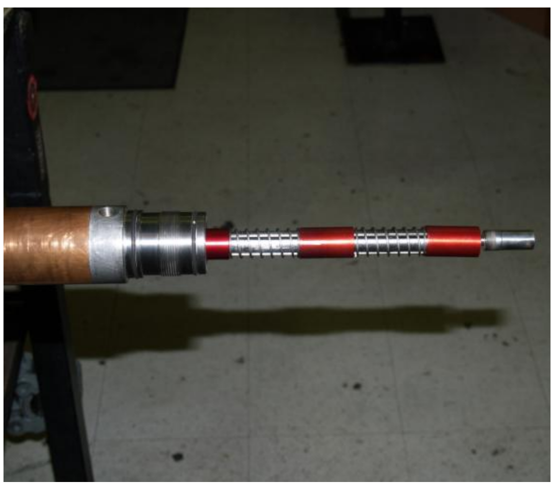
Replace the spacer and Drive Cap.



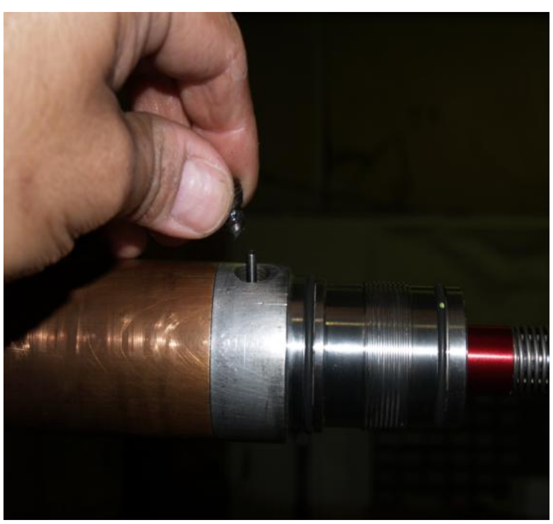
Ball Screw Pulser Shaft Assembly is reinstalled next.

Attach the Housing for the Compass Pulser Motor.

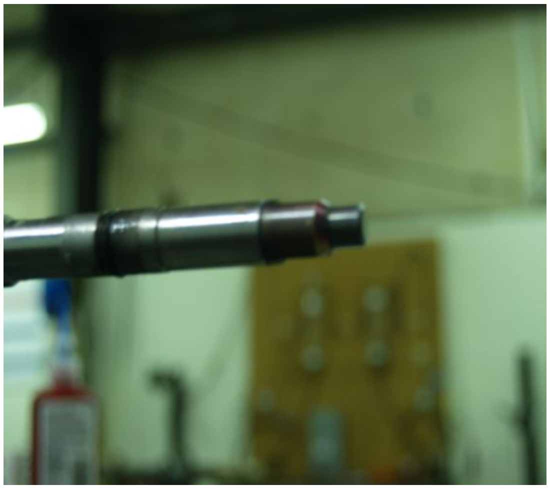
Mount the Ball screw housing over the Pulser shaft.



Replace the springs and spacer by sliding them back on the Pulser shaft.



Insert the pin and lock screw.

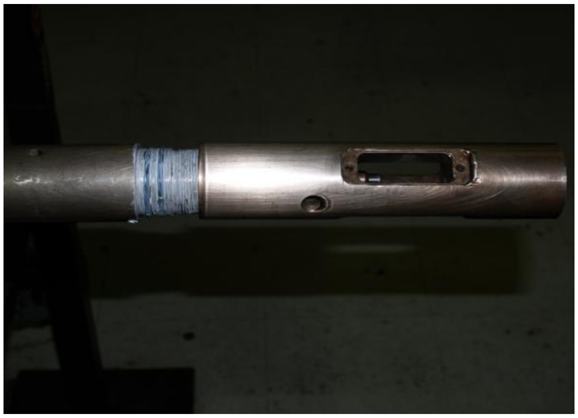


Install the Servo-poppet tip.

Picture of compensator housing and screen housing. With a compensator and membrane below

Here is a picture of a compensator housing with the compensator already installed.

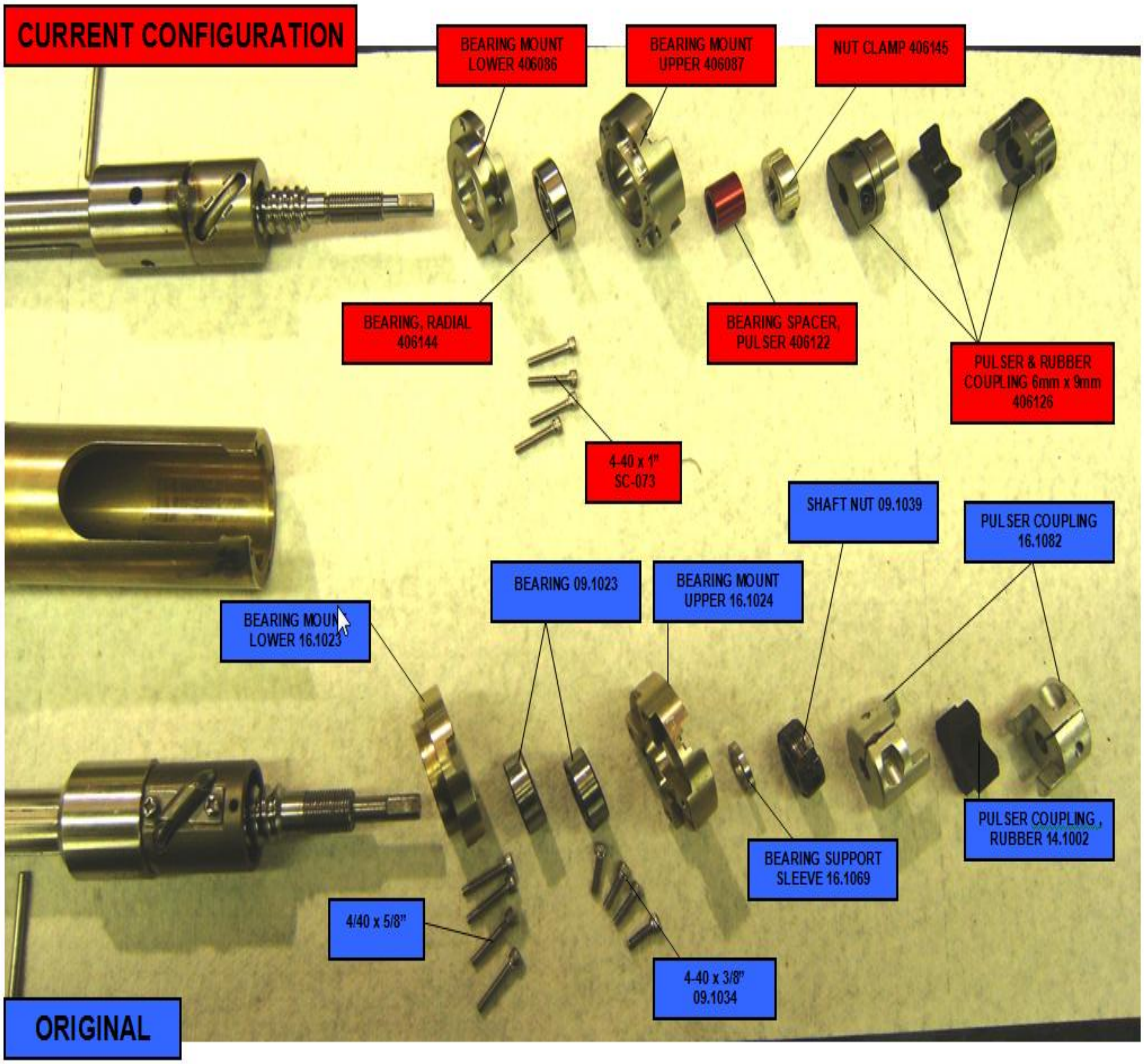
The entire compensator assembly is then added to the pulser.



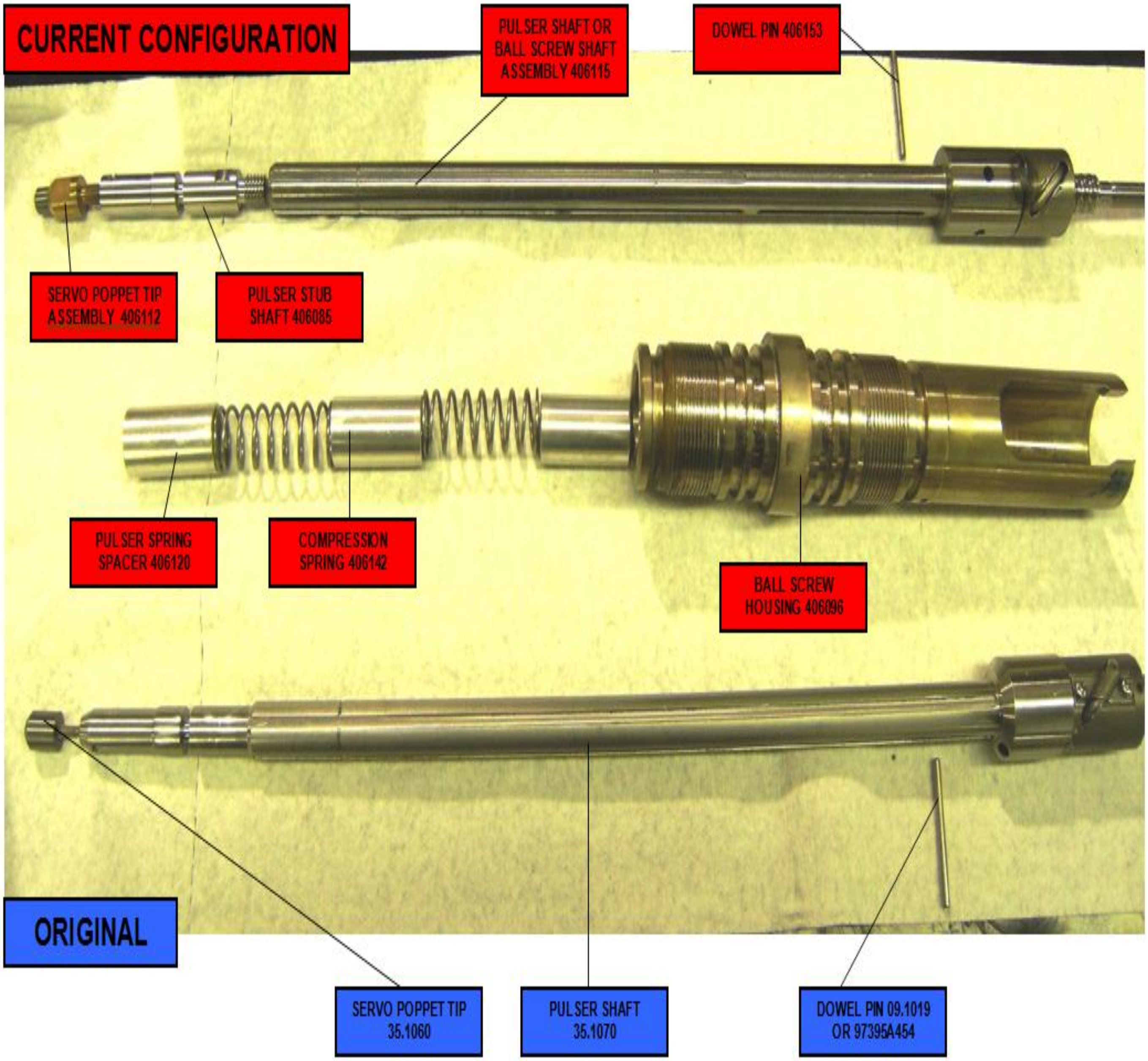
Followed by the screen housing.

Here the screens are installed along with the lock screw.

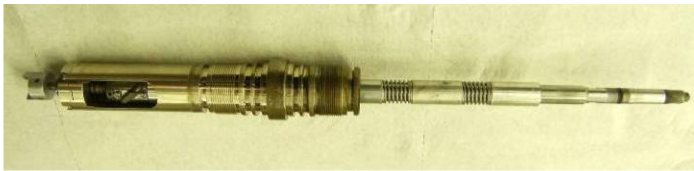
Compass Stepper Pulser Upgrade



UPPER ASSEMBLY

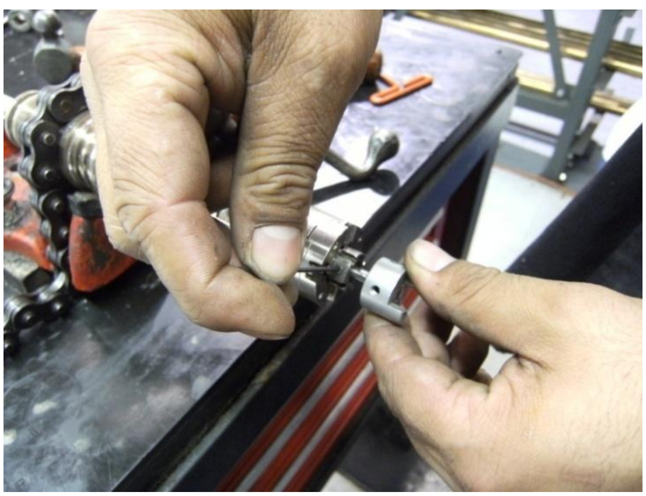


LOWER ASSEMBLY



Shown to the left is an earlier version of the Ball Screw Pulser Shaft Assembly still inside the Ball Screw Housing.

On the lower end which is shown protruding below the Ball Screw Housing Assembly above, remover the Spacers and springs by simply sliding them off of the shaft

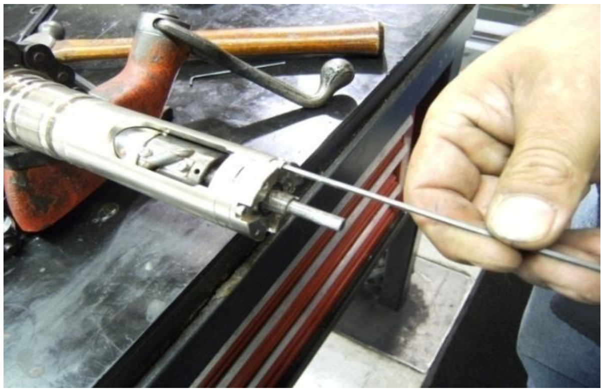


On the upper end of the Ball Screw Assembly the set screw in the Lock Nut will need to be loosened using an Allen Wrench. The screws on the shaft nut are loosened so it can be unscrewed.

Once the set screw has been loosened unscrew the lock nut with pliers while keeping the shaft from rotating with a wooden stick in the lugs on the coupling. The coupling is Aluminum and using the wooden dowel will avoid damaged.

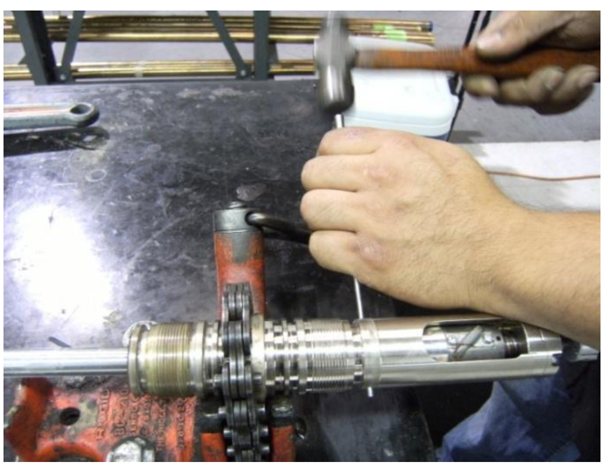
Once the Lock Nut is off the threads, loosen the set screw in the coupling. Once this is done the coupling and lock nut can be removed from the shaft. .

Remove spacer as shown.



The Bearing Mount is the next component you will see on top of the assembly. Remove the four screws that hold the bearing mount to the ball screw housing.

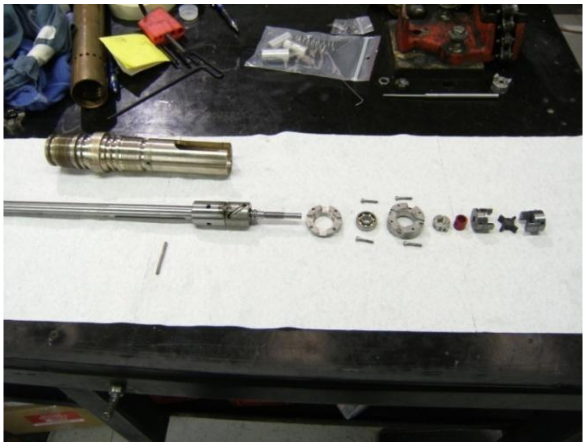
Remove mount and bearing from ball screw housing.



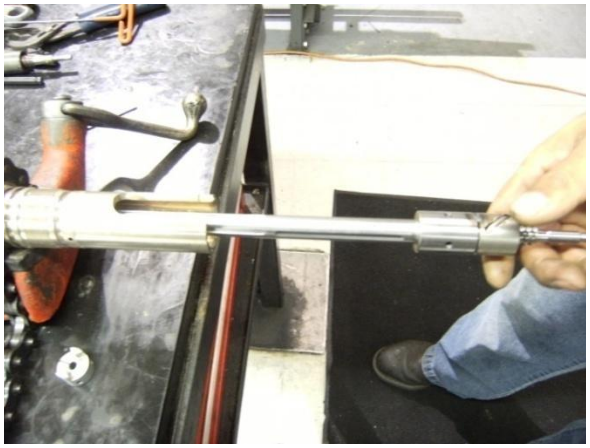
Knock out pin with punch and hammer.

With the pin removed the old shaft can be removed from Ball Screw Housing.

Shown are the parts that were removed with the old shaft. They are laid out in the order in which they are mounted on the complete assembly.

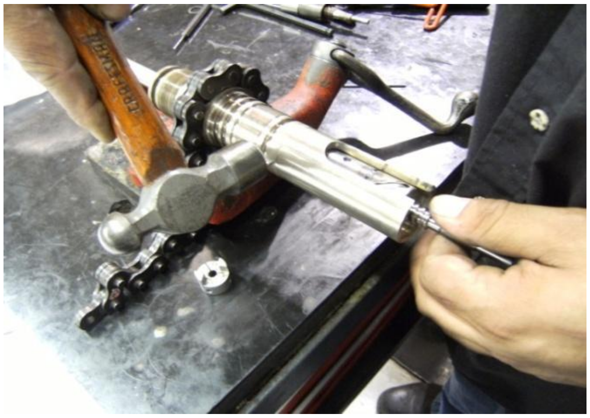


Shown are the new shaft with the new parts that are going to be needed. The major changes are improvements to the Ball Screw Assembly including the Servo Poppet Tip, a stronger and simpler bearing unit and a simpler coupling assembly.



We are now going to assemble the drive assembly utilizing the new components.

Shown in the picture we are sliding the Ball Screw Shaft into the Ball Screw Housing.



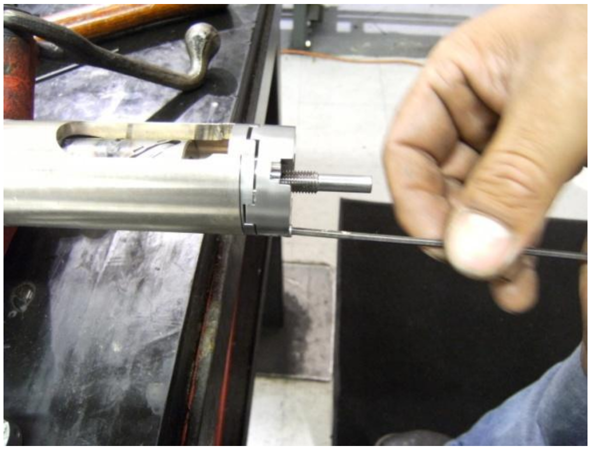
Align the hole in the Ball Screw Housing with the hole in the Ball Screw Shaft. Tap in the pin that aligns the Pulser shaft.

You may want to use an aligning dowel from the opposite side to keep the two pieces aligned.

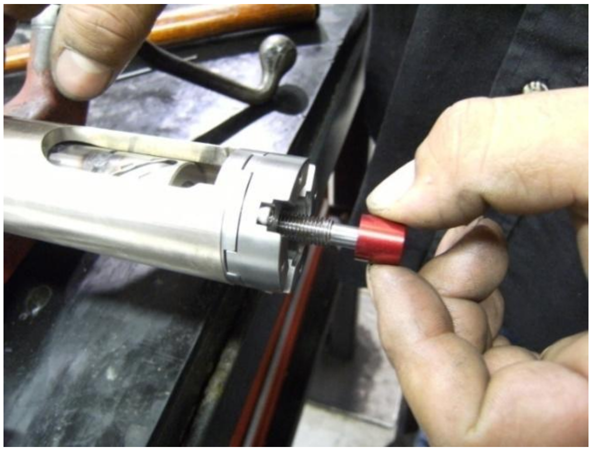
Place the thinner half of the bearing retainer on the Ball Screw Housing and align and insert the key into the slot in the ball screw housing.

Next, the Bearing is placed in the thin half of the Bearing Mount that was previously put on the shaft.

The thicker bearing mount is now placed to secure the bearing in place. The lugs will fit into the appropriate recess on the thin bearing mount.

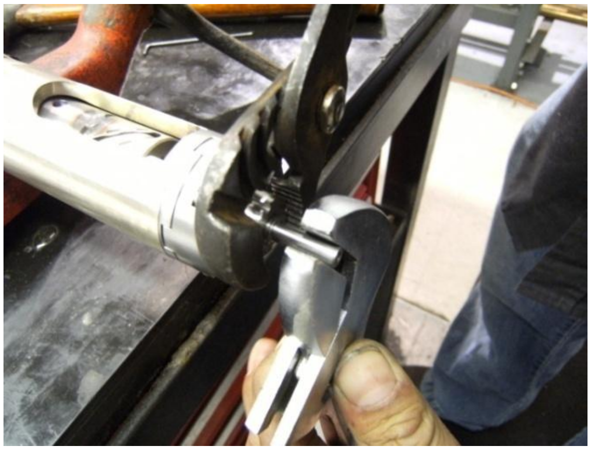


Now the four screws (4-40 x 5/8”) are screwed in and tightened to hold all three pieces together.

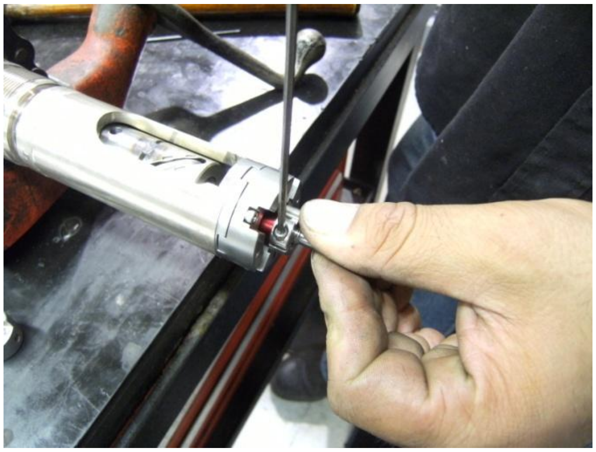


Next a spacer is placed on the shaft prior to installing the shaft nut.

Prior to installing the shaft nut use a <u>little</u> bit of Loctite and then screw the new shaft nut onto the new Pulser shaft.



Tighten the shaft nut with some pliers while holding the shaft with an adjustable wrench that will fit onto the flat on the shaft. Do not over-tighten. Snug is good enough.



Apply Loctite to the screw in the shaft nut and tighten it down.

Install the new coupling on shaft while aligning the set screw with the wrench flat and ensuring the shaft is flush with the coupling body as is shown.

Loctite and tighten all of the screws.

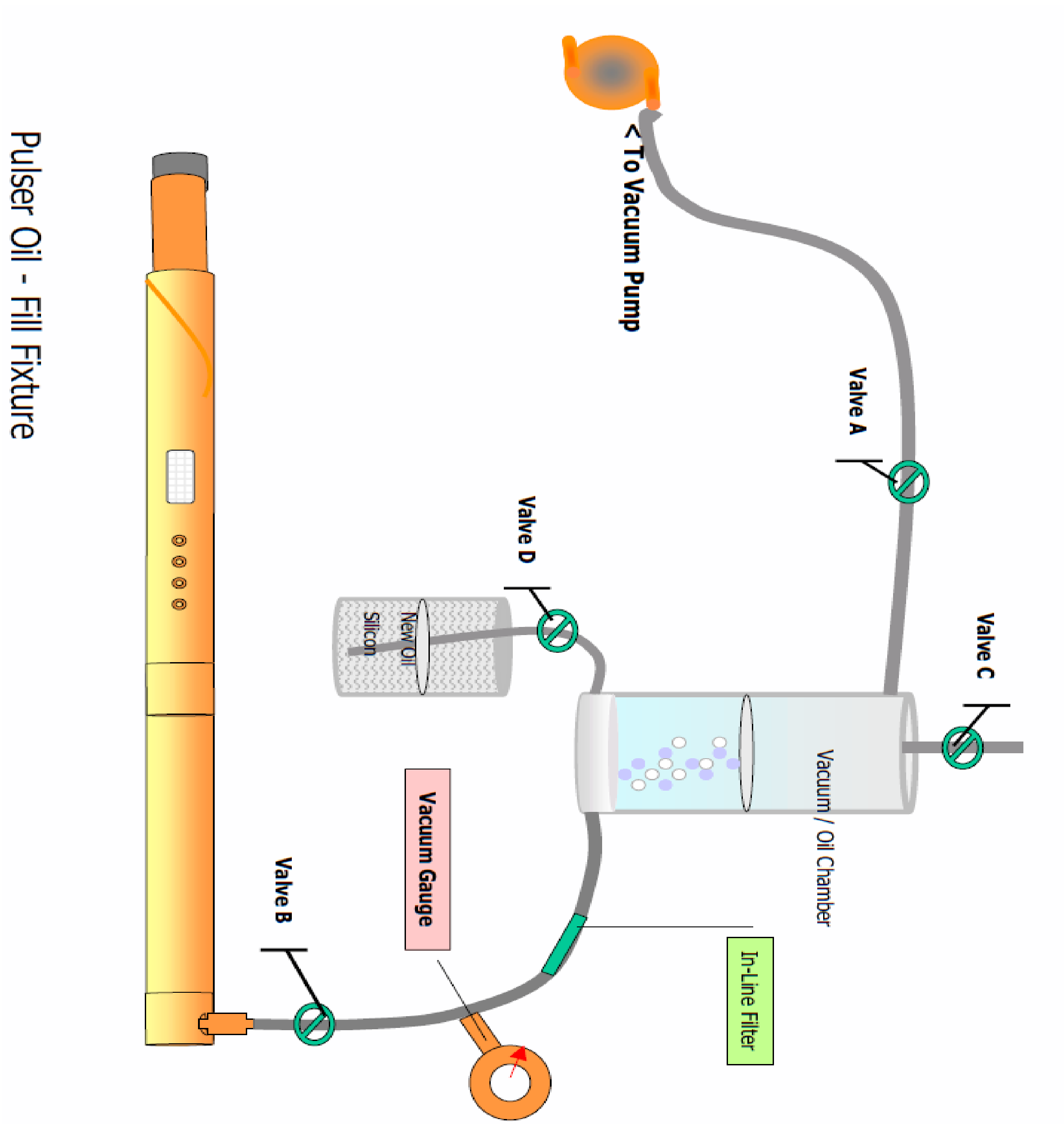
Place new rubber bushing on the new coupling.

On the motor side the matching coupling will have to be installed in the same manner.

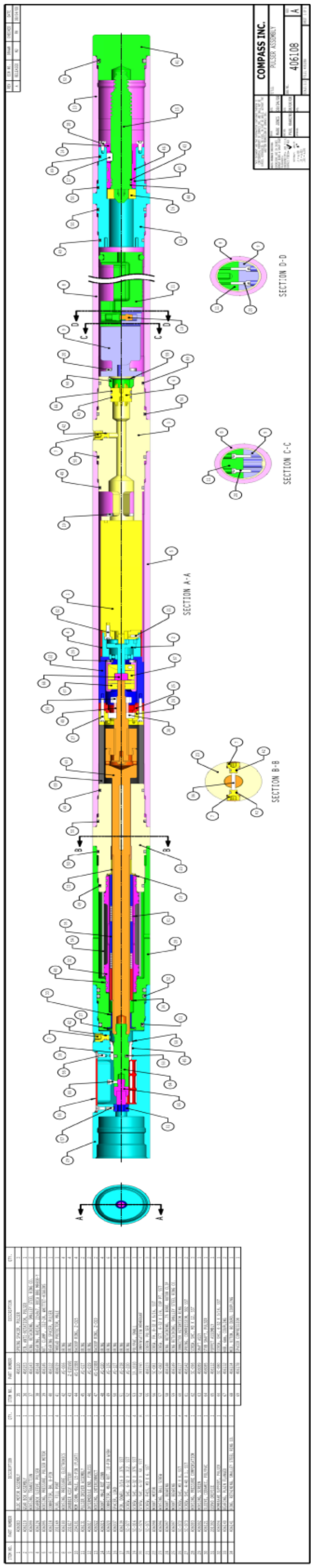
Now you can place the springs and spacers back onto your Pulser shaft.

Note that in some cases the Pulser shaft will be a assembled unit and much simpler to install than has been shown in this sequence of photos.

C.2 PULSER OIL-FILL FIXTURE COLOR DIAGRAM



C.3 ASSEMBLY DRAWING



C.4 BOM

BOM: Pulser Assembly (Compass)

Asset

Part Number	Size	Product Line	Description
406169	Common	MWD	Pulser System w/Driver 150 C, Compass

Serialized Part

Part Number	Size	Product Line	Description
406083	Common	MWD	BLDC Motor (OS)
406131	Common	MWD	Motor Driver, Compass 150 C
406169S	Common	MWD	Pulser System w/Driver 150 C, Compass

Non-Serialized Part

Part Number	Size	Product Line	Description	Quantity
201509	1-7/8"	MWD	Housing, Interconnect	1.00
201514	1-7/8"	MWD	Intermodule End	1.00
09.1038	Common	MWD	Ring, Anderton Internal Snap	2.00
09.1049	Common	MWD	Ring, Snap (upper)	1.00
13.1010	Common	MWD	Polypac, Small	1.00
16.1022	Common	MWD	Screen, Lrg. Pulser (Slots)	3.00
201169	Common	MWD	Plug, Oil Fill	4.00
201190	Common	MWD	Compensation Membrane	1.00
201392	Common	MWD	Servo Orifice	1.00
201505	Common	MWD	Bulkhead Retainer, Top (90 Degree)	1.00
201506	Common	MWD	Split Shell	2.00
201616	Common	MWD	Snubber Assembly, Battery	1.00
204101	Common	MWD	MDM Connector, 15pin (Male)	1.00
406085	Common	MWD	Shaft, Poppet Stub	1.00
406089	Common	MWD	Assembly, Pulser Shaft	1.00
406092	Common	MWD	Housing, Pulser Screen (OS)	1.00
406093	Common	MWD	Housing, Mud Compensator	1.00
406094	Common	MWD	Membrane Support	1.00
406095	Common	MWD	Housing, Compass Pulser Motor Pressure	1.00
406096	Common	MWD	Housing, Ball Screw	1.00
406097	Common	MWD	Mount, Bearing	1.00
406098	Common	MWD	Mount, Motor	1.00
406099	Common	MWD	Housing, Transition	1.00
406100	Common	MWD	Housing, Compass Pulser Driver Pressure	1.00
406112	Common	MWD	Servo Tip Assembly, Pilot (OS)	1.00
406117	Common	MWD	Ring, Connector Retention	1.00
406118	Common	MWD	Connector, Bulkhead (OS)	1.00
406119	Common	MWD	Gear Box (OS)	1.00
406120	Common	MWD	Spacer, Spring	3.00
406121	Common	MWD	Sleeve, Ceramic	1.00
406122	Common	MWD	Spacer, Bearing	1.00
406124	Common	MWD	Sleeve, Gearbox	1.00
406125	Common	MWD	Assembly, 6mm x 6mm Coupling	1.00
406140	Common	MWD	Bearing, Plain, Flanged	2.00
406142	Common	MWD	Spring, Compression, 302 SST	2.00
406144	Common	MWD	Bearing	1.00
406145	Common	MWD	Clamp Nut	1.00
406149	Common	MWD	Retaining Ring, #81 Spiral	1.00
406153	Common	MWD	Pin, Anti-Rotation	1.00

Non-Serialized Part

Part Number	Size	Product Line	Description	Quantity
406178	Common	MWD	Compression Spacer	1.00
406179	Common	MWD	Bearing Mount, Downhole, Pulser	1.00
AS-006	Common	MWD	AS-006 O-Ring, Viton	4.00
AS-015	Common	MWD	AS-015 O-Ring, Viton	4.00
AS-015BR	Common	MWD	AS-015 Back-up Ring, Viton	4.00
AS-017	Common	MWD	AS-017 O-Ring, Viton	2.00
AS-020	Common	MWD	AS-020 O-Ring, Viton	4.00
AS-124	Common	MWD	AS-124 O-Ring, Viton	1.00
AS-125	Common	MWD	AS-125 O-Ring, Viton	6.00
AS-127	Common	MWD	AS-127 O-Ring, Viton	6.00
AS-217	Common	MWD	AS-217 O-Ring, Viton	2.00
AS-218	Common	MWD	AS-218 O-Ring, Viton	1.00
AS-220	Common	MWD	AS-220 O-Ring, Viton	3.00
SC-011	Common	MWD	Screw, 8-32 x 5/16 Phil/Flat, SS	6.00
SC-013	Common	MWD	Screw, 6-32 x 1/2" SHCS, SS	8.00
SC-015	Common	MWD	Screw, 4-40 x 1/4" SHCS, SS	1.00
SC-036	Common	MWD	Screw, 6-32 X 5/16" SHCS, SS	1.00
SC-071	Common	MWD	Screw, M3 x 6, FHCS	3.00
SC-073	Common	MWD	Screw, 4-40 x 1, SHCS	4.00
SC-078	Common	MWD	Screw, 6-32 x 3/4", SHC, SST	4.00
SC-082	Common	MWD	Screw, 8-32 x 1/4, Cup Point Socket Set, Alloy Steel	3.00
SC-095	Common	MWD	Screw, M3 x 8, SHCS, SS	4.00
SC-096	Common	MWD	Screw, M3 x 12, SHCS, SS	3.00

D.BATTERY PACK ASSEMBLY

D.1 MAINTENANCE

Battery Maintenance

MWD Battery Housing

This section of the Manual is designed to instruct the shop technician to totally disassemble and re-assemble the battery module. Total disassembly is required every time a battery housing is returned to the shop from a job.

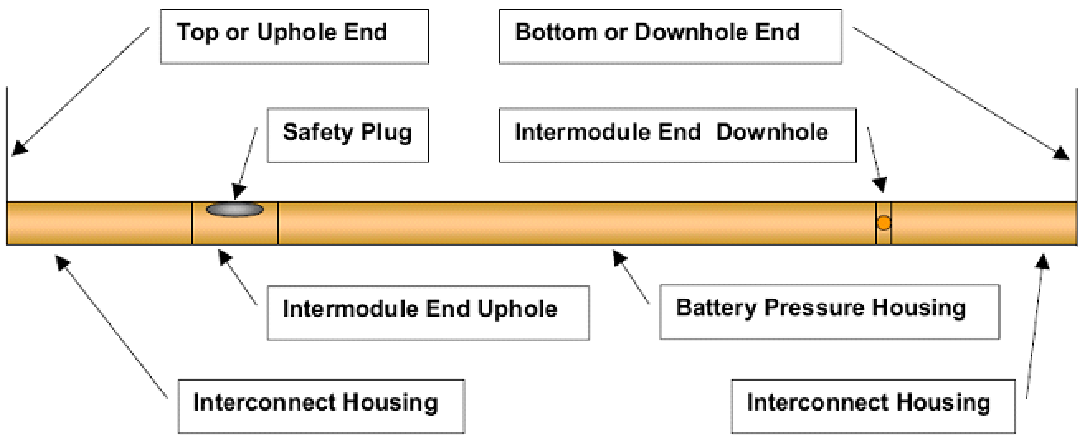
The Compass MWD field operator should be knowledgeable in performing the assembly and disassembly of battery housings in the field to the point of being able to remove discharged battery packs and installing new battery packs into the battery housing. In the case of high temperature environments, the field operator must be able to perform the total break down of the module to change the required elastomers.

Battery maintenance should normally be performed in the shop and should only be performed in the field under special circumstances. i.e. remote location, weather or premature battery depletion.

Extreme care should be taken and all steps properly followed to prevent accidents.

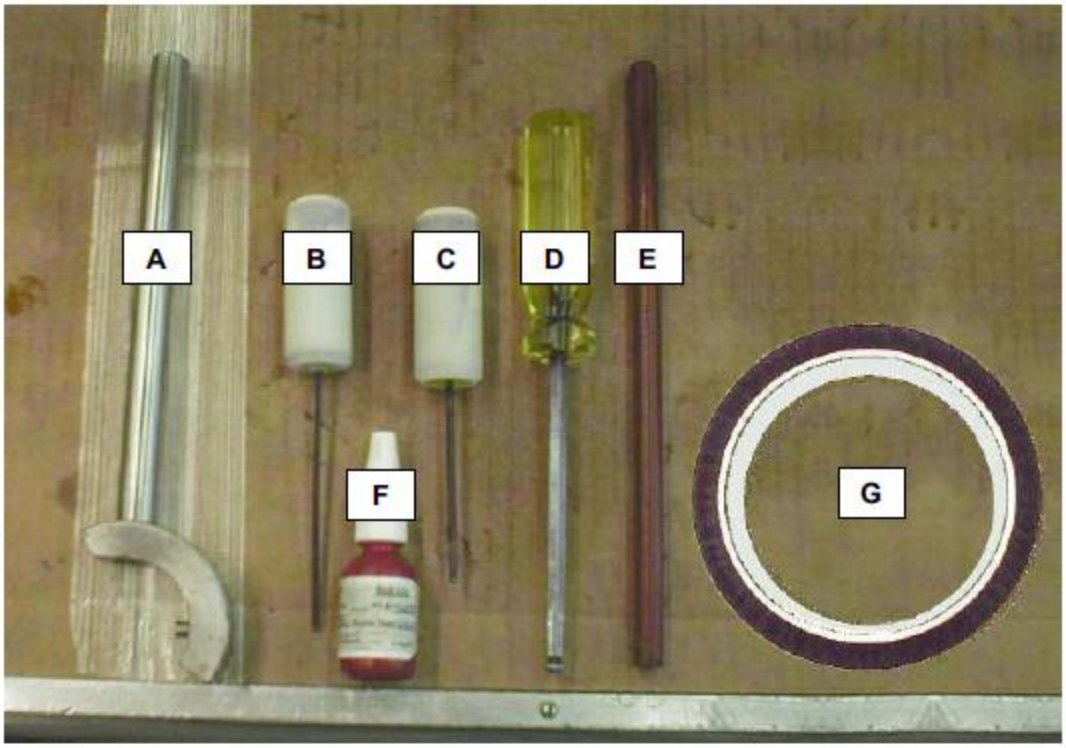
CHANGE BATTERIES

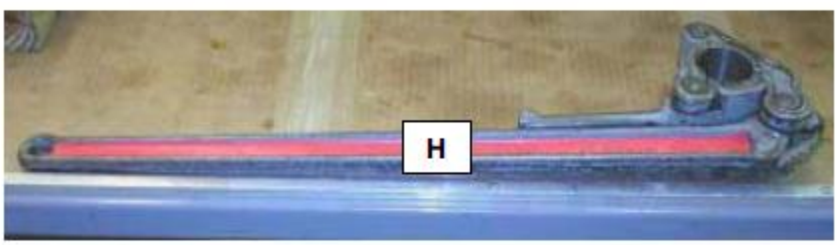
1.0 The Battery Housing



Note: Disassembly of the battery module must <u>always</u> start at the <u>uphole</u> end.

2.0 Tools Required



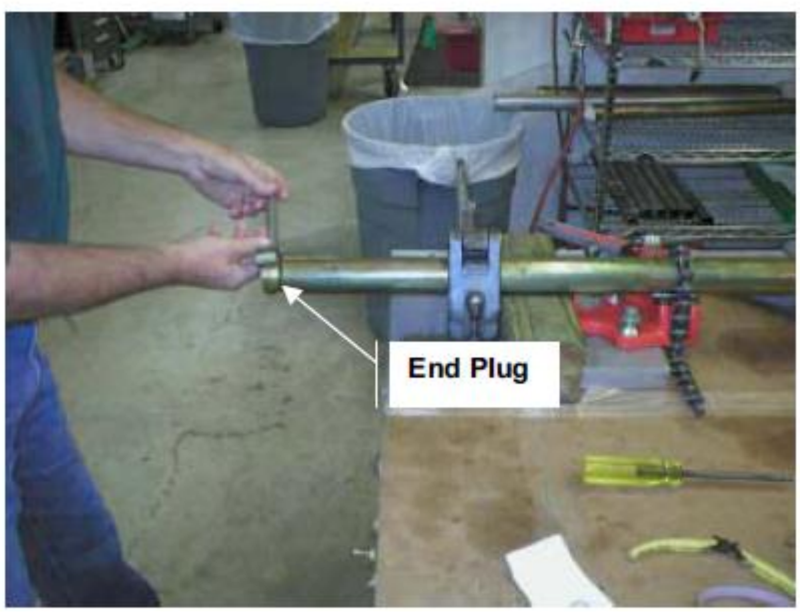


A. Spanner Wrench	E. Wooden Dowel
B. 3/32" Hex Driver	F. Loctite 242 Blue
C. 1/8" Hex Driver	G. Kapton Tape
D. ¼" Hex Driver	H. 1 7/8" Gearench

3.0 Disassembly: Uphole End

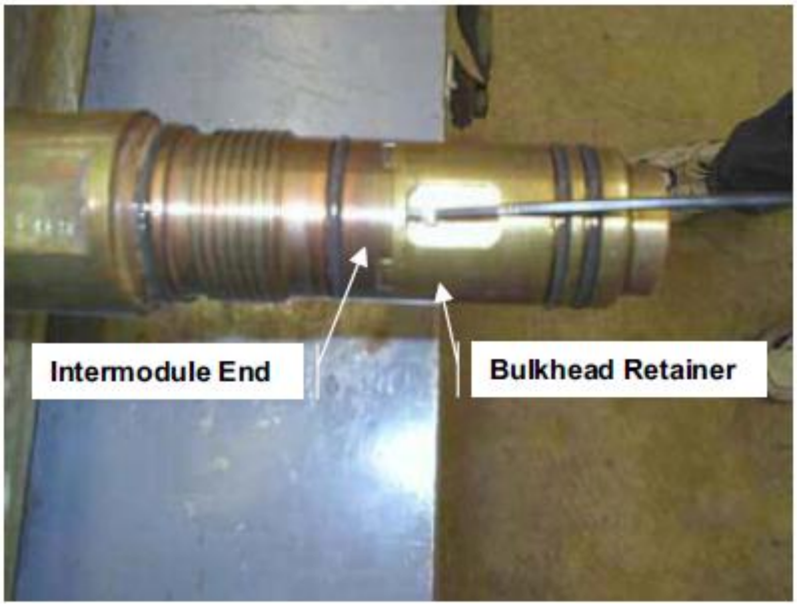
3.1 Remove the Safety Plug from the side of the battery housing, near the Uphole end, with a ¼" Hex driver.

3.2 Unscrew the Uphole End Plug protector with the Spanner Wrench.



3.3 **Using two Gearenches, break the connection between the Interconnect Housing and the Intermodule end. Remove the Interconnect Housing, exposing the Bulkhead Retainer.**

3.4 **Remove the two screws holding the Bulkhead Retainer to the Intermodule End with a 3/32" Hex driver.**



3.5 **Push the 6-Pin Connector through the Bulkhead Retainer using the Wooden Dowell and remove the bulkhead retainer.**

3.6 **The 6-Pin Connector and wires are now exposed. The Intermodule End may now be removed.**

3.7 **Loosen the Uphole Intermodule End using two Gearenches. Unscrew the Intermodule End.**

3.8 **Remove the Uphole Intermodule End**

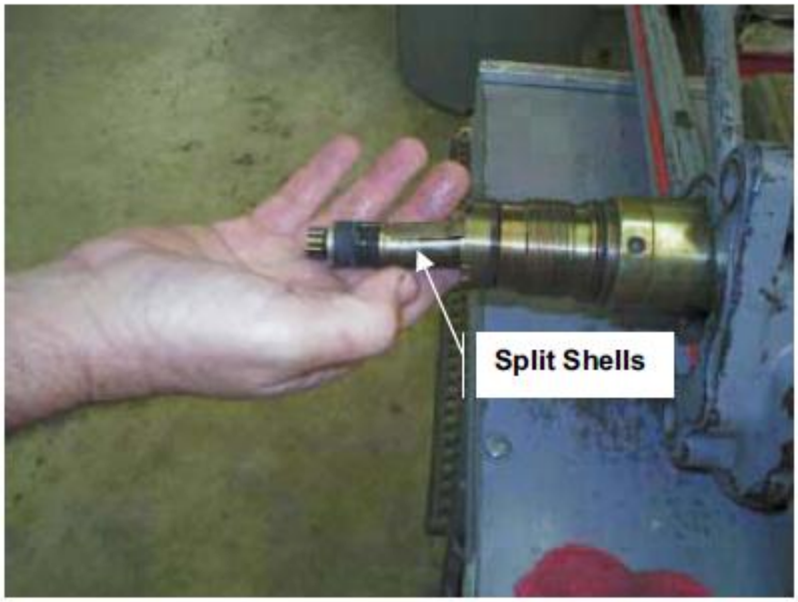
4.0 Disassembly – Downhole End

4.1 Remove Downhole End Plug

Note: For field maintenance, do not remove the Interconnect Housing from the Downhole Intermodule End: Skip Steps 4.2 to 4.6.

4.2 Break the connection between the Downhole Interconnect Housing and the Intermodule End.

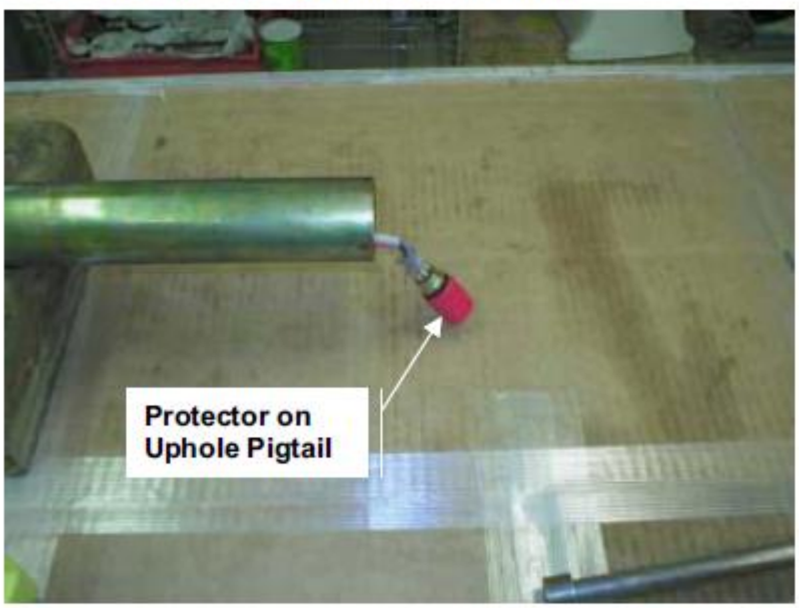
4.3 **Remove the Bulkhead Retainer using the same procedure listed in steps 3.3 to 3.8. After the Downhole Bulkhead Retainer is removed, two Split Shells are exposed. Remove the Split Shells.**



4.4 **Using two Gearenches, break the connection between the Downhole Intermodule End and the Battery Pressure Housing.**

4.5 Use the Spanner Wrench to remove the Intermodule End. Make sure that the Uphole pigtail rotates freely while removing the Intermodule End.

4.6 Place a protector over the Uphole pigtail.



4.7 Pull the Battery out of the Battery Pressure Housing far enough to expose the Snubber Unit.

4.8 Remove Kapton Tape from the Snubber Unit.

4.9 **Hold the Snubber Unit sideways and remove the four screws holding the snubber unit to the battery.**

4.10 **Remove old battery and locate the fresh battery.**

5.0 Replacing the Battery

5.1 Remove the battery from the plastic bag. Save the paperwork included with the battery for record keeping.

5.2 Insert Battery into Downhole end of Battery Pressure Housing.

Note: Battery replacement must always start at the Downhole end of the Battery Pressure Housing.

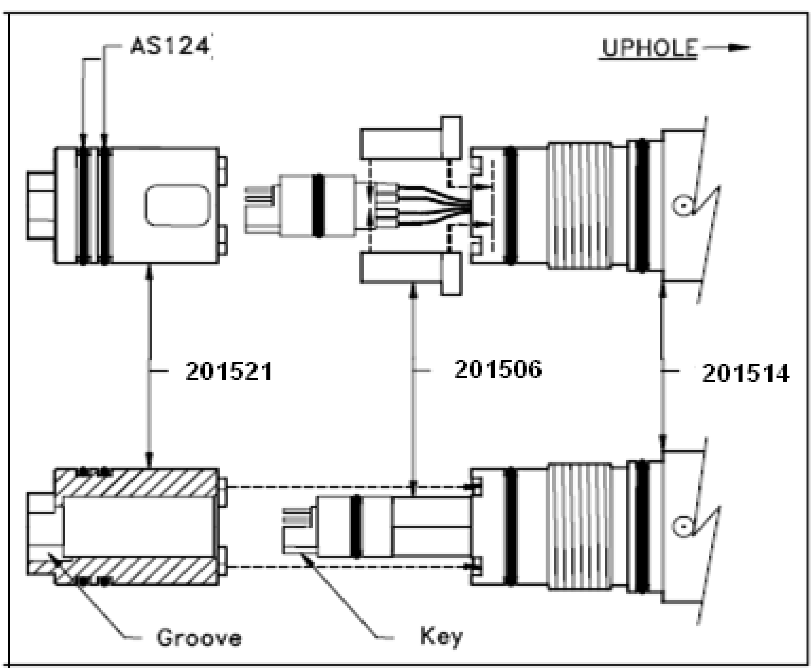
5.3 Put Loctite 246 Blue on threads of Downhole Intermodule End / Snubber Unit screws.

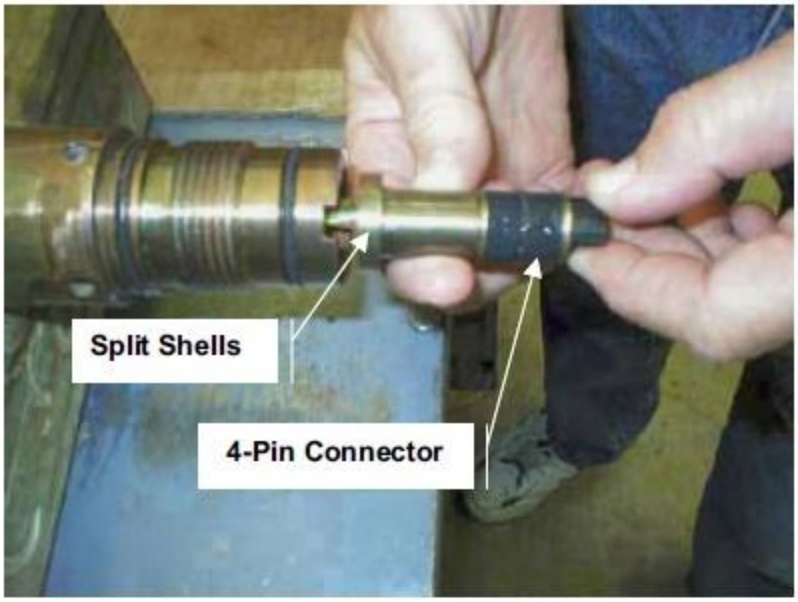
5.6 Insert Battery into Battery Pressure Housing.

5.7 Screw the Battery with Downhole Intermodule End / Snubber Unit into Battery Pressure Housing using the Spanner Wrench

5.8 Torque the Intermodule End to the Battery Pressure Housing witl two Gearenches.

5.9 Place two Split Shells on end of Pig Tail. Apply grease to O-ring on 4-Pin Connector.

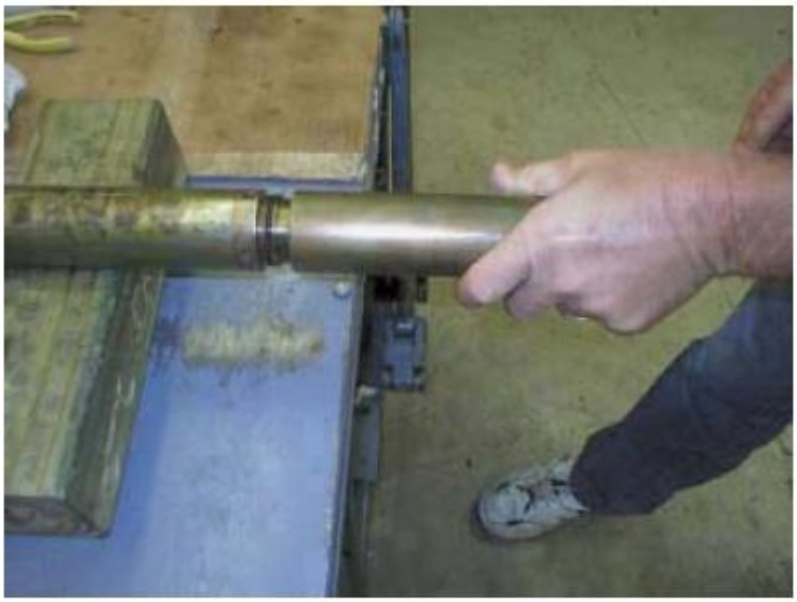




5.10 Connect the Downhole Bulkhead Retainer to the Intermodule End with two screws. Use the 3/32" Hex driver to tighten the screws.

Note: Tighten the two screws only until barely snug to allow the Bulkhead Retainer to "self-align" when the Interconnect housing is installed.

5.11 **Install the Interconnect Housing over the Bulkhead Retainer and screw on to the threaded portion of the Intermodule End. Tighten the Interconnect Housing with two Gearenches.**



5.12 **At the Uphole end of the Battery Pressure Housing, install the Uphole Intermodule End, then torque tight with two Gearenches.**

5.13 Connect the Bulkhead Retainer to the Intermodule End with two screws. Tighten the screws with the 1/8” Hex driver.

5.14 Install the Interconnect Housing and torque it tight with two Gearenches.

5.15 Install the End Protectors.

5.16 Install the Safety Plug into the side of the battery housing, near the uphole end, with a ¼" Hex driver.

D.2 BILL OF MATERIALS

BOM: Battery Module (EM)

Non-Serialized Part

Part Number	Size	Product Line	Description	Quantity
201509	1-7/8"	MWD	Housing, Interconnect	2.00
201514	1-7/8"	MWD	Intermodule End	1.00
201650	1-7/8"	MWD	Housing, Battery Vent Plug	1.00
201845	1-7/8"	MWD	Thread Protector, Male	2.00
601001	1-7/8"	EM	Battery Barrel (Long)	1.00
201505	Common	MWD	Bulkhead Retainer, Top (90 Degree)	1.00
201506	Common	MWD	Split Shell	2.00
201521	Common	MWD	Bulkhead Retainer, Bottom (45 Degree)	1.00
201617	Common	MWD	Snubber Assembly, Battery	1.00
201645	Common	MWD	Battery Vent Plug	1.00
201991	Common	MWD	Pigtail, Battery	1.00
601142	Common	EM	Antenna Rod	1.00
601145	Common	EM	Kit, Bow Spring (EM)	1.00
AS-011	Common	MWD	AS-011 O-Ring, Viton	1.00
AS-016	Common	MWD	AS-016 O-Ring, Viton	1.00
AS-124	Common	MWD	AS-124 O-Ring, Viton	2.00
AS-127	Common	MWD	AS-127 O-Ring, Viton	2.00
AS-217	Common	MWD	AS-217 O-Ring, Viton	4.00
AS-218	Common	MWD	AS-218 O-Ring, Viton	2.00
AS-220	Common	MWD	AS-220 O-Ring, Viton	4.00
SC-013	Common	MWD	Screw, 6-32 x 1/2" SHCS, SS	4.00
SC-014	Common	MWD	Screw, 6-32 x 3/4" SHCS, SS	4.00
SC-015	Common	MWD	Screw, 4-40 x 1/4" SHCS, SS	4.00
SC-031	Common	MWD	Screw, 2-56 x 1/4" Phil/Flat	2.00

BOM: Battery Module (Tensor)

Asset

Part Number	Size	Product Line	Description
201675	Common	MWD	Battery Housing Module

Serialized Part

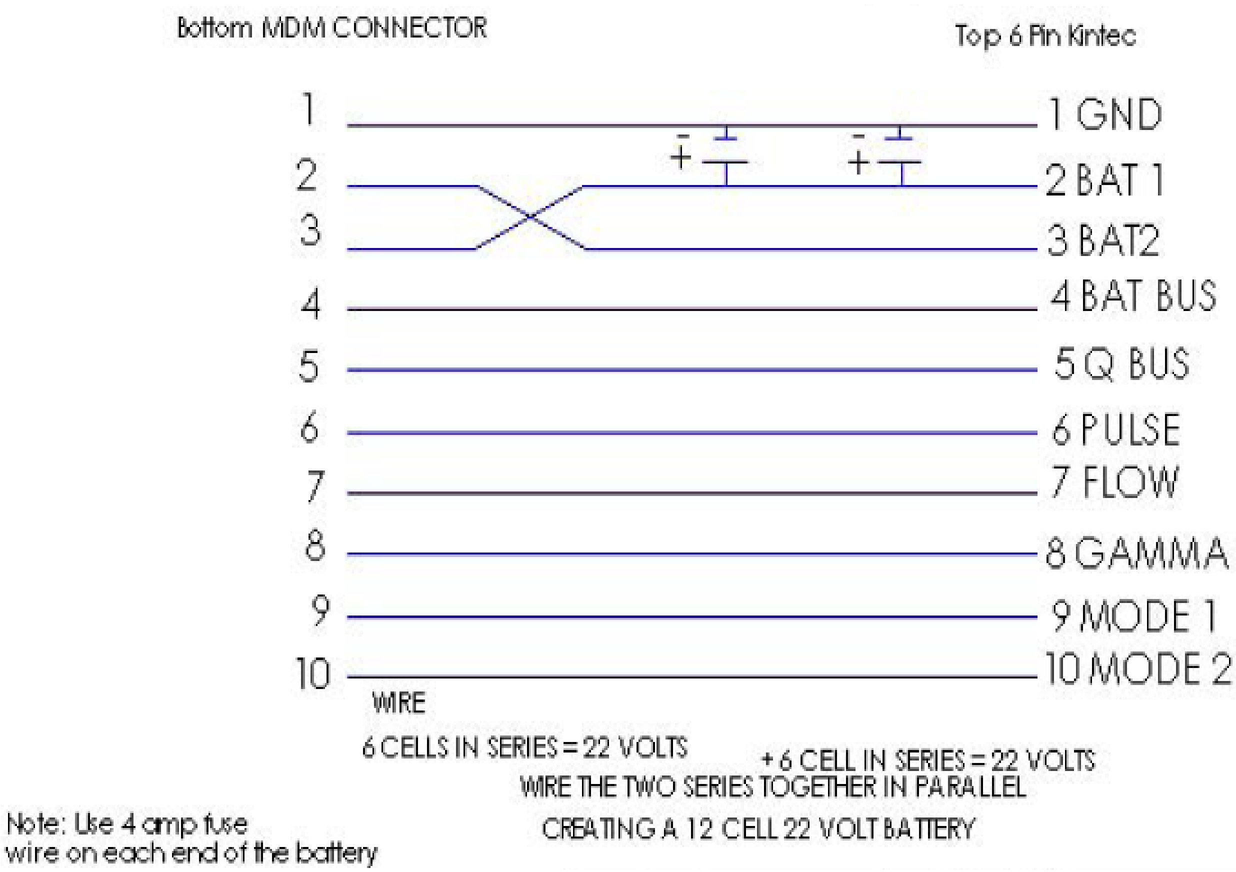
Part Number	Size	Product Line	Description
201675S	Common	MWD	Battery Housing Module

Non-Serialized Part

Part Number	Size	Product Line	Description	
201509	1-7/8"	MWD	Housing, Interconnect	2.00
201514	1-7/8"	MWD	Intermodule End	1.00
201635	1-7/8"	MWD	Battery Barrel Housing	1.00
201650	1-7/8"	MWD	Housing, Battery Vent Plug	1.00
201845	1-7/8"	MWD	Thread Protector, Male	2.00
201505	Common	MWD	Bulkhead Retainer, Top (90 Degree)	1.00
201506	Common	MWD	Split Shell	2.00
201521	Common	MWD	Bulkhead Retainer, Bottom (45 Degree)	1.00
201617	Common	MWD	Snubber Assembly, Battery	1.00
201645	Common	MWD	Battery Vent Plug	1.00
201991	Common	MWD	Pigtail, Battery	1.00
AS-011	Common	MWD	AS-011 O-Ring, Viton	1.00
AS-016	Common	MWD	AS-016 O-Ring, Viton	1.00
AS-124	Common	MWD	AS-124 O-Ring, Viton	2.00
AS-127	Common	MWD	AS-127 O-Ring, Viton	2.00
AS-217	Common	MWD	AS-217 O-Ring, Viton	4.00
AS-218	Common	MWD	AS-218 O-Ring, Viton	2.00
AS-220	Common	MWD	AS-220 O-Ring, Viton	4.00
SC-013	Common	MWD	Screw, 6-32 x 1/2" SHCS, SS	4.00
SC-014	Common	MWD	Screw, 6-32 x 3/4" SHCS, SS	4.00

D.3 EM BATTERIES

EM Battery Configuration



The fibreglass tube should be cut to 65.5 in with regular QDT ends on both sides.

BATTERY HOUR CALCULATIONS

100 AH Batteries (50 AH per pack)

		Amps			
		6	5	3	Pulses/minute
	0.25	38	60	97	50
	0.375	62	97	153	30
Data Rate	0.5	91	139	215	20
	0.6	112	169	256	16

Assuming TLSQ 1 (Pulse width = 0.375)

80 AH packs (40 AH per pack)

		6	5	3	Pulses/minute
	0.25	30	48	77	50
Data Rate	0.375	50	77	122	30
	0.5	73	111	172	20
	0.6	89	135	205	16

Assuming TLSQ 1 (Pulse width = 0.375)

High Voltage Tool (28 V packs at 25 AH per pack for a total of 50 AH)

		4	2.5	1	Pulses/minute
	0.25	37	57	124	50
Data Rate	0.375	59	89	180	30
	0.5	84	124	230	20
	0.6	102	147	263	16

D.4 BATTERY SAFETY

BATTERY SAFETY

SAFE STORAGE & HANDLING

In most cases, improper handling and storage, resulting in such problems as overheating and short-circuiting cause damage to batteries. The common safety practices have been outlined below; safety precautions to take with regard to all aspects of battery storage and handling.

- **Storage**

1. Shelf Batteries should be stored in their original shipping boxes, if possible, to keep them isolated from each other, preventing external short circuits. Do not store batteries loosely, and do not place batteries on metal surfaces.

2. Temperatures and Environment Batteries should be stored in a cool, dry, well-ventilated area with an optimal storage temperature range of 0-25□C. If prolonged storage is anticipated, batteries should be protected against excessive humidity. This will prevent moisture from forming an electrical pathway between the feed-through terminal and battery cover, which can lead to severe galvanic corrosion of the feed-through pin, thus compromising the hermeticity of the battery.

3. Hazard Consideration Lithium battery storage areas should be clearly marked and provided with “Lith-X” fire extinguishing material. Batteries might burst if subjected to excessive heating. In case of fire, only “Lith-X” fire extinguisher should be used, as water will cause exposed lithium to ignite. Signs should clearly state - **WATER IS NOT TO BE USED IN CASE OF FIRE.**

INCOMING INSPECTION

The proposed flow of batteries throughout the facility should be thoroughly reviewed by plant safety personnel to identify and eliminate potential sources of electrical and physical damage to the batteries. Conditions that can short circuit, recharge, over-discharge, puncture, crush, or overheat the batteries must be avoided, and all personnel involved in the handling should be properly trained.

- **Testing**

Physical dimensioning should be performed with all-plastic callipers, and no electrical tests other than open circuit voltage checks should be performed without first consulting the battery manufacturer. Short circuit and load tests can degrade battery performance. If batteries are to be tested at elevated temperatures, the test chambers must have over-temperature protection.

Note: Abuse testing should not be performed without first consulting the battery manufacturer.

SAFE TRANSPORTATION

All lithium/thionyl chloride batteries with a lithium content of greater than 0.5 grams are restricted and they are subject to DOT (49 CFR 172.101) and International Air Transport Association (IATA) shipping regulations. Those batteries that contain less than 0.5 grams of lithium are unrestricted, and they can be shipped by any means (ref. U.S. DOT 173.185(I) and IATA section 4.5.A45). Because the shipping regulations are very complex, shippers of lithium batteries are urged to obtain copies of the 49 CFR (DOT regulations) and IATA regulations. These regulations also explain how the paperwork is to be filled out. This brochure will not attempt to explain paperwork because every carrier has different requirements.

- **U.S. DOT**

  The proper shipping name is *LITHIUM BATTERY, 9 (UN3090), PG II*. The Regulations State that the batteries must be separated to prevent external short circuits, and they must be packed in inner fiberboard containers (no more than 500 grams of lithium per inner container). The inner containers can then be packed with at least one inch of non-combustible packing material (such as vermiculite) separating each inner package in 4G fiberboard boxes, 1A2 or 1B2 steel drums, 1G fiber drums, or 4C1, 4C2, 4D, 4F wooden boxes.

  Motor freight, rail freight, water, or Cargo Aircraft can ship the batteries only. Restricted batteries cannot be carried aboard passenger-carrying aircraft. Boxes must be labelled MISANEOUS (CLASS 9). If the batteries are to be shipped by air, then the package has to have a CARGO AIRCRAFT ONLY label, also known as DANGER LABEL attached. Boxes must be marked with the proper shipping name and the UN number near the shipping labels.

- **INTERNATIONAL AIR TRANSPORT ASSOCIATION (IATA)**

  IATA regulations are very similar to the DOT regulations except for paperwork and packaging. Packaging for IATA shipments has to be performance tested before the packages are used for shipping. These packages have to be marked with a United Nations Marking Symbol (section 6.0 of IATA shipping regulations).

SAFE DISPOSAL

Lithium/thionyl chloride batteries must be disposed of properly in accordance with 40 CFR PARTS 261 & 262. Lithium batteries for disposal are classified as Waste Lithium Batteries, 9, UN3090, II for shipping purposes, and they have an EPA waste disposal code of D003 and D001.

The products of lithium/thionyl chloride battery deactivation are not toxic (non-hazardous), once neutralized. Lithium/thionyl chloride batteries should be disposed of by an EPA permitted treatment, storage, and disposal facility. Because each state and country has different disposal regulations, contact your local environmental agency for instructions on how to properly manage and dispose of waste lithium batteries.

EMERGENCY CONDITIONS

Because of the high energy density inherent in lithium/thionyl chloride batteries, the potential for hazardous situations does exist. Most hazards are due to internal or external heating of a hermetically sealed battery. Overheating causes liquid electrolyte to expand, increasing hydrostatic pressure inside the can. This might cause the battery to burst. Further heating can cause the lithium anode to melt, which, in turn, will react spontaneously with the electrolyte and bring about a violent reaction of the battery.

CAUSES OF HAZARDOUS CONDITIONS - ELECTRICAL AND PHYSICAL

Hazardous electrical conditions include recharging, short-circuiting, and forced discharging (voltage reversal).

Hazardous physical conditions include external heating due to uncontrolled storage, incineration, and physical destruction of the battery case via crushing, puncturing, and disassembly. Excessive heating can cause violent behavior with any type of battery. Physical destruction can result in leakage of toxic and highly corrosive electrolyte.

EMERGENCY PROCEDURES

- ✓ **OSHA** Safety Regulations must be followed, at all times, the OSHA regulatory references are found in 29 CFR PART 1910. In the unlikely event of violent battery behaviour, the area should be evacuated immediately. Unless they are wearing personal protection devices, all workers should stay away from the area for at least 15 minutes rather than trying to correct the situation. Burning or fuming batteries should be left isolated until expert handling can correct the condition. Lithium fires should never be extinguished with equipment other than that which is designed for lithium fires (i.e., “Lith-X”).

- ✓ ***In case of leakage***, leaking batteries should be isolated from all personnel and equipment. Since electrolyte can be neutralized with common baking soda, leaking batteries should be placed in sealed plastic bags containing baking soda. The bags should be placed in a sealed and labelled drum. Vermiculite should be used to cushion the batteries.

Note: Personal protective equipment should always be used around leaking batteries

SAFETY EQUIPMENT AND MATERIALS

Common personal protective equipment and material that should be available in the event of a lithium thionyl chloride battery being involved in an incident such as a crush puncture, or fire is as follows:

- ✓ **Rubber Gloves**-Fisher Scientific #11-394-23A or equal
- ✓ **Rubber Boots**-Uniroyal Steel Shank Rubber Boot or equal
- ✓ **Respirator**-MSA 4571000 Al Front Mounted Gas Mask
- ✓ Acid Gasses and Carrying Case #84494
- ✓ Acid Gas Canister or equal
- ✓ **Lab Apron**-Lab Safety Supply #R3003 or equal
- ✓ Neutralization Materials-10 lbs. Industrial Grade Sodium Bicarbonate

LITHIUM BATTERY SAFETY MANUAL

APPENDIX: HANDLING OF LITHIUM THIONYL CHLORIDE BATTERIES UNDER **ABNORMAL CONDITIONS**.

The following paragraphs will discuss the safe handling of Lithium Thionyl Chloride (LTC) batteries under the abnormal hazardous conditions of:

- **Leaking or venting batteries**
- **Hot batteries**
- **Exploding batteries**
- **Lithium fires**

Personnel Protective Equipment Required:

- Safety Glasses, Rubber Gloves, Helmet with full face shield, Flak Jacket with gloves, Riot Shield, Respirator with canisters for Acid Gases or full-face respirator with acid gas cartridges.

Other Equipment Required:

- Infrared Temperature Probe, Sodium Carbonate (Soda Lime) or Sodium Bicarbonate (Baking Soda), Vermiculite, Fire Extinguisher containing Lith-X Graphite powder, extended Non-conductive pliers or tongs, Thermal resistant gloves (welding gloves).

PROCEDURE FOR LEAKING OR VENTED BATTERIES

Leaking or vented batteries should be isolated from personnel and equipment. If possible, the area should be vented to the outside. Prior to handling, the temperature of the batteries should be checked with a remote-sensing device such as an infrared temperature probe. If the batteries are at ambient temperature, they should be handled with rubber gloves or non-conductive pliers or tongs and placed in plastic bags containing Sodium Carbonate. Spilled electrolyte should be absorbed with Sodium Carbonate and placed in plastic bags. All bags should be placed in a sealed and labelled drum with Vermiculite or other non-flammable cushioning material such as sand or Sodium Carbonate to cushion the batteries. These materials should be disposed as previously discussed under **Safe Disposal** in the Lithium Battery Safety Manual.

PROCEDURE FOR HOT BATTERIES

As soon as a hot battery is detected, **all personnel should be evacuated from the area**. The temperature of the battery should be monitored with a remote-sensing device such as an infrared temperature probe. The area should remain evacuated until the battery has cooled to ambient temperature. When the battery has returned to ambient temperature, it can be handled by an operator wearing protective equipment (face shield, flak jacket and gloves) with non-conductive pliers or tongs. The batteries should be placed in plastic bags containing Sodium Carbonate and then placed in labelled drums containing Vermiculite or other non-flammable cushioning material such as sand or Sodium Carbonate. These materials should be disposed of as previously discussed under **Safe Disposal** in the Lithium Battery Safety Manual.

OR

If liquid nitrogen is available, the battery should be placed in liquid nitrogen/or dry ice with a pair of tongs. Once frozen, the battery must be dissected and the components neutralized in a soda ash water bath. Unused or partially used Lithium must be set aside to hydrolyze.

If the battery is thawed and not dissected, the battery will return to its original state of being hot (short-circuited) and may explode.

If the battery vents or explodes, it should be handled with the procedure for vented or exploding batteries.

PROCEDURE FOR EXPLODING BATTERIES

If a battery explodes, **all personnel should be evacuated from the area.** The area should be vented to the outside until the pungent odor is no longer detectable. If the expelled material is on fire, it should be treated as described below in the procedure for a Lithium fire. After the residue has cooled, it can be absorbed with Sodium Carbonate and placed in plastic bags. All bags should be placed in a sealed and labelled drum with Vermiculite or other non-flammable cushioning material such as sand or Sodium Carbonate to cushion the s. These materials should be disposed as previously described under **Safe Disposal** in the Lithium Battery Safety Manual.

PROCEDURE FOR A LITHIUM FIRE

Evacuate the premises. Personnel should avoid breathing the smoke from a lithium fire, as it may be corrosive. Trained personnel wearing self-contained breathing apparatus or a respirator with acid gas cartridges should use Lith-X fire extinguishers to fight the fire. When the fire is extinguished and the residue cooled, it can be absorbed with Sodium Carbonate and placed in plastic bags. All bags should be placed in a sealed and labelled drum with Vermiculite or other non-flammable cushioning material such as sand or Sodium Carbonate to cushion the s. These materials should be disposed as previously described under **Safe Disposal** in the Lithium Battery Safety Manual.

LITHIUM BATTERY SAFETY

With proper use and handling, lithium batteries have demonstrated an extensive safety record. The success and wide use of lithium batteries is partially because they contain more energy per unit weight than conventional batteries. However, the same properties, which result in a high energy density also, contribute to potential hazards if the energy is released at a fast and uncontrolled rate. In recognition of the high-energy content of lithium systems, safety has been incorporated into the design and manufacture of all batteries. However, abuse or mishandling of lithium batteries can still result in hazardous conditions. The information provided here is intended to give users some guidelines to safe handling and use of lithium batteries.

Abuse

In general, the conditions that cause damage to batteries and jeopardize safety are summarized on the label of each. These conditions include:

- Short Circuit
- Charging
- Forced Over-discharge
- Excessive heating or incineration
- Crush, puncture, or disassembly

Very rough handling or high shock and vibration could result in damage.

NOT DESIGNED FOR CHARGING OR RECHARGING

PRODUCT NAME:	Lithium Oxyhalide Primary Battery (MWD)
CHEMISTRY SYSTEM:	Lithium/Thionyl Chloride
CHEMICAL FORMULAS:	Li/ SOCI2

TOXIC, CAUSTIC OR IRRITANT CONTENT

Important Note: *The battery container should not be opened or incinerated since the following ingredients contained within could be harmful under some circumstances if exposed.*
In case of accidental ingestion of a cell or its contents, obtain prompt medical advice.

MATERIALS

Lithium is included in this section due to its vigorous reaction with water forming a caustic hydroxide.

Lithium (Li)	(CAS # 7439-93-2)
Thionyl Chloride (SOCI2)	(CAS # 7719-09-7)

STORAGE AND DISPOSAL TIPS

STORAGE: Store in a cool place but prevent condensation on the batteries. Elevated temperatures can result in shortened battery life.

FIRE: If batteries are directly involved in a fire, *DO NOT USE WATER, CO2, DRY CHEMICAL OR HALOGEN EXTINGUISHERS.*

A Lith-X (graphite base) fire extinguisher or material is the only recommended extinguishing media for fires involving lithium metal or batteries. If a fire is in an adjacent area, and batteries are packed in their original containers, the fire can be fought based on fuelling material, e.g., paper, and plastic products. Avoid fume inhalation.

DISPOSAL: DO NOT INCINERATE or subject batteries to temperatures in excess of 212°F (100°C). Such abuse can result in loss of seal, leakage, and/or explosion. Dispose of in accordance with appropriate Federal, State, and Local regulations.

HANDLING AND USE PRECAUTIONS

MECHANICAL CONTAINMENT: Encapsulation (some potting) will not allow for expansion. Such enclosure can result in high-pressure explosion from heating due to inadvertent charging or high temperature environments (i.e., in excess of 100°C).
SHORT-CIRCUIT: Batteries should always be packaged and transported in such a manner as to prevent direct contact with each other. Short-circuiting will cause heat and reduce capacity. Jewellery, such as rings and bracelets, should be removed or insulated before handling the batteries to prevent inadvertent short-circuiting through contact with the battery terminals. Burns to the skin may result from the heat generated by a short- circuit.
CHARGING: These batteries are not designed to be charged or recharged. To do so may cause the batteries to leak or explode.
OTHER: If soldering or welding to the terminals or case of the battery is required, exercise proper precautions to prevent damage to the battery which may result in loss of capacity, seal, leakage, and/or explosion. DO NOT SOLDER to the case. Batteries should not be subjected to excessive mechanical shock & vibration.

HANDLING AND INSPECTION GUIDELINES

The most frequent forms of abuse can easily be identified and controlled in the workplace. All spirally, wound batteries are internally protected against the hazards associated with short circuits. This is accomplished by incorporating a fast acting fuse under the terminal cap. It is our experience that inadvertent short circuits (resulting in open fuses) are the largest single cause of field failures. Batteries with open fuses (characterized by zero voltage) should be disposed of or returned to the manufacturer for rework. Never attempt to remove the terminal cap or replace the internal fuse. Problems associated with shorting as well as other hazardous conditions can be greatly reduced by observing the following guidelines:

- ✓ Cover all metal work surfaces with an insulating material.
- ✓ The work area should be clean and free of sharp objects that could puncture the insulating sleeve on the battery.
- ✓ Never remove the shrink-wrap from a battery pack.
- ✓ All persons handling batteries should remove jewellery items such as rings, wristwatches, pendants, etc. that could be exposed to the battery terminals.
- ✓ If batteries are removed from their original packages for inspection, they should be neatly arranged to preclude shorting.
- ✓ Individual cells should be transported in plastic trays set on pushcarts. This will reduce the chances of the batteries being dropped on the floor, causing physical damage.
- ✓ All inspection tools (callipers, rulers, etc.) should be made from non-conductive materials, or covered with a non-conductive tape.
- ✓ Batteries should be inspected for physical damage. Batteries with dented cases or terminal caps should be inspected for electrolyte leakage. If any is noted, the battery should be disposed of in the proper manner.

STORAGE

Batteries should be stored in their original containers. Store batteries in a well ventilated, cool, dry area. Store batteries in an isolated area, away from combustible materials. Never stack heavy objects on top of boxes containing lithium batteries to preclude crushing or puncturing the case.

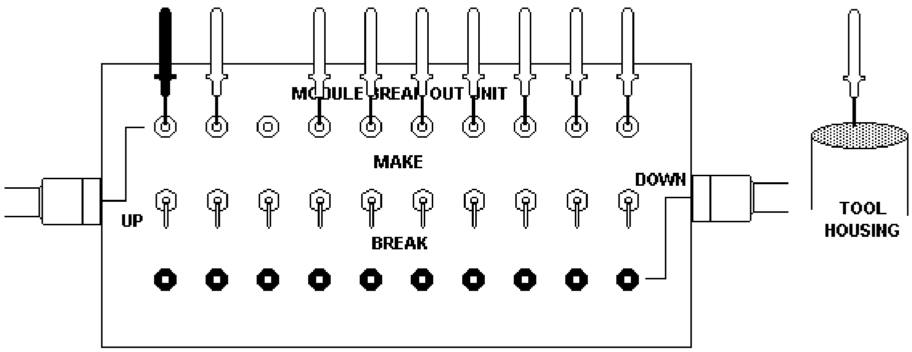
HANDLING DURING PRODUCT ASSEMBLY

- ✓ All personnel handling batteries should wear appropriate protective equipment such as safety glasses.
- ✓ Do not solder wires or tabs directly to the battery. Only solder to the leads welded to the battery by the manufacturer.
- ✓ Never touch a battery case directly with a hot soldering iron. Heat sinks should be used when soldering to the tabs, and contact with the solder tabs should be limited to a few seconds.
- ✓ Batteries should not be forced into (or out of) battery holders or housings. This could deform the battery pack causing an internal short circuit, or fracturing the glass to metal hermetic seal.
- ✓ All ovens or environmental chambers used for testing batteries should be equipped with an over-temperature controller to protect against excessive heat.
- ✓ Do not connect batteries of different chemistries together.
- ✓ Do not connect batteries of different size together.
- ✓ Do not connect old and new batteries together.
- ✓ Consult manufacturer before encapsulating batteries during discharge. Batteries may exceed their maximum rated temperature if insulated.

BATTERY INSULATION CHECK

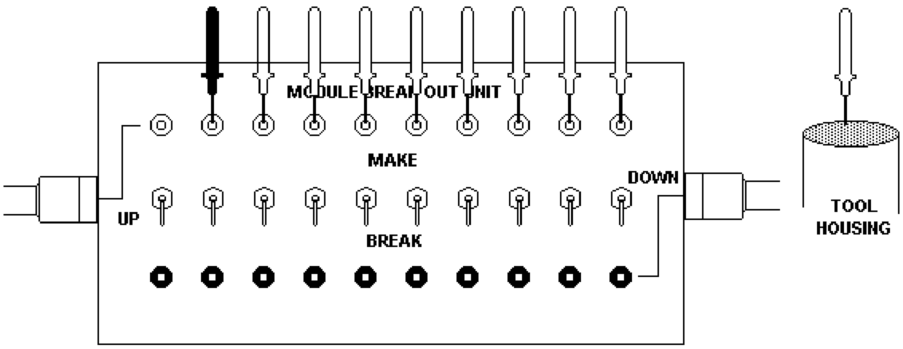
1: Install break out box in both ends of battery, with all switches in the break position.
2: Set Fluke meter to read ohms and install in red plugs 1 and 2. Check for a reading of 0L (Open)
3: Move the red lead to red plug 4, then 5 and so on down to plug 10 and finally the housing.

NOTE: Voltage will be seen across plugs 1 and 3 in this attitude and hooking an ohmeter at this point could potentially damage it.



4: Move the black lead to red plug 2 again check for a complete open.(0L)
5: Move the red lead to plug 3 and so on as in Step 3.
6: Continue moving the black lead to the right and moving the red lead to the remaining plugs and the housing until all combinations have been covered.
7: A reading of anything but 0L (Open) indicates a leak or poor insulation and the tool should not be run until the cause is identified and remedied.

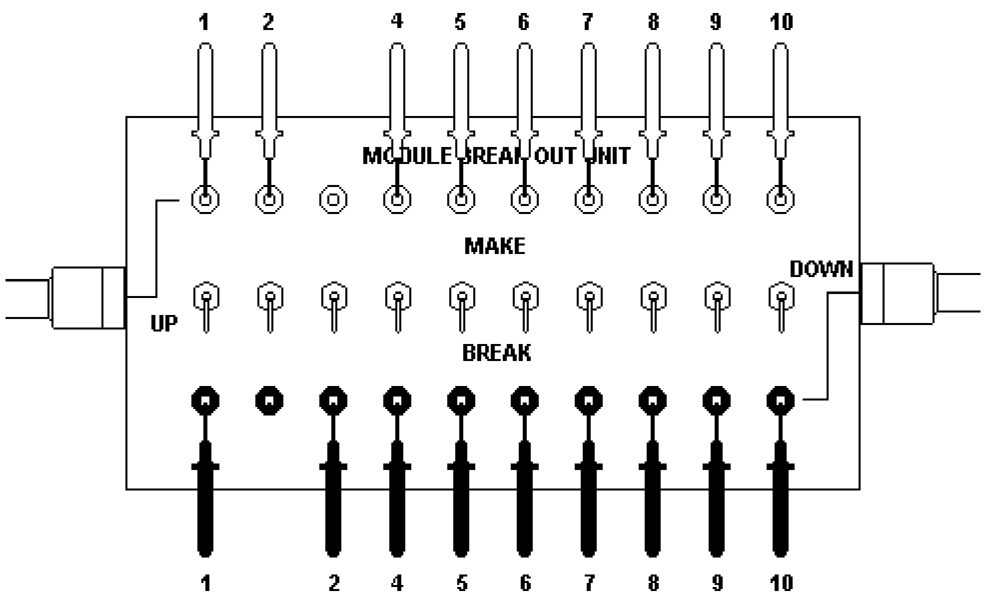
NOTE: Poor readings are often caused by dirty connections between the tool and break out box. Clean and re-check before tearing tool down.



BATTERY CONTINUITY CHECK

1: Hook up break out box to both ends of battery with switches in the BREAK position
2: Check for continuity with the Fluke meter on and leads in Black plug 1 and Red plug 1.
3: A reading of less than 1.0 Ohms should be observed and an audible beep heard.
4: Move the red lead to red plug 2 and the black lead to black plug 3 again check for less than 1.0 Ohms.
5: Do not check between Red plug 3 and Black plug 2 as the battery will be seen there.

NOTE: To facilitate running 2 batteries line 2 and 3 are switched internally in the battery.



6: Continue checking between red plug 4 and black plug 4 and so on to plug 10.

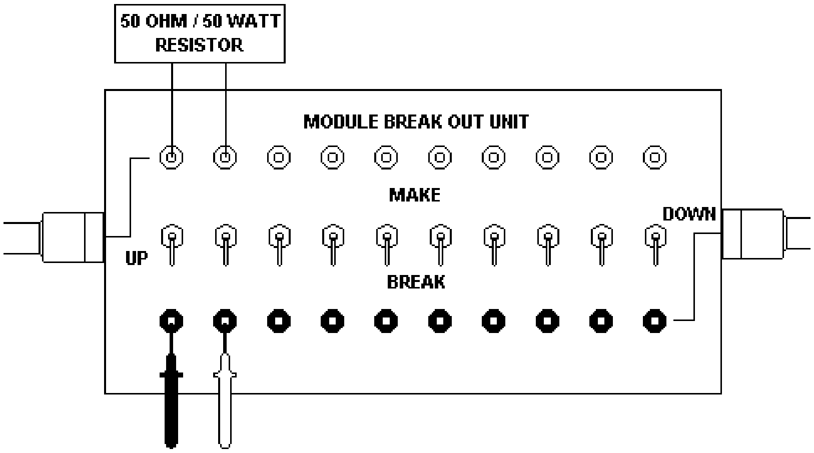
NOTE: All readings should be less than 1.0 Ohms and an audible beep should be heard if using the diode check position on the Fluke meter.

: If an Open is observed in any of these checks the tool should not be run until the cause is identified and remedied.

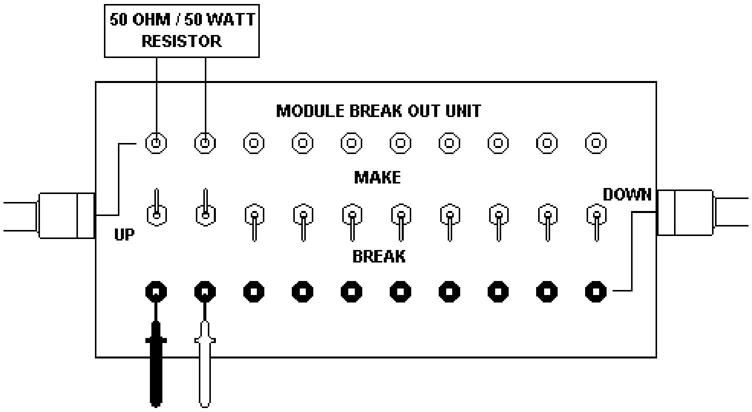
: Make sure the connection between battery and break out box is clean and a good connection is made.

BATTERY VOLTAGE CHECK OUT PROCEDURE

1: Install break out box in the top of the battery, with all switches in the break position.
2: Install load resistor in red plugs 1 and 2
3: Set Fluke meter to measure DC Volts and install in black plugs 1 and 2
4: A Voltage of **28 - 29 VDC** should be observed on standard batteries.
A voltage of 21-24 VDC should be observed on EM batteries.



5: Make switches 1 and 2, loading the battery (Max. 30 seconds)
6: A voltage of **25 - 26 VDC** should be observed for a fully charged battery
A voltage of 21-23 should be observed for a fully charged EM battery.

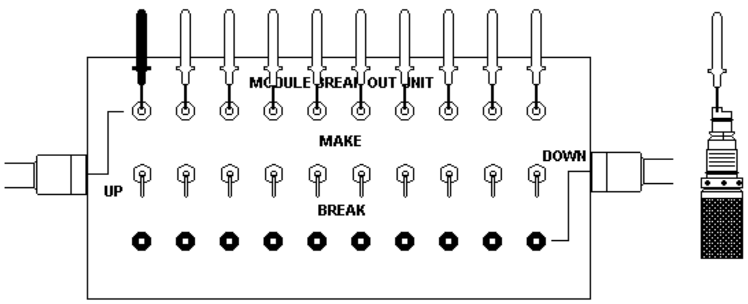


7: A loaded voltage of less than 18 **VDC** would indicate the battery is unusable.
8: If battery has sufficient voltage proceed to **BATTERY CONTINUITY AND INSULATION CHECK.**

NOTE : These tests can be performed through the electronics if the tool is assembled.
: Tests can also be performed through the bottom of the battery using plugs 1 and 3.

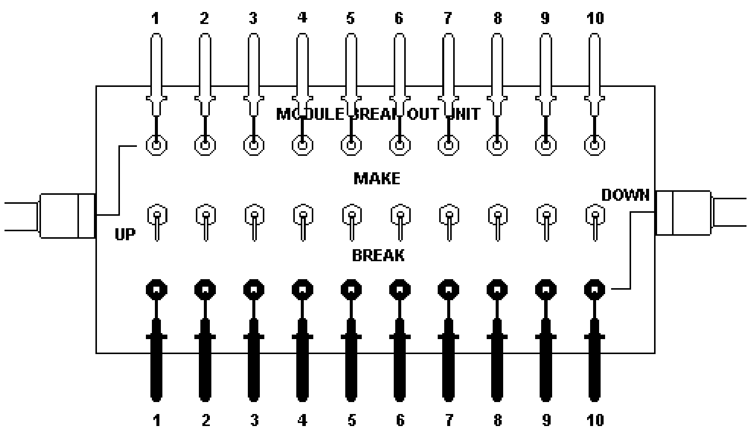
INTERMODULE CONNECTOR/BOW SPRING/FIN CENTRALIZER INSULATION AND CONTINUITY CHECK

1: Hook up break out box to both ends of interconnect with switches in the break position.
2: Hook Fluke meter set to Ohms in Red Plugs 1 and 2.
3: Move the red lead to plug 3, 4 and so on through 10 and finally the housing.
4: Readings of 0L (Open) should be observed.
5: Move the black lead to plug 2 and move the red lead to 3 through 10 and the housing.
6: Continue moving the the black lead to the right and moving the red lead to the remaining plugs and housing until all combinations have been covered.



NOTE: A reading of anything but 0L (Open) would indicate possible moisture invasion or a short, the interconnect should not be run until the cause is identified and remedied.

7: Check for continuity with the Fluke meter on and leads in Black plug 1 and Red plug 1.
8: A meter reading of less than 1.0 Ohms should be observed and an audible beep heard.

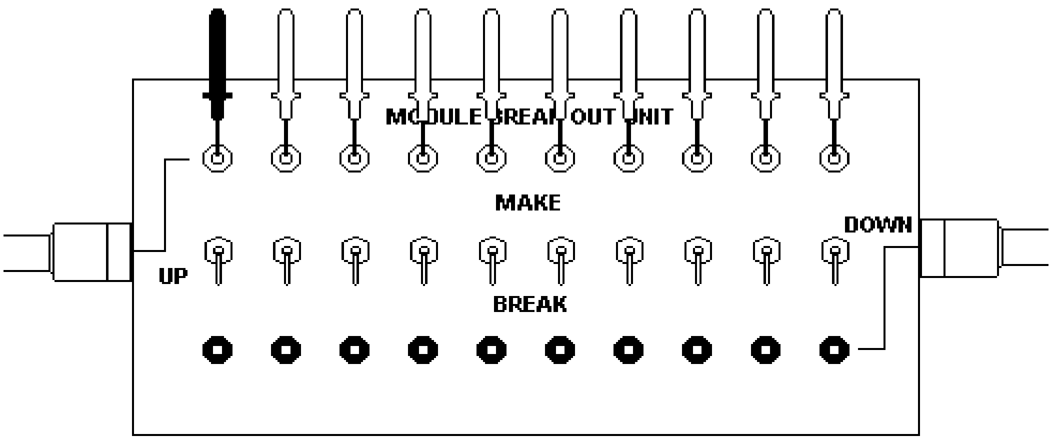


9: Continue checking between 2 - 2, and so on to 10 -10.
10: A reading other than 0 - 1 ohms without the beep would indicate an open in one of the wires.

NOTE: Poor readings could be caused by a poor connection with the break out box, clean and retest. In certain situations an interconnect failing a continuity test could be run above the electronics.

ELECTRONICS INTEGRITY AND RING OUT TEST

1: Hook up break out box on both ends of electronics with switches in the break position.
2: Set the Fluke meter to read Ohms
2: Pay particular attention to the orientation of the leads as reversing the polarity will affect readings.



3: Follow the instructions on the RING OUT TEST SHEET using the Black lead for the first plug of the combination. i.e. 4-5, Black lead in Red plug 4 and Red lead in Red plug 5.
4: Record readings on a blank ring out sheet.
5: Compare readings to ring out sheet example. Resistance readings may vary slightly from the example but Opens should be open as a variance here would indicate a leak/short.
6: If there is any extreme variances tool should not be run until the cause is determined and remedied.

NOTE: There is a protection circuit (transorbs) in the electronics to protect from over voltage a blown diode in this circuit would be evident by showing an Open instead of 0 - 1 Ohms during the 1-1, 2-2, 3-3 etc.,checks.

7: Perform a Roll test following instructions in the Roll Test Section.

E. DIRECTIONAL MODULE ASSEMBLY

E.1 MAINTENANCE

Directional Module Maintenance Procedures

The Directional Module contains the Orientation Module (OM), the Data Acquisition Assembly (DAQ), and the Electronics Strongback, which contains the Triple Power Supply (3xPS) and the Microprocessor (MPTx).

These three units are assembled
together to make the Directional Module. The OM contains the accelerometer and magnetometer sensor packages used to gather the required directional measurements used to derive the survey and toolface data necessary to drill a well. Many other forms of data can be derived from this data and from the sensors contained within the OM.

The DAQ is an analog-to-digital converter.
It is also an
integral part of the package, and must remain mated with the matching OM package. The Electronics Strongback contains the power supply that controls the power throughout the probe and the microprocessor that contains all of the firmware to operate the probe and all of the calibration data for the OM package.

These three

units operate in unison to make up the Directional Module. The integrity of the system must be maintained to assure survey accuracy and continued quality service. Technicians in the shop and operators in the field should regularly perform the MWDRoll procedure (see the following pages).

The MWDRoll procedure is included

in this manual and in the Operations Manual. The results of the MWDRoll procedure will test the calibration integrity of the module to insure that the system is providing accurate survey data and performance. It will also indicate whether any of the six sensors in the module may be defective or failed. Ideally, the test should be run before and after each run in the hole. The maintenance technician should also maintain a file on each module and perform a roll test in the shop prior to shipping the tool out to each job.

In addition to the MWDRoll test, all technicians should conduct a Ringout test (see the following pages) when the system returns to the shop. This test will inform the technician of any developing problems with the electrical integrity of the module.

In

case of any concerns with the data from the Ringout test, the technician can transmit the data to GE Power Systems for analysis. Note the different Ringout tables for the different Directional Modules in service.

Trained technicians in the shop should periodically inspect the mechanical integrity of the Directional Module. Only disassemble the module in a clean environ

ment using

complete Electro-Static Discharge (ESD) controls. ESD controls are vital to protect the electronics contained in the Directional Module. Please follow the enclosed disassembly and inspection instructions.

E.2 DISASSEMBLY, INSPECTION & REASSEMBLY

Directional Module

Disassembly, Inspection and Reassembly Procedures

Note: A roll test must be performed prior to any disassembly of the Directional Module. Repair of electronics and proper calibration of the QDT MWD orientation module can only be properly performed at the factory. Should the unit fail to pass a roll test, it should be returned to the factory for full servicing.

Servicing of MWD Directional Module

(following successful completion of MWDRoll test)

1.1. Removal of Electronics Assembly from Pressure Housing.

Note: When making or breaking threaded connections, use onlyPetol-Gearench, Parmalee wrenches, or equivalent tools with
smooth gripping surfaces to grip the barrel.

1.1.1. From the UpHole end of the module, first remove the Thread Protector (201845), then remove the Interconnect Housing (201509).

Note: The exposed connector should have 6pins/4 sockets.

1.1.2. Support the Top Bulkhead retainer (201505) and remove the two 4-40 X ¼ SCS screws (102010), which fasten it to the Intermodule End (201514). Carefully pull and disengage the tabs and slots of the Top bulkhead Retainer and the Intermodule End.

1.1.3. Rotate the Top Bulkhead Retainer to align the tabs of both pieces. While supporting the Top Bulkhead Retainer with one hand, use a ½" wooden or plastic dowel to push the 6-pin/4-socket connector in order to break free the O-ring seal. Use the ½" dowel to hold the connector while sliding the Top Bulkhead Retainer away from the assembly. Remove both halves of the Split Shell (201506).

1.1.4. Slowly unscrew the UpHole Intermodule End from the Sensor Pressure Housing (201725) while carefully passing the connector through the Intermodule End. Avoid stressing the solder connections on the connector.

1.1.5. From the DownHole end of the module, first remove the Thread Protector (201845), then remove the Interconnect Housing (201509). Carefully unscrew the remaining Intermodule End from the Sensor Pressure Housing. With the entire module lying flat, slowly slide the Intermodule End with the electronics assembly attached, from the Pressure Housing far enough to expose the Snubber Shock Assembly (201730).

Inspection of Directional Module

Note: ESD controls must be used when performing this inspection.

2.1. Inspect all accessible fasteners and check for tightness.

2.2. Inspect the UpHole end of the Snubber Shock Assembly and the DownHole end of the OM, where the two ends are joined, to make sure that the ends DO NOT rotate with respect to each other and DO NOT move lengthwise with respect to each other.

2.3. Inspect the rubber-like compound on the snubber shock for any visible signs of deterioration or separation from the structure. Check for any traces of black powder residue or other foreign matter that may indicate excessive abrasion and wear in the area of the Snubber Shock.

2.4. Check all screw connections along the assembly as it is carefully removed from the Pressure Housing. It is very important to provide support to the Snubber Shock as the tool is removed.

Reassembly of Directional Module

3.1. Clean and inspect all O-rings. Replace all damaged or old O-rings. Lubricate O-rings thoroughly with DC4 (400041). Clean and inspect all mating threads and O-ring surfaces.

3.2. Carefully slide the assembly back into the lower end of the pressure Housing and screw together hand tight.

3.3. Carefully thread the pigtail through the UpHole Intermodule End and screw it in place hand tight.

Note: The castellated end with the two screw holes should be left exposed.
3.4. Match the Split Shell pair around the UpHole 6-pin connector and hold with one hand. Line up the slot, in the UpHole end of the Top Bulkhead Retainer, with the key on the 6-pin connector and carefully slide the retainer over the connector into place. Insure that the connector key engages properly into the slot of the retainer.

3.5. Rotate the Top Bulkhead Retainer to align the two screw holes (and also align the tabs with the Top Bulkhead Retainer slots and the UpHole Intermodule End.) Secure the Top Bulkhead Retainer with two 4-40 X ¼ SCS screws (102010) and removable Loctite 243 in paste form. (Refer to Notes on Assembly Procedure.)

3.6. Install the remaining Interconnect Housing and make up all connections with the barrel wrenches to approximately 120 ft-lb. torque.

3.7. Perform the MWDRoll test procedure. Install two thread protectors with O-rings (381611) installed and greased.

Note: If the Directional Module fails to pass the roll test, transmit the data to GE Power Systems Tensor MWD Technical Services. GE Power Systems personnel will review the data to determine whether the module should be returned to the factory. Should the Directional Module continue to fail the MWDRoll test procedure, then it must be returned to the manufacturer for proper testing and re-calibration.

E.3 RING OUT SHEET

RING OUT SHEET

Ring Out Sheet for the MWD Directional Module containing the Single Port MPU w/8MB Recorder Memory, PN 384086

1-BAR>1M ohm	2-BAR>1M ohm	3-BAR>1M ohm	4-BAR>1M ohm	5-BAR>1M ohm	6-BAR>1M ohm	7-BAR>1M ohm	8-BAR>1M ohm	9-BAR>1M ohm	10-BAR>1M ohm
1-1<1 ohm				Notes: Do NOT use MEGGER type meters: they will DAMAGE the electronic modules. Use a Fluke brand Digital Voltmeter (DVM) to make all measurements. Polarity must be observed to make correct measurements, connect the; Red or (+) lead to the DownHole end. Black or (-) lead to the UpHole end. Pay close attention to the "<" & " >" signs on the chart. Resistances can vary due to normal variation in electronic components, but should never be > the max. or < the min. readings shown.					
1-2>1M ohm	2-2<1 ohm								
1-3>1M ohm	2-3>1M ohm	3-3<1 ohm							
1-4>37.5 K ohm	2-4>1M ohm	3-4>1M ohm	4-4<1 ohm						
1-5>35 K ohm	2-5>1M ohm	3-5>1M ohm	4-5>75 K ohm	5-5<1 ohm					
1-6>45 K ohm	2-6>1M ohm	3-6>1M ohm	4-6>45 K ohm	5-6>100 K ohm	6-6<1 ohm				
1-7>1M ohm	2-7>1M ohm	3-7>1M ohm	4-7>1M ohm	5-7>1M ohm	6-7>1M ohm	7-7<1 ohm			
1-8>35 K ohm	2-8>1M ohm	3-8>1M ohm	4-8>25 K ohm	5-8>75K ohm	6-8>80 K ohm	7-8>1M ohm	8-8<1 ohm		
1-9>1M ohm	2-9>1M ohm	3-9>1M ohm	4-9>1M ohm	5-9>1M ohm	6-9>1M ohm	7-9>1M ohm	8-9>1M ohm	9-9<1 ohm	
1-10>45K ohm	2-10>1M ohm	3-10>1M ohm	4-10>75K ohm	5-10>75K ohm	6-10>75K ohm	7-10>1M ohm	8-10>75K ohm	9-10>1M ohm	10-10<1 ohm

Ring Out Sheet for the MWD Directional Module containing the Single Port MPU without Recorder Memory, PN 384040

1-BAR>1M ohm	2-BAR>1M ohm	3-BAR>1M ohm	4-BAR>1M ohm	5-BAR>1M ohm	6-BAR>1M ohm	7-BAR>1M ohm	8-BAR>1M ohm	9-BAR>1M ohm	10-BAR>1M ohm
1-1<1 ohm									
1-2>1M ohm	2-2<1 ohm								
1-3>1M ohm	2-3>1M ohm	3-3<1 ohm							
1-4>37.5 K ohm	2-4>1M ohm	3-4>1M ohm	4-4<1 ohm						
1-5>1M ohm	2-5>1M ohm	3-5>1M ohm	4-5>1M ohm	5-5<1 ohm					
1-6>45 K ohm	2-6>1M ohm	3-6>1M ohm	4-6>45 K ohm	5-6>1M ohm	6-6<1 ohm				
1-7>1M ohm	2-7>1M ohm	3-7>1M ohm	4-7>1M ohm	5-7>1M ohm	6-7>1M ohm	7-7<1 ohm			
1-8>30 K ohm	2-8>1M ohm	3-8>1M ohm	4-8>25 K ohm	5-8>1M ohm	6-8>80 K ohm	7-8>1M ohm	8-8<1 ohm		
1-9>1M ohm	2-9>1M ohm	3-9>1M ohm	4-9>1M ohm	5-9>1M ohm	6-9>1M ohm	7-9>1M ohm	8-9>1M ohm	9-9<1 ohm	
1-10>1M ohm	2-10>1M ohm	3-10>1M ohm	4-10>1M ohm	5-10>1M ohm	6-10>1M ohm	7-10>1M ohm	8-10>1M ohm	9-10>1M ohm	10-10<1 ohm

Notes:

Do NOT use MEGGER type meters: they will DAMAGE the electronic modules.
Use a Fluke brand Digital Voltmeter (DVM) to make all measurements.

Polarity must be observed to make correct measurements, connect the;

Red or (+) lead to the DownHole end.

Black or (-) lead to the UpHole end.

Pay close attention to the "<" & " >" signs on the chart.
Resistances can vary due to normal variation in electronic components, but should never be > the max. or < the min. readings shown.

MWD 150C MPU Ringout Sheet

Ring Out Sheet for the MWD Direction Module
Containing the 150 C Single Port MPU without Recorder Memory,PN 384085

1-BAR>1M ohm	2-BAR>1M ohm	3-BAR>1M ohm	4-BAR>1M ohm	5-BAR>1M ohm	6-BAR>1M ohm	7-BAR>1M ohm	8-BAR>1M ohm	9-BAR>1M ohm	10-BAR>1M ohm
1-1<1ohm									
1-2>1M ohm	2-2<1 ohm								
1-3>1M ohm	2-3>1M ohm	3-3<1 ohm							
1-4>37.5K ohm	2-4>1M ohm	3-4>1M ohm	4-4<1 ohm						
1-5>1M ohm	2-5>1M ohm	3-5>1M ohm	4-5>1M ohm	5-5<1 ohm					
1-6>45K ohm	2-6>1M ohm	3-6>1M ohm	4-6>45K ohm	5-6>1M ohm	6-6<1 ohm				
1-7>1M ohm	2-7>1M ohm	3-7>1M ohm	4-7>1M ohm	5-7>1M ohm	6-7>1M ohm	7-7<1 ohm			
1-8>30K ohm	2-8>1M ohm	3-8>1M ohm	4-8>25K ohm	5-8>1M ohm	6-8>80K ohm	7-8>1M ohm	8-8<1 ohm		
1-9>1M ohm	2-9>1M ohm	3-9>1M ohm	4-9>1M ohm	5-9>1M ohm	6-9>1M ohm	7-9>1M ohm	8-9>1M ohm	9-9<1 ohm	
1-10>1M ohm	2-10>1M ohm	3-10>1M ohm	4-10>1M ohm	5-10>1M ohm	6-10>1M ohm	7-10>1M ohm	8-10>1M ohm	9-10>1M ohm	10-10<1 ohm

Document #0014

MWD 175C MPU Ringout Sheet

Ring Out Sheet for the MWD Direction Module
Containing the 175 C Single Port MPU w/8MB Recorder Memory,PN 384086

1-BAR>1M ohm	2-BAR>1M ohm	3-BAR>1M ohm	4-BAR>1M ohm	5-BAR>1M ohm	6-BAR>1M ohm	7-BAR>1M ohm	8-BAR>1M ohm	9-BAR>1M ohm	10-BAR>1M ohm
1-1<1ohm									
1-2>1M ohm	2-2<1 ohm								
1-3>1M ohm	2-3>1M ohm	3-3<1 ohm							
1-4>37.5K ohm	2-4>1M ohm	3-4>1M ohm	4-4<1 ohm						
1-5>35K ohm	2-5>1M ohm	3-5>1M ohm	4-5>75K ohm	5-5<1 ohm					
1-6>45K ohm	2-6>1M ohm	3-6>1M ohm	4-6>45K ohm	5-6>100K ohm	6-6<1 ohm				
1-7>1M ohm	2-7>1M ohm	3-7>1M ohm	4-7>1M ohm	5-7>1M ohm	6-7>1M ohm	7-7<1 ohm			
1-8>35K ohm	2-8>1M ohm	3-8>1M ohm	4-8>25K ohm	5-8>75K ohm	6-8>80K ohm	7-8>1M ohm	8-8<1 ohm		
1-9>1M ohm	2-9>1M ohm	3-9>1M ohm	4-9>1M ohm	5-9>1M ohm	6-9>1M ohm	7-9>1M ohm	8-9>1M ohm	9-9<1 ohm	
1-10>45K ohm	2-10>1M ohm	3-10>1M ohm	4-10>75K ohm	5-10>75K ohm	6-10>75K ohm	7-10>1M ohm	8-10>75K ohm	9-10>1M ohm	10-10<1 ohm

Document #0015

E.4 BOM COMPASS

BOM: Directional Module (Tensor - Compass)

Asset

Part Number	Size	Product Line	Description
502001	1-7/8"	MWD	Directional Module, Compass, 150° C

Serialized Part

Part Number	Size	Product Line	Description
502001S	1-7/8"	MWD	Directional Module, Compass, 150° C
502005	Common	MWD	Directional Sensor, Compass, 150° C
502006	Common	MWD	Directional Sensor, Compass, 175° C Hot Hole
502010	Common	MWD	Directional Interface, Compass 175° C Hot Hole

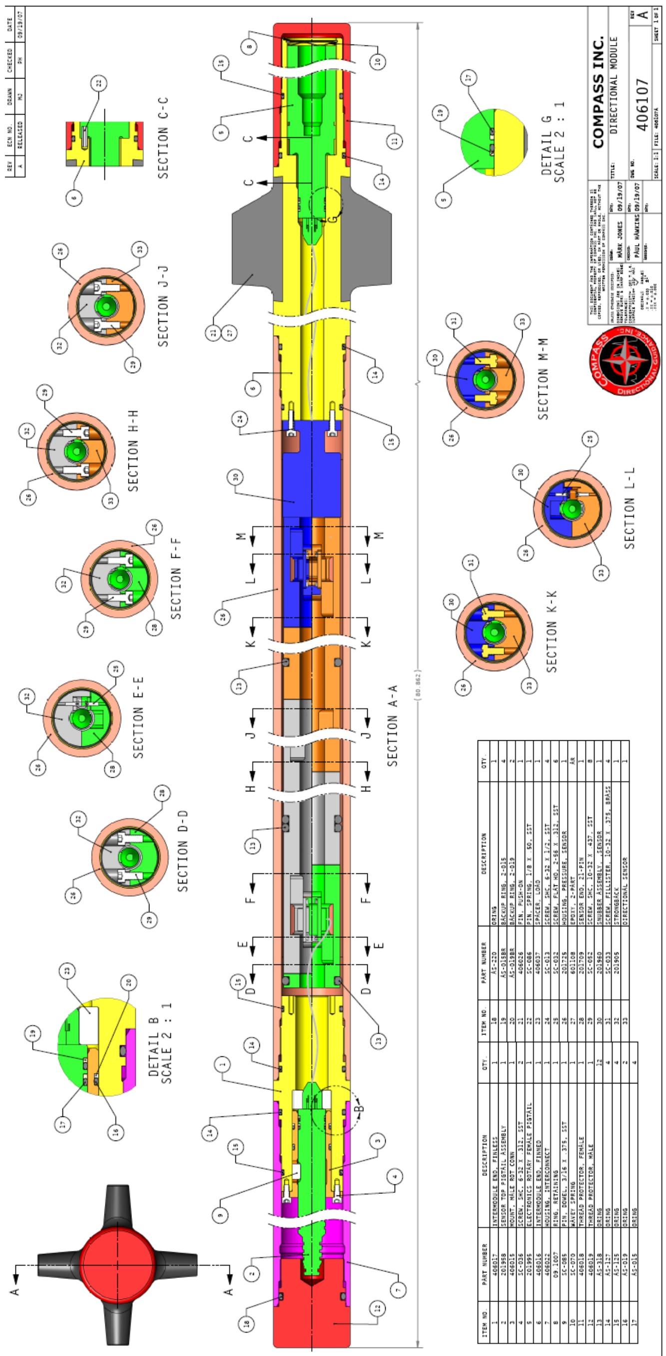
Non-Serialized Part

Part Number	Size	Product Line	Description	Quantity
201509	1-7/8"	MWD	Housing, Interconnect	2.00
201514	1-7/8"	MWD	Intermodule End	2.00
201725	1-7/8"	MWD	Housing, Sensor	1.00
201845	1-7/8"	MWD	Thread Protector, Male	2.00
120001	Common	MWD	Temp Tab "B"	1.00
120002	Common	MWD	Temp Tab "C"	1.00
201505	Common	MWD	Bulkhead Retainer, Top (90 Degree)	1.00
201506	Common	MWD	Split Shell	2.00
201521	Common	MWD	Bulkhead Retainer, Bottom (45 Degree)	1.00
201709	Common	MWD	Sensor End	1.00
201957	Common	MWD	Pigtail, Electronics	1.00
201959	Common	MWD	Snubber, Electronics	1.00
201993	Common	MWD	Transorb	1.00
AS-124	Common	MWD	AS-124 O-Ring, Viton	2.00
AS-127	Common	MWD	AS-127 O-Ring, Viton	2.00
AS-217	Common	MWD	AS-217 O-Ring, Viton	4.00
AS-218	Common	MWD	AS-218 O-Ring, Viton	2.00

Non-Serialized Part

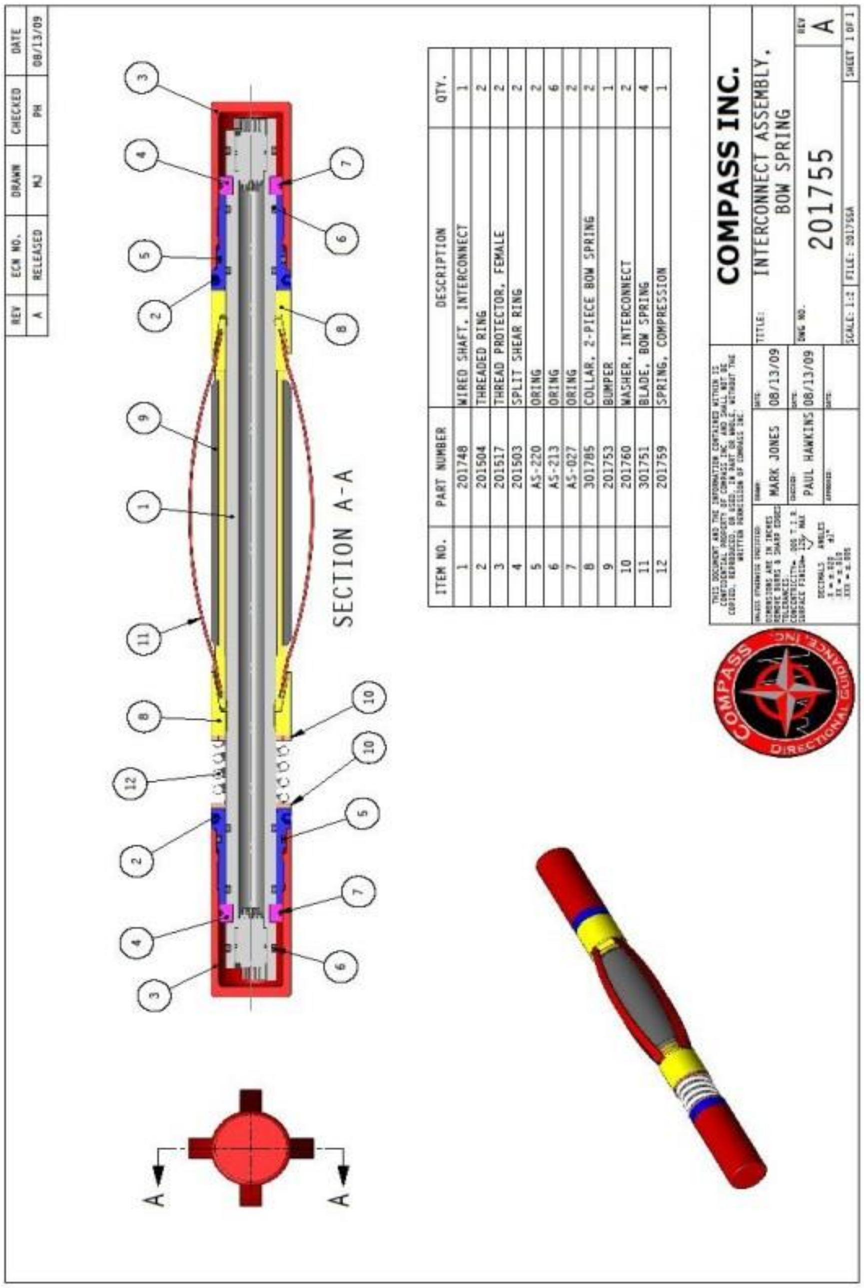
Part Number	Size	Product Line	Description	Quantity
AS-220	Common	MWD	AS-220 O-Ring, Viton	4.00
SC-013	Common	MWD	Screw, 6-32 x 1/2" SHCS, SS	4.00
SC-015	Common	MWD	Screw, 4-40 x 1/4" SHCS, SS	4.00
SC-016	Common	MWD	Screw, 6-32 x 3/8" SHCS, SS	2.00
SC-033	Common	MWD	Screw, 10-32 x 3/8" Fillister Brass	4.00
SC-049	Common	MWD	Shim, MDM Connector, Brass	8.00
SC-052	Common	MWD	Screw, 10-32 x 3/8" SHCS, SS	8.00
SC-059	Common	MWD	Screw, 2-56 x 1/4" Pan Head, SS	4.00

E.5 BOM SOC


COMPASS INC.
DIRECTIONAL MODULE
406107
SECTION A-A
SECTION C-C
SECTION D-D
SECTION E-E
SECTION F-F
SECTION H-H
SECTION J-J
SECTION K-K
SECTION L-L
SECTION M-M
DETAIL B
SCALE 2 : 1
DETAIL G
SCALE 2 : 1

F. CENTRALIZERS

F 1 ASSEMBLY DRAWING– BOW SPRING



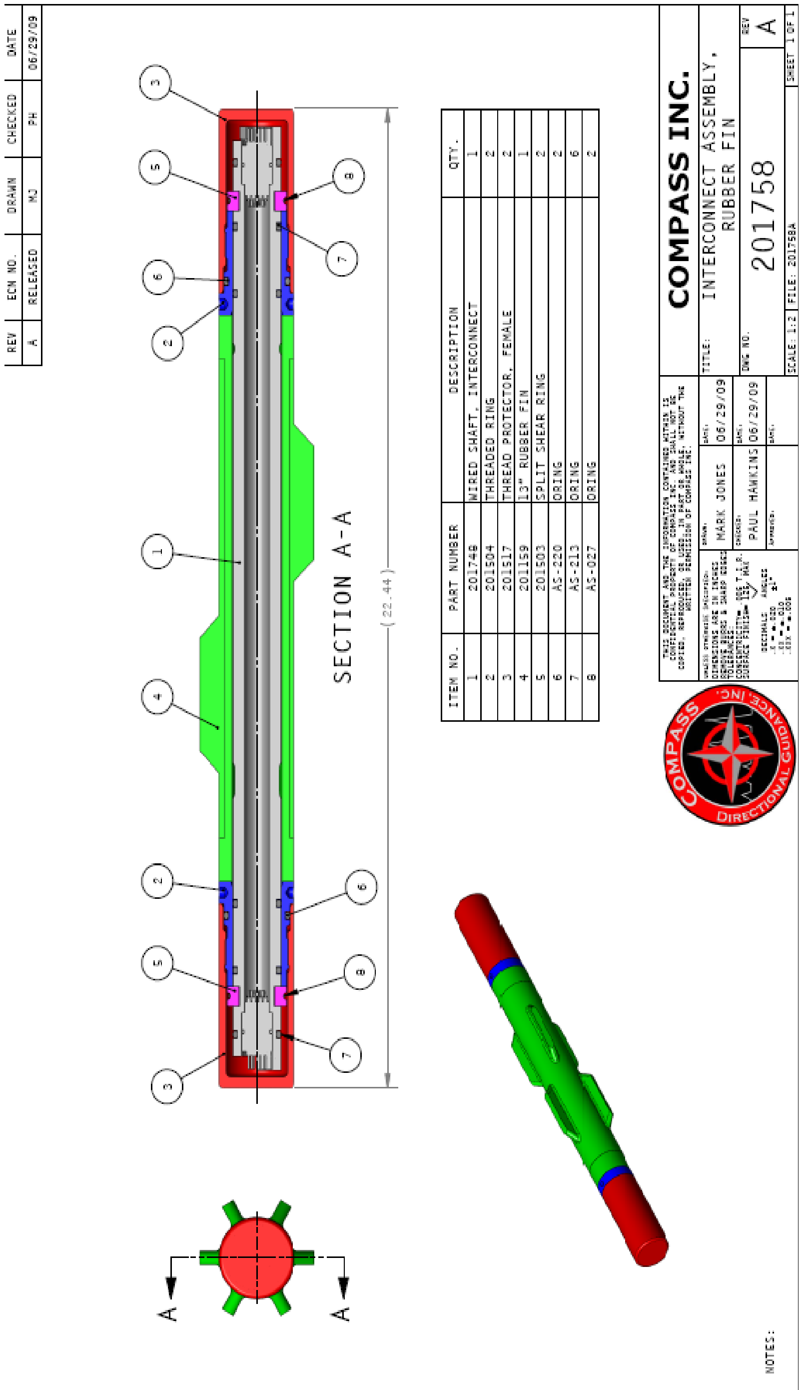
F.2 BOM BOW SPRING

BOM: Interconnect Assembly, Bow Spring

Non-Serialized Part

Part Number	Size	Product Line	Description	Quantity
201504	1-7/8"	MWD	Threaded Rings	2.00
201517	1-7/8"	MWD	Thread Protector, Female	2.00
201503	Common	MWD	Split Shear Rings	2.00
201748	Common	MWD	Wired Shaft, Interconnect	1.00
201751	Common	MWD	Blade, Bow Spring	4.00
201753	Common	MWD	Bumper	1.00
201755	Common	MWD	Interconnect, Bow Spring Assembly	1.00
201759	Common	MWD	Spring, Compression	1.00
201760	Common	MWD	Washer, Interconnect	2.00
301785	Common	MWD	Collar, 2-Piece Bow Spring, 4 Blade	2.00
AS-027	Common	MWD	AS-027 O-Ring, Viton	2.00
AS-213	Common	MWD	AS-213 O-Ring, Viton	6.00
AS-220	Common	MWD	AS-220 O-Ring, Viton	2.00
SC-020	Common	MWD	Roll Pin, 5/32" x 1"-420 SS Muleshoe Key	1.00

F.3 ASSEMBLY DRAWING – RUBBER FIN



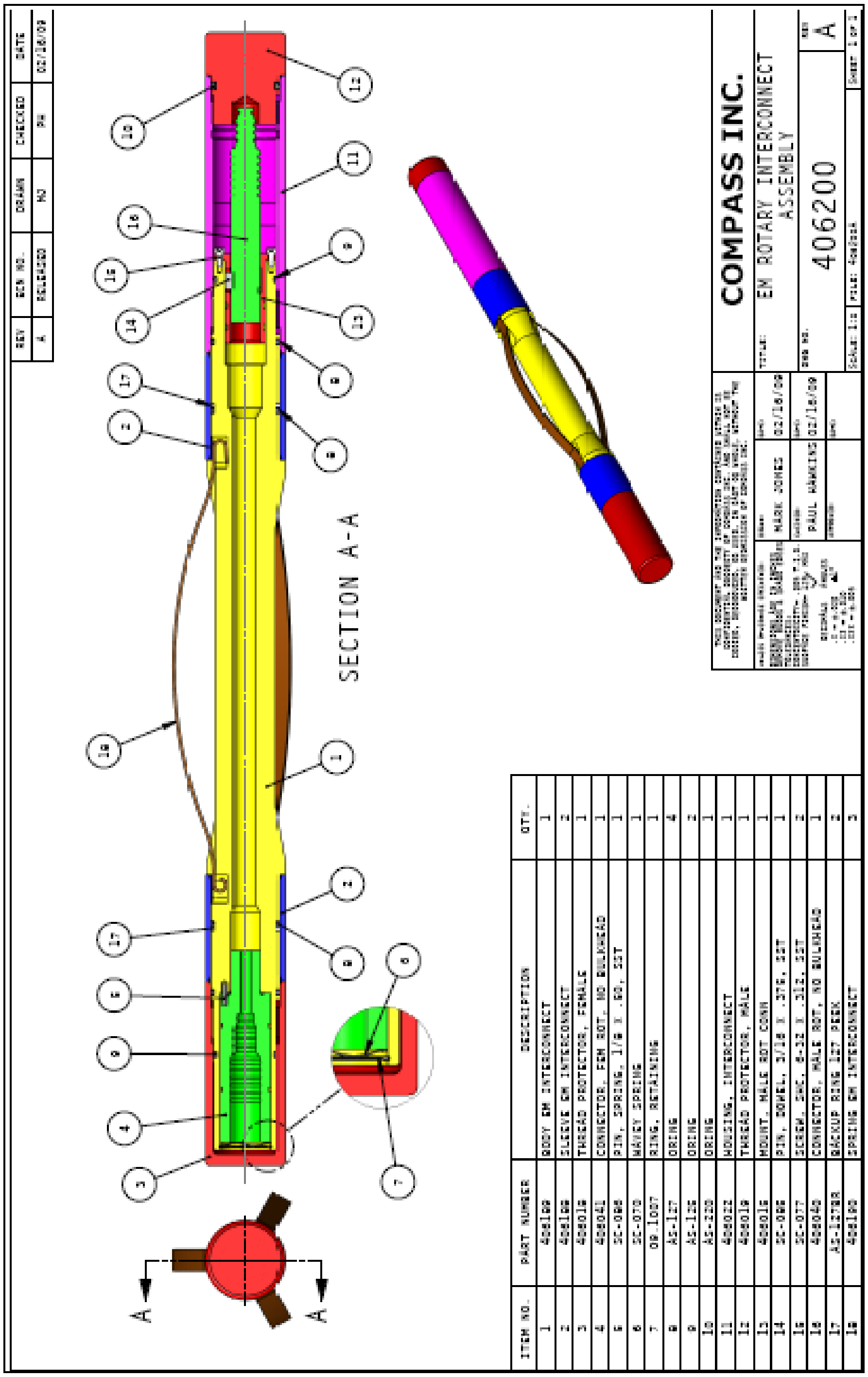
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	201748	WIRED SHAFT, INTERCONNECT	1
2	201504	THREADED RING	2
3	201517	THREAD PROTECTOR, FEMALE	2
4	201159	13" RUBBER FIN	1
5	201503	SPLIT SHEAR RING	2
6	AS-220	ORING	2
7	AS-213	ORING	6
8	AS-027	ORING	2

F.4 BOM – BOW SPRING

BOM: Kit, Bow Spring (EM)

Non-Serialized Part

Part Number	Size	Product Line	Description	Quantity
201753	Common	MWD	Bumper	1.00
201754	Common	MWD	Interconnect Spacer	2.00
201759	Common	MWD	Spring, Compression	1.00
301751	Common	MWD	Blade, EM Bow Spring	4.00
301785	Common	MWD	Collar, 2-Piece Bow Spring, 4 Blade	2.00
384035	Common	MWD	Connector, DB9 (Female)	1.00



F.5 BOM – COMPASS ROTARY

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	406199	BODY EM INTERCONNECT	1
2	406198	SLEEVE EM INTERCONNECT	2
3	406019	THREAD PROTECTOR, FEMALE	1
4	406041	CONNECTOR, FEM ROT, NO BULKHEAD	1
5	SC-088	PIN, SPRING, 1/8 X .60, SST	1
6	SC-070	WAVEY SPRING	1
7	09.1007	RING, RETAINING	1
8	AS-127	ORING	4
9	AS-126	ORING	2
10	AS-220	ORING	1
11	406022	HOUSING, INTERCONNECT	1
12	406019	THREAD PROTECTOR, MALE	1
13	406016	MOUNT, MALE ROT CONN	1
14	SC-086	PIN, DOWEL, 3/16 X .375, SST	1
15	SC-077	SCREW, SHC, 8-32 X .312, SST	2
16	406040	CONNECTOR, MALE ROT, NO BULKHEAD	1
17	AS-127BR	BACKUP RING 127 PEEK	2
18	406190	SPRING EM INTERCONNECT	3

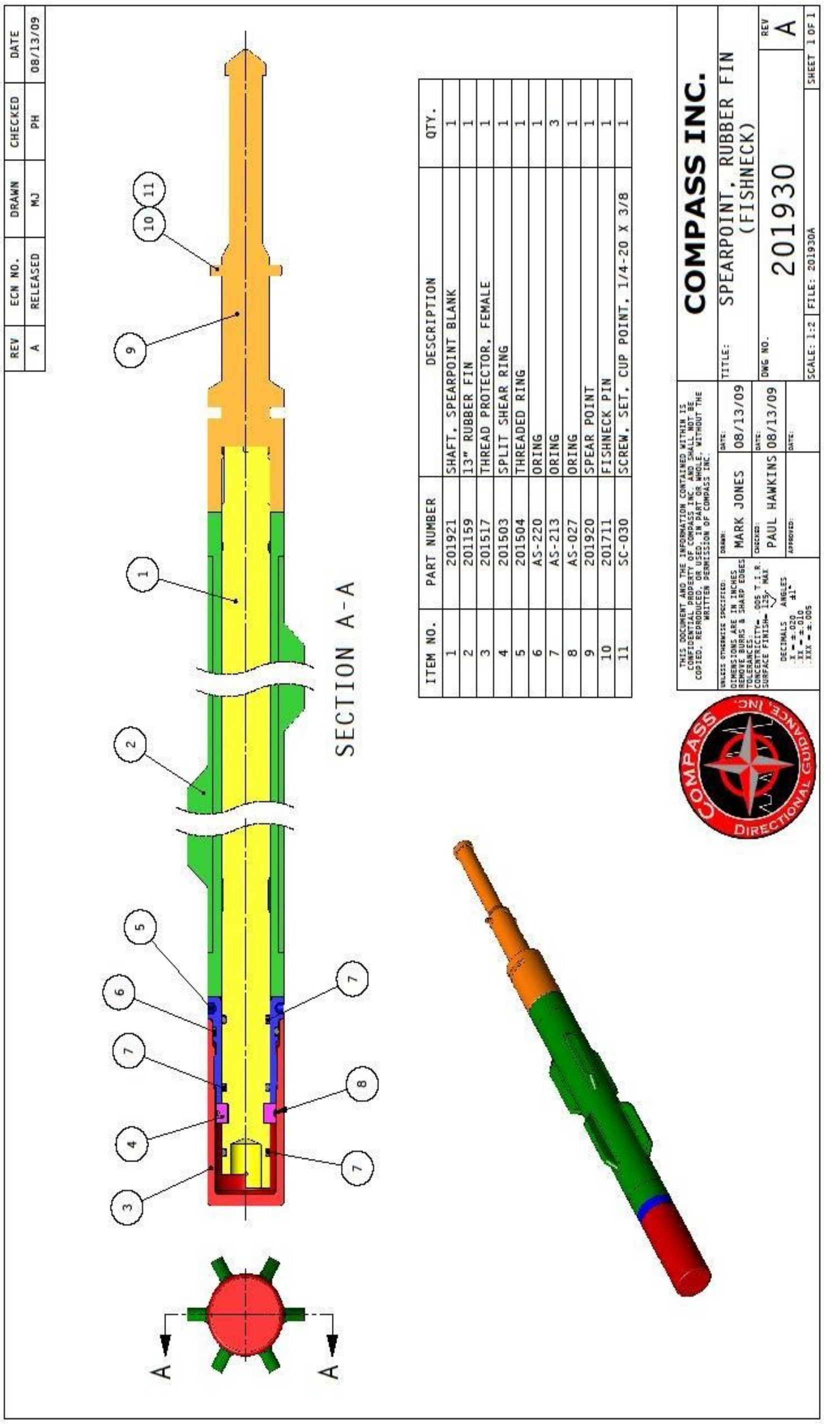
F.6 SLIPOVER CENTRALIZER PART NUMBER 601159

Side View

Cross Section View

G. SPEARPOINT-201925

G.1 ASSEMBLY DRAWING



G.2 BOM – SPEARPOINT ASSEMBLY

BOM: Spearpoint Kit, Rubber Fin (Fishneck)

Non-Serialized Part

Part Number	Size	Product Line	Description	Quantity
201504	1-7/8"	MWD	Threaded Rings	1.00
201517	1-7/8"	MWD	Thread Protector, Female	1.00
201920	1-7/8"	MWD	Spear Point	1.00
201930	1-7/8"	MWD	Spearpoint Kit (Rubber Fin)	1.00
201159	Common	MWD	13" Rubber Fin	1.00
201503	Common	MWD	Split Shear Rings	1.00
AS-027	Common	MWD	AS-027 O-Ring, Viton	1.00
AS-213	Common	MWD	AS-213 O-Ring, Viton	3.00
AS-220	Common	MWD	AS-220 O-Ring, Viton	1.00
T-15	Common	MWD	Blank Shaft	1.00

H. MWD PULSER SETUP & TOOL PARAMETERS

H.1 MWD PULSER SETUP & PARAMETERS

Pulser/MWD Probe Operational Parameters

When preparing the system for a job, the field operator must choose several hardware and software parameters. The well environment where the system will be used determines the choices. This document names the parameters, discusses some of the options and leaves other options to the MWD operator's discretion.

1. Hardware Parameters:
   a. Drill Collar Size
   b. MWD System Module Selection and Configuration
   c. Signal Orifice Size Selection
   d. Poppet End Size Selection

2. Software Parameters (That Affect System Operation)
   a. Data Word Update Times (Pulse Durations)
   b. Survey Data Selection for Transmission
   c. Toolface/Logging Data Selection for Transmission
   d. Downlinking Capabilities

All parameters, hardware and software, are synergistic: changing one may affect another. Therefore, consider all settings before deploying the system into the field.

1. Hardware Parameters
a. Drill Collar Size

The well design will determine the BHA and the collars used in it. However, the MWD operators must be extremely aware of the parameters of the well sections that will use the MWD system. Extreme flow around the body of the MWD probe can cause severe damage to the pressure barrels and other parts exposed to severe turbulent flow. Therefore, it is extremely important for the MWD operators to determine the maximum possible flow rates planned for the well in each of the different well sections.
Refer to *Figure 1* to assist in determining which I.D. would be best suited for the flow rates selected for each hole section involved. Flow velocities of over 40 feet/second can begin rapid erosion of the BeCu pressure barrels and other metal parts on the probe.

FLUID Velocities in NMDC

Fluid velocities in and around the MWD tool are extremely important. The MWD operator is required to KNOW the ID of the NMDC and what the maximum flow for that particular size collar is allowed. The chart is calculated on the use of water with very low solids.

Across the top of the chart is the list of collar ID sizes from 2.25" minimum ID to 4.00" maximum ID. The list of collar ID sizes coordinate with colors to match the curve drawn on the chart. On the left side of the chart is the scale for fluid velocities from 0 ft/second to 50 ft/second. The red line across the top indicates a velocity of 40 ft/second. Along the bottom of the chart is the scale for gallons per minute (GPM), from 0 GPM to 1200 GPM. Along the top of the chart, the red line indicates 40 feet/second flow velocity. At 40 feet/ second, the critical flow rate, water flow at that rate will begin to remove metal from the body of the MWD tool. Add to the water, solids and sand, the velocity of the fluid will become more hazardous to the condition of the metal.

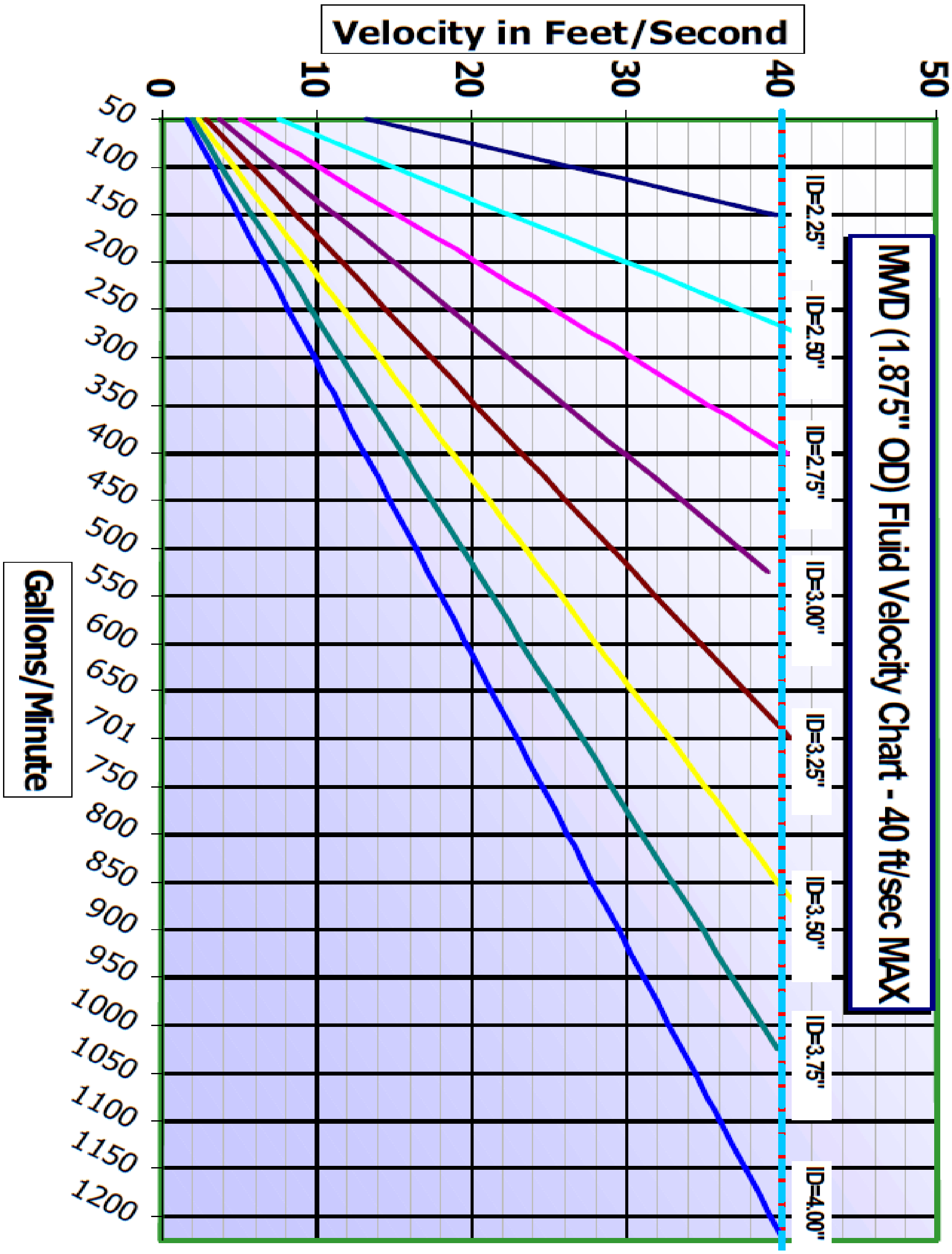
To use the chart, select the ID size of the collar being used on the job and select the curve that most closely relates to the size. Always select the next smaller size ID for calculations, should the ID of the collar on the rig site not perfectly match the size on the chart. Select the maximum flow rate expected for the job on the bottom scale and move up the chart until the line representing the ID size of the collar being used is intersected. Move across to the left of the chart to the scale on the left to determine the expected fluid velocity for the job.

If the GPM selected intersects the curve above the 40 ft/second line, then adjustments must be made in either the selected flow or the ID of the drill collar.

Example: Using a 3.0" ID collar, with an expected flow of 500 GPM. This would result in a **37 feet/second** flow velocity around the MWD tool.

Example: Using a 2.5" ID collar, with an expected flow of 450 GPM would result in a fluid velocity in excess of 65 feet/second. This is not acceptable and a change in the collar with a larger ID must be made, or the flow must be reduced to a range below 300 GPM.

COMPASS DIRECTIONAL GUIDANCE, INC.



MWD System Module Selection and Configuration

Battery selection is a very important decision to be made when designing the configuration of the tool module location. The MWD tool is designed to run either one or two battery packs, depending upon the design of the bit run the tool will be used in. There are numerous options to consider when designing the MWD tool to match the conditions of the bit run. The conditions of the bit run to consider are: (the order of the list is not relevant to the importance of each item – each item must be considered for its individual importance in relation to the bit run)

(i) Duration of the bit run.

(ii) Pulse width choice.

(iii) Sensor choice – gamma sensor reduces battery duration by a factor of ½.

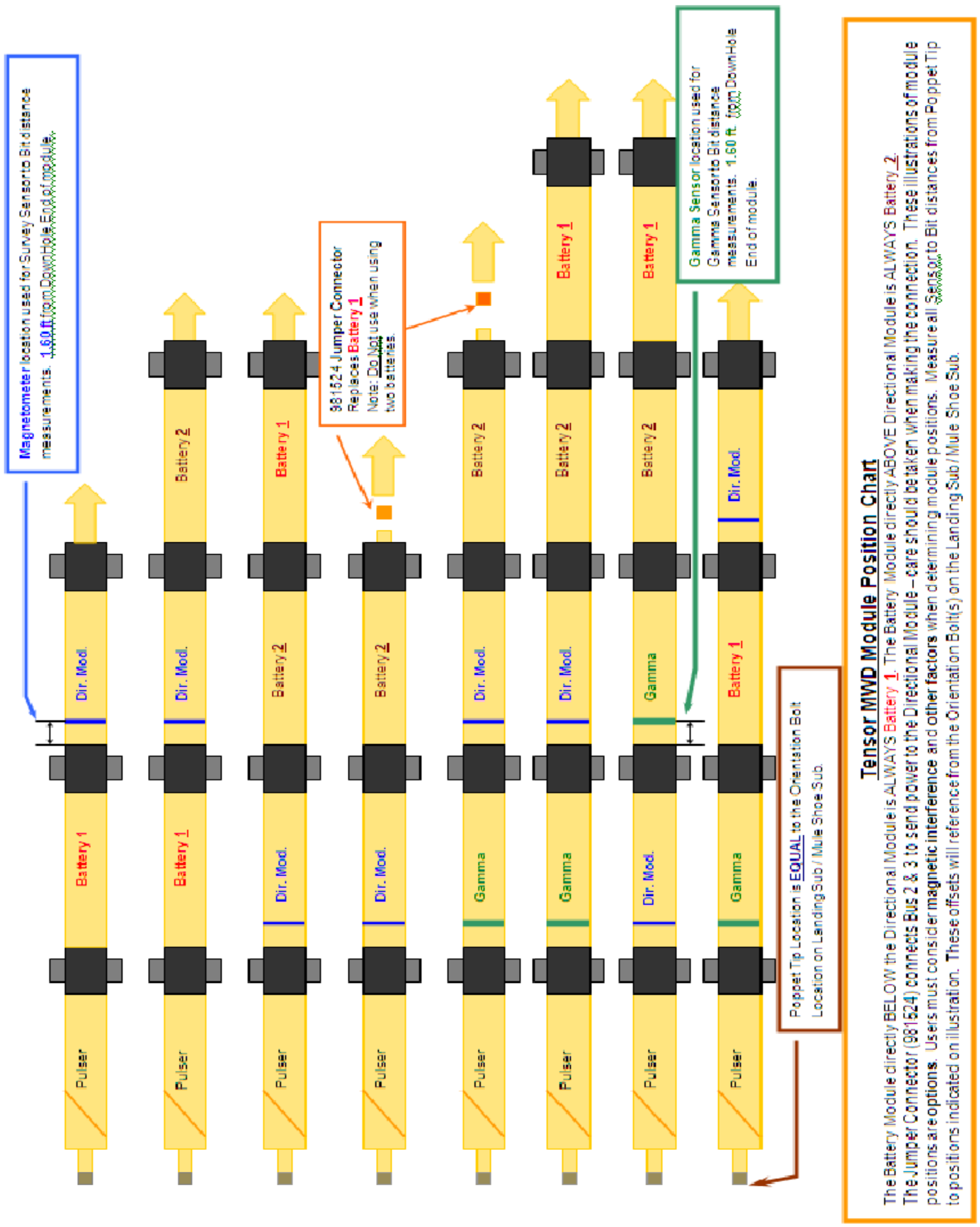
(iv) Desire to deplete used battery and switch to new battery during run.

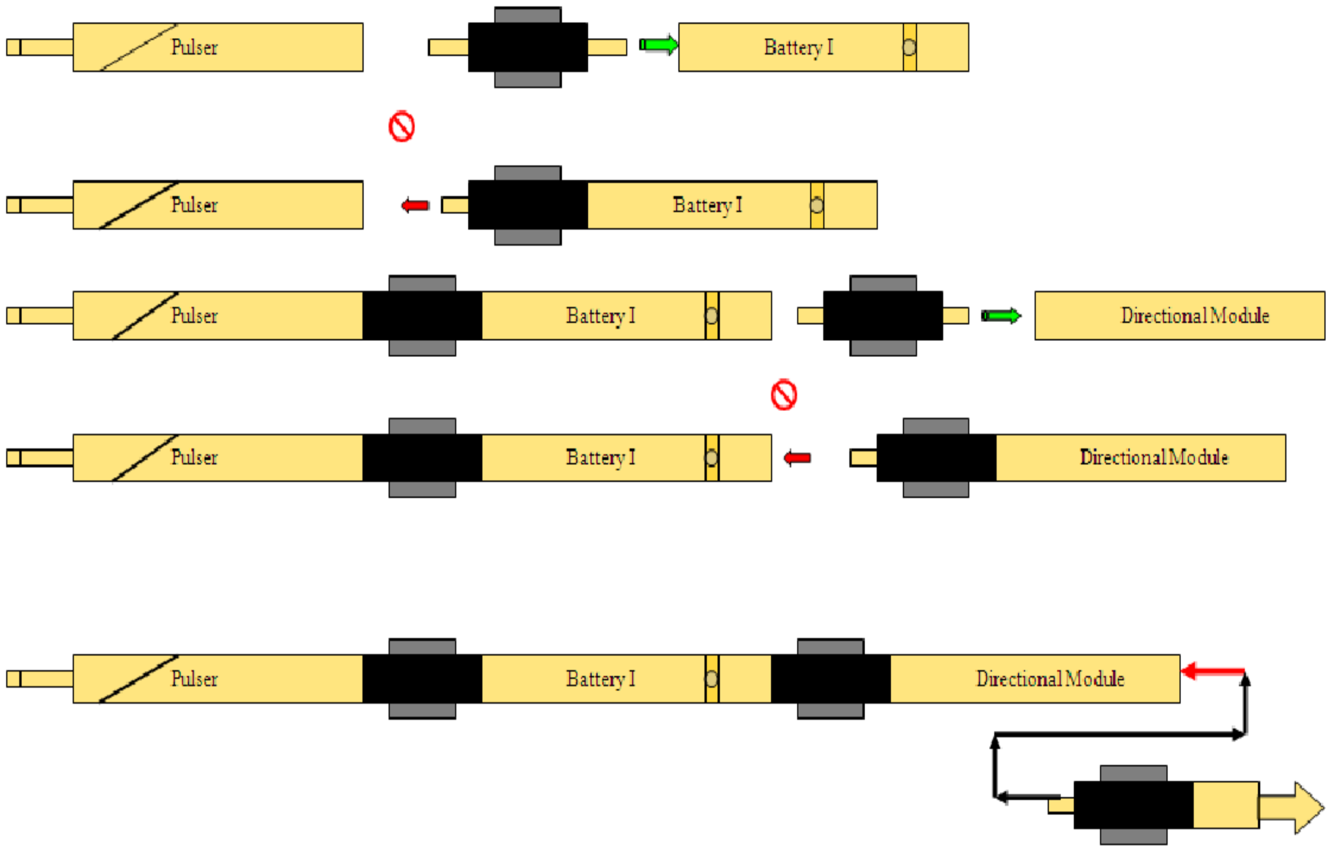
Calculations and testing have shown that one lithium battery pack will operate the basic MWD system (pulser, directional module, battery) for 200 hours at a 2-second pulse width. To determine the potential of a battery pack, the operator should multiply the pulse width by a factor of 100. The addition of the gamma module changes the factor to 50.

Table 1: Battery Duration Chart

Pulse Width	Standard Tool Configuration Factor	Duration in Hours
2.00	100	200
1.50		150
1.20		120
1.00		100
0.80		80
Pulse Width	Gamma w/One Battery Factor	Duration in Hours
2.00	50	100
1.50		75
1.20		60
1.00		50
0.80		40
Pulse Width	Gamma w/Two Batteries Factor	Duration in Hours
2.00	100	200
1.50		150
1.20		120
1.00		100
0.80		80

TOOL CONFIGURATIONS





Tensor MWD ASSEMBLY/BUILD PROCEDURE

The UpHole end of a connected intermodule (centralizer) has exposed pins, which can cause failures if shorted to each other. Therefore, always install the intermodule (centralizer) into the BOTTOM of the unit above (UpHole), before stabbing it into the unit below (DownHole) it. See sequence illustrated above. Use this procedure for the expanded module probes also.

Standard Tool Configuration = pulser/battery/directional module.
Gamma w/one battery = pulser/gamma/battery/directional module.
Gamma w/two batteries = Pulser/gamma/battery 1/directional module/battery 2.
Note: Other configurations are possible. Refer to Module Position Options page.
The type of service provided and the requirements of the well determine the selection of specific MWD modules and their configuration in the probe design. Refer to Figure 2 for a layout of the various module configurations available with the MWD.

Signal Orifice Size Selection

There are six sizes of orifices to choose from when using the 6 ½" or the 4 ¾" muleshoe sleeves. The sizes available are:

(i) 1.28" [201068]
(ii) 1.35" [201067]
(iii) 1.40" [201066]
(iv) 1.50" [201051]
(v) 1.55" [201059]
(vi) 1.60" [201060]

The signal orifice is placed in the lower end of the mule shoe sleeve, with the beveled edge facing UpHole. Refer to Table 2 for references to orifice selection sizes.

Poppet End Size Selection

There are three poppet end sizes to choose from when configuring the MWD probe. The sizes available are:

(i) 1.122" [201140]
(ii) 1.086" [201213]
(iii) 1.040" [201214]

Refer to Tables 2 and 3 for references to poppet end selection sizes. The combination of these six orifice sizes and the three poppet tip sizes allows for numerous variations in configurations to accommodate the various flow regimes encountered in the field.

H.2 POPPET / ORIFACE TABLE

Table 2: Poppet / Orifice Selection Chart for 6 ½" and 4 ¾" Muleshoes

Main Orifice I.D.	Part No.	Poppet End O.D.	Part No.	Flow Area [in2]	Flow Ranges [GPM]
1.28	201068	1.122	201140	0.297	Below 250
1.28		1.086	201213	0.360	200-375
1.28		1.040	201214	0.437	300-500
1.35	201067	1.122	201140	0.443	225-475
1.35		1.086	201213	0.505	350-550
1.35		1.040	201214	0.582	475-600
1.40	201066	1.122	201140	0.550	350-575
1.40		1.086	201213	0.612	450-650
1.40		1.040	201214	0.690	475-700
1.50	201051	1.122	201140	0.778	475-750
1.50		1.086	201213	0.840	500-800
1.50		1.040	201214	0.918	Over 700
1.55	201059	1.122	201140	0.898	
1.55		1.086	201213	0.961	
1.55		1.040	201214	1.037	
1.60	201060	1.122	201140	1.022	
1.60		1.086	201213	1.084	
1.60		1.040	201214	1.161	

Table 3: Poppet / Orifice Selection Chart for 3 ½" Muleshoes

Main Orifice I.D.	Part No.	Poppet End O.D.	Part No.	Flow Area [in2]	Flow Ranges [GPM]
1.20	201967	1.122	201140	0.1423	50-100
1.20		1.086	201213	0.2047	75-120
1.20		1.040	201214	0.2815	100-150
1.23	201966	1.122	201140	0.1995	60-110
1.23		1.086	201213	0.2619	80-120
1.23		1.040	201214	0.3387	
1.25	201961	1.122	201140	0.2383	80-130
1.25		1.086	201213	0.3007	
1.25		1.040	201214	0.3775	

POPPET/ORIFICE CONFIGURATIONS –

FLOW/TFA

A. In Order of Poppet/Orifice Size Increase				Pulse @ Tool			B. In Order of TFA Size Increase				Pulse @ Tool	
Orifice ID Inches	Poppet OD Inches	TFA Inches^2	Flow Range GPM	Min	MAX	SET	Orifice ID Inches	Poppet OD Inches	TFA Inches^2	Flow Range GPM	Min	Max
1.28	1.167	0.217	<200	384	683	1	1.28	1.167	0.217	<200	384	683
1.28	1.125	0.293	200-225	367	464	2	1.28	1.125	0.293	200-225	367	464
1.28	1.090	0.354	250-375	383	862	3	1.28	1.090	0.354	250-375	383	862
1.28	1.040	0.437	300-475	345	865	5	1.35	1.167	0.362	250-400	300	949
1.35	1.167	0.362	250-400	300	949	6	1.28	1.040	0.437	300-475	345	865
1.35	1.125	0.437	300-500	354	982	7	1.35	1.125	0.437	300-500	354	982
1.35	1.090	0.498	350-550	359	809	9	1.40	1.167	0.470	325-525	360	939
1.35	1.040	0.582	475-600	461	736	10	1.35	1.090	0.498	350-550	359	809
1.40	1.167	0.470	325-525	360	939	11	1.40	1.125	0.545	350-575	290	806
1.40	1.125	0.545	350-575	290	806	12	1.35	1.040	0.582	475-600	461	736
1.40	1.090	0.606	450-650	386	805	13	1.40	1.090	0.606	450-650	386	805
1.40	1.040	0.690	500-700	348	682	14	1.40	1.040	0.690	500-700	348	682
1.50	1.167	0.698	475-710	324	725	13	1.50	1.167	0.698	475-710	324	725
1.50	1.125	0.773	525-750	309	631	14	1.50	1.125	0.773	525-750	309	631
1.50	1.090	0.834	575-800	306	593	15	1.50	1.090	0.834	575-800	306	593
1.50	1.040	0.918	625-825	281	489	16	1.50	1.040	0.918	625-825	281	489
1.60	1.167	0.941	650-1000	309	525	17	1.60	1.167	0.941	650-1000	309	525
1.60	1.125	1.017	725-1050	314	658	18	1.60	1.125	1.017	725-1050	314	658
1.60	1.090	1.077	800-1150	326	673	19	1.60	1.090	1.077	800-1150	326	673
1.60	1.040	1.161	850-1000	296	640	20	1.60	1.040	1.161	850-1000	296	640

Select a flow range at least 100 gpm below and 100 gpm above the expected flow range that the system will be operating.

Software Parameters (That Affect System Operation)

Data Word Update Times (Pulse Durations)

Real-time Data Word *Updates* are *dependent* upon *Pulse Length* and the *Number of Bits per Word*. The following chart of **Empirical Data** indicates the time required for Data Word updates for three different word lengths per pulse length. The resolution of the Data Word value transmitted is dependent on the number of bits per Word.

Observe that as the pulse width lengthens the data bits per word become extremely important. A decision to sacrifice resolution for a faster update is crucial, and the course of action must be determined. Obviously, a 12-bit word is almost twice as long as a 6-bit word, but a 12-bit word is *NOT* twice as accurate as a 6-bit word. For example, the resolutions for each of the different length Toolface data words are:

(i) 12 bits = 0.1°
(ii) 8 bits = 1.5°
(iii) 6 bits = 5.5°

The accuracy is dependent on the values of the least significant bits. This dependency will somewhat affect the accuracy of the gTFA measurements, but not as adversely as the time necessary to transmit the data. The decision is up to the operator and the end user of the data. It can be concluded that the difference in resolution and the resultant accuracy of the Toolface data word is minimal for the decreased Toolface update time.
The resolution of Survey Data Words and Logging Data words is of utmost importance. That is why it is so important to insure that the required number of bits is used to transmit the Data Word.

Table 4: MWD Data Update Chart: Data Word Transmission Times

	Pulse Width (seconds)	Bits/Word	Update Time
A.	0.250	6	4 seconds
		8	5 seconds
		12	7 seconds
B.	0.325	6	5 seconds
		8	6 seconds
		12	9 seconds
C.	0.500	6	7 seconds
		8	9 seconds
		12	13 seconds
D.	0.600	6	8 seconds
		8	10 seconds
		12	16 seconds
E.	0.800	6	11 seconds
		8	14 seconds
		12	21 seconds
F.	1.000	6	14 seconds
		8	18 seconds
		12	26 seconds
G.	1.200	6	17 seconds
		8	22 seconds
		12	31 seconds
H.	1.500	6	21 seconds
		8	27 seconds
		12	39 seconds
I.	2.000	6	28 seconds
		8	36 seconds
		12	52 seconds
J.	3.000	6	42 seconds
		8	54 seconds
		12	78 seconds

Survey Data Selection for Transmission

The following two pages illustrate, with empirical data obtained from Compass' Flow Simulation Test Fixture, the potential times elapsed for different types of survey configurations and Toolface/logging configurations.

Category A configuration: Inc:12:P Azm:12:P aTFA:6:P DipA:12:P MagF:12:P Temp:8:P BatV:8:P Grav:12:P

Category B configuration: Inc:12:P Azm:12:P aTFA:6:P TmpW+BatW+MagW:P Toolface/Logging Sequence: aTFA:6:P XX {Gama:8:P}
(XX denotes the number of repetitions before starting the string over)

Table 5: Category A: Survey Duration Comparison

Pulse Width	1.0 sec	1.5 sec.	2.0 sec.
Parameter 60 sec TxDT	Elapsed Time	Elapsed Time	Elapsed Time
Synch:	1:14	1:22	1:27
Inclination:	1:48	2:14	2:37
Azimuth:	2:15	2:52	3:28
Static Toolface:	2:28	3:13	3:55
Dip Angle:	2:55	3:52	4:47
Total Mag Field:	3:20	4:30	5:36
Tool Temperature:	3:37	4:56	6:11
Battery Volts:	3:55	5:24	6:46
Total Gravity:	4:21	6:01	7:36
Dynamic Toolface:	4:42	6:33	8:20
1st Gamma:	5:00	6:58	8:54
Gamma Update Rate:	±18 3.33 g/min	±27 2.22 g/min	±36 1.66 g/min
Gamma Pts. / Foot @ 70 Ft. / Hr. ROP	2.86	1.9	1.66
Gamma Pts. / Foot @ 30 Ft. / Hr. ROP	6.66	4.44	3.33

Table 6: Category B: Survey Duration Comparison

Pulse Width	1.0 sec	1.5 sec.	2.0 sec.
Parameter 60 sec TxDT	**Elapsed Time**	**Elapsed Time**	**Elapsed Time**
Synch:	1:14	1:22	1:27
Inclination:	1:48	2:14	2:37
Azimuth:	2:15	2:52	3:28
Static Toolface:	2:28	3:13	3:55
Warnings for Dip Angle+Mag Field+ Temperature+ Battery Voltage:	2:37	3:27	4:11
Dynamic Toolface:	2:59	3:57	4:54
1st Gamma:	3:18	4:25	5:29
Gamma Update Rate:	±18 3.33 G/min	±27 2.22 G/min	±36 1.66 G/min
Gamma Pts. / Foot @ 70 Ft. / Hr. ROP	2.86	1.9	1.43
Gamma Pts. / Foot @ 30 Ft. / Hr. ROP	6.66	4.44	3.33

Note: The data used in these examples was compiled from a Simulated Flow Lab Test Fixture. The times presented may vary ±3.5 seconds using the same configurations.

Table 7: O-Rings

O-Rings, in Numerical AS-###
O-ring, AS-003, Viton, 75D
O-ring, AS-006, Viton
O-ring, AS-009, Viton, 70D
O-ring, AS-011, Viton
O-ring, AS-012, Viton
O-ring, AS-016, Viton
O-ring, AS-020, Viton
O-ring, AS-027, Viton
O-ring, AS-110, Viton, 75A
O-ring, AS-113, Viton, 70D
O-ring, AS-116, Viton
O-ring, AS-124, Viton
O-ring, AS-125, Viton
O-ring, AS-126, Viton, 70D
O-ring, AS-127, Viton, 70D
O-ring, AS-128, Viton, 70D
O-ring, AS-136, Viton,
O-ring, AS-140, Viton
O-ring, AS-209, Viton
O-ring, AS-213, Viton
O-ring, AS-218, Viton
O-ring, AS-220, Viton, 70D
O-ring, AS-221, Viton
O-ring, AS-227, Viton,
O-ring, AS-233, Viton
O-ring, AS-234, Viton
O-ring, AS-238, Viton
O-ring, AS-245, Viton
O-ring, AS-325, Viton
O-ring, AS-345, Viton
Standard Polypak Seal
Wiper

Poppet / Orifice Table
3 1/2 Tool String

Measured Depth	Flow Rate	SPP	Pulse Amplitude	Pulse Length	Orifice Size	Poppet Size	Mud Type	Mud Weight	Mud Vis	Solids %	Bit TFA	Hole Size	Drill Pipe	Collar ID	Job No.	County ST	Comments Closed Area
0																	
8600	140	UK	20	UK	1.230	1.122	Water	8.6	UK	UK	UK		2 7/8	2.25	0		0.199
9000	140	UK	45	UK	1.200	1.122	Water	8.6	UK	UK	UK		2 7/8	2.25	0		0.142
11012	140	UK	38	UK	1.200	1.122	Water	8.6	UK	UK	UK		2 7/8	2.25	0		0.142
11081	140	UK	23	UK	1.200	1.086	Water	8.6	UK	UK	UK		2 7/8	2.25	0		0.205
12400	140	UK	25	UK	1.200	1.122	Water	8.6	UK	UK	UK		2 7/8	2.25	0		0.238
6517	110	2800	29	1.5	1.250	1.122	Lig	11	UK	UK	UK		2 7/8	2.375	SJ99107	Maverick	
6533	126	2950	37	1.5	1.250	1.122	Lig	11	UK	UK	UK		2 7/8	2.375	SJ99107	Maverick	
0	130	850	26	1.2	1.200	1.122	Water	10.3	21	10	UK		2 7/8	2.2	SJ00064	Burleson	
0	150	1000	38	1.2	1.200	1.122	Water	10.3	21	10	UK		2 7/8	2.2	SJ00064	Burleson	
9500	150	2200	38	1.2	1.200	1.122	Water	10.3	21	10	0.45		2 7/8	2.2	SJ00064	Burleson	Horizonal
9500	130	1800	22	1.2	1.200	1.122	Water	10.3	21	10	0.45		2 7/8	2.2	SJ00064	Burleson	Horizonal
9800	150	3500	53	1.2	1.200	1.122	Water	10.6	24	11	0.45		2 7/8	2.2	SJ00064	Burleson	Horizonal
10000	145	3000	43	1.2	1.200	1.122	Water	10.6	24	11	0.45		2 7/8	2.2	SJ00064	Burleson	Horizonal
10300	145	3300	36	1.2	1.200	1.122	Water	10.6	24	11	0.45		2 7/8	2.2	SJ00064	Burleson	Horizonal
10700	150	3100	38	1.2	1.200	1.122	Water	10.6	24	11	0.45		2 7/8	2.2	SJ00064	Burleson	Horizonal
11000	150	3300	34	1.2	1.200	1.122	Water	9.6	25	9	0.45		2 7/8	2.2	SJ00064	Burleson	Horizonal
11500	150	3200	30	1.2	1.200	1.122	Water	9.4	10	9	0.45		2 7/8	2.2	SJ00064	Burleson	Horizonal
11700	150	2500	39	1.2	1.200	1.122	Water	9.6	10	9	0.45		2 7/8	2.2	SJ00064	Burleson	Horizonal
11700	130	1200	22	1.2	1.200	1.122	Water	9.6	10	9	0.45		2 7/8	2.2	SJ00064	Burleson	Horizonal
12200	150	3200	48	1.2	1.200	1.122	Water	9.6	10	9	0.45		2 7/8	2.2	SJ00064	Burleson	Horizonal
12400	150	3500	45	1.2	1.200	1.122	Water	9.6	10	9	0.45		2 7/8	2.2	SJ00064	Burleson	Horizonal
13200	140	2800	30	1.2	1.200	1.122	Water	9.8	15	11	0.45		2 7/8	2.2	SJ00064	Burleson	Horizonal
13700	150	3000	30	1.2	1.200	1.122	Water	10	4	10	0.45		2 7/8	2.2	SJ00064	Burleson	Horizonal

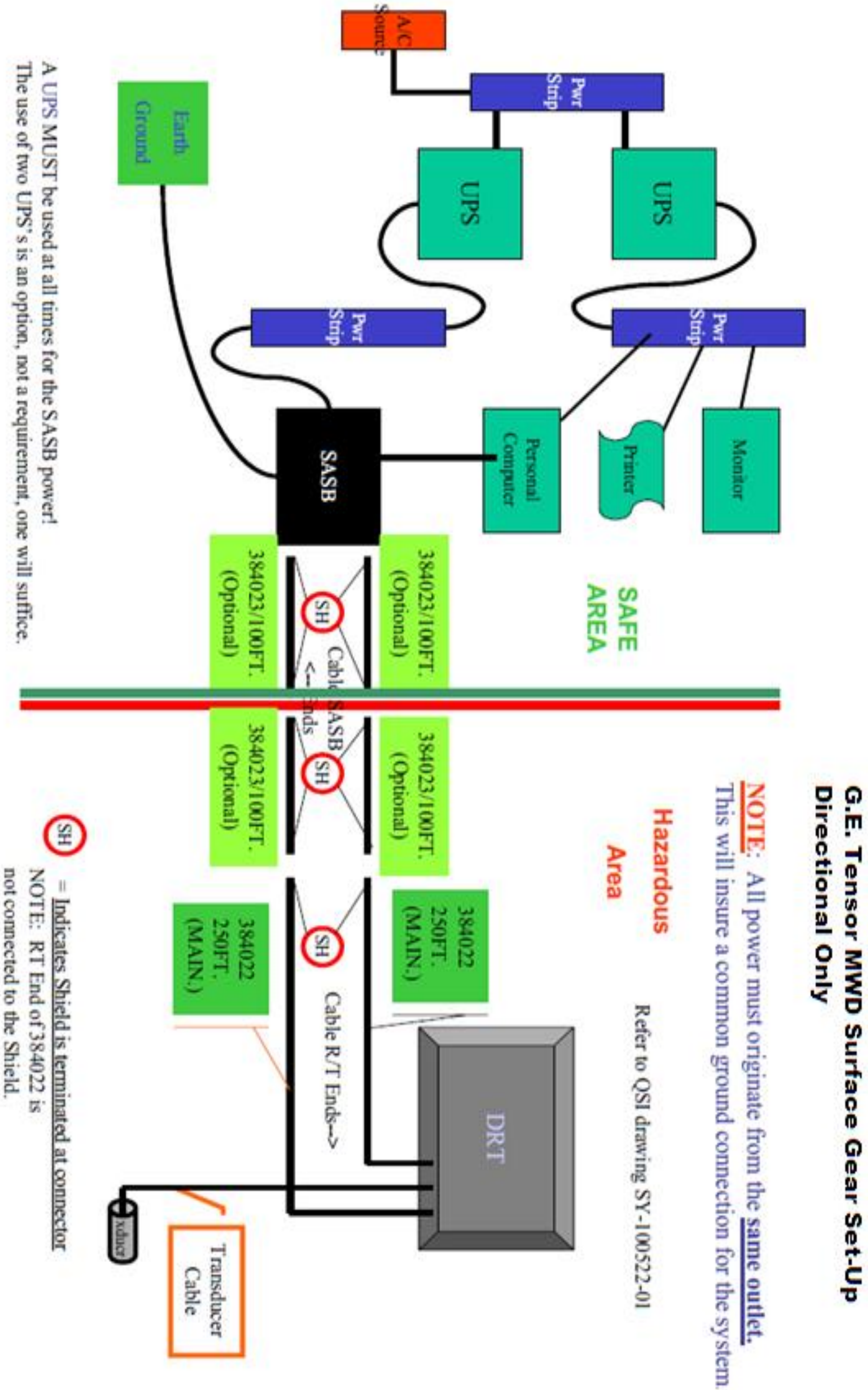
Poppet / Orifice Table
3 1/2 Tool String

Measured Depth	Flow Rate	SPP	Pulse Amplitude	Pulse Length	Orifice Size	Poppet Size	Mud Type	Mud Weight	Mud Vis	Solids %	Bit TFA	Hole Size	Drill Pipe	Collar ID	Job No.	County ST	Comments Closed Area
9200	110	2300	40	1.5	1.200	1.122	WB	9	15	4	0.589	4.75	2 7/8	2.438	HJ01006	OK	
9300	110	2400	37	1.5	1.200	1.122	WB	9	17	4	0.589	4.75	2 7/8	2.438	HJ01006	OK	
9400	110	2400	31	1.5	1.200	1.122	WB	9	17	4	0.589	4.75	2 7/8	2.438	HJ01006	OK	
9450	110	2400	33	1.5	1.200	1.122	WB	9.2	18	4	0.589	4.75	2 7/8	2.438	HJ01006	OK	
0	107	2200	45	1.5	1.200	1.122	WB	8.8	16		0.518	4.75	2 7/8	2.2	HJ00145	OK	Horizontal
9000	107	2200	42	1.5	1.200	1.122	WB	8.8	16		0.518	4.75	2 7/8	2.2	HJ00145	OK	
9000	107	2200	37	1.5	1.200	1.122	WB	8.8	16		0.518	4.75	2 7/8	2.2	HJ00145	OK	
9100	107	2300	39	1.5	1.200	1.122	WB	8.8	16	5	0.518	4.75	2 7/8	2.2	HJ00145	OK	
9200	107	2300	44	1.5	1.200	1.122	WB	8.8	16	5	0.518	4.75	2 7/8	2.2	HJ00145	OK	
9300	107	2300	42	1.5	1.200	1.122	WB	8.8	16	5	0.518	4.75	2 7/8	2.2	HJ00145	OK	
9400	107	2650	46	1.5	1.200	1.122	WB	8.8	16	5	0.518	4.75	2 7/8	2.2	HJ00145	OK	
9500	107	2350	36	1.5	1.200	1.122	WB	8.8	16	5	0.518	4.75	2 7/8	2.2	HJ00145	OK	
9500	107	2200	35	1.5	1.200	1.122	WB	8.8	16	5	0.518	4.75	2 7/8	2.2	HJ00145	OK	
9600	107	2200	25	1.5	1.200	1.122	WB	8.8	16	5	0.518	4.75	2 7/8	2.2	HJ00145	OK	
9700	107	2200	24	1.5	1.200	1.122	WB	8.8	16	5	0.518	4.75	2 7/8	2.2	HJ00145	OK	
9100	107	2250	26	1.5	1.200	1.122	WB	8.8	16	5	0.518	4.75	2 7/8	2.2	HJ00145	OK	Side track 1
9200	107	2100	19	1.5	1.200	1.122	WB	8.8	17	5	0.518	4.75	2 7/8	2.2	HJ00145	OK	
9300	107	2300	22	1.5	1.200	1.122	WB	9	17	5	0.518	4.75	2 7/8	2.2	HJ00145	OK	
9400	107	2200	21	1.5	1.200	1.122	WB	9	17	5	0.518	4.75	2 7/8	2.2	HJ00145	OK	
9600	107	2300	22	1.5	1.200	1.122	WB	9	17	5	0.518	4.75	2 7/8	2.2	HJ00145	OK	
9500	107	2300	22	1.5	1.200	1.122	WB	9	17	5	0.518	4.75	2 7/8	2.2	HJ00145	OK	Side track 2
9600	107	2400	31	1.5	1.200	1.122	WB	9	17	5	0.518	4.75	2 7/8	2.2	HJ00145	OK	

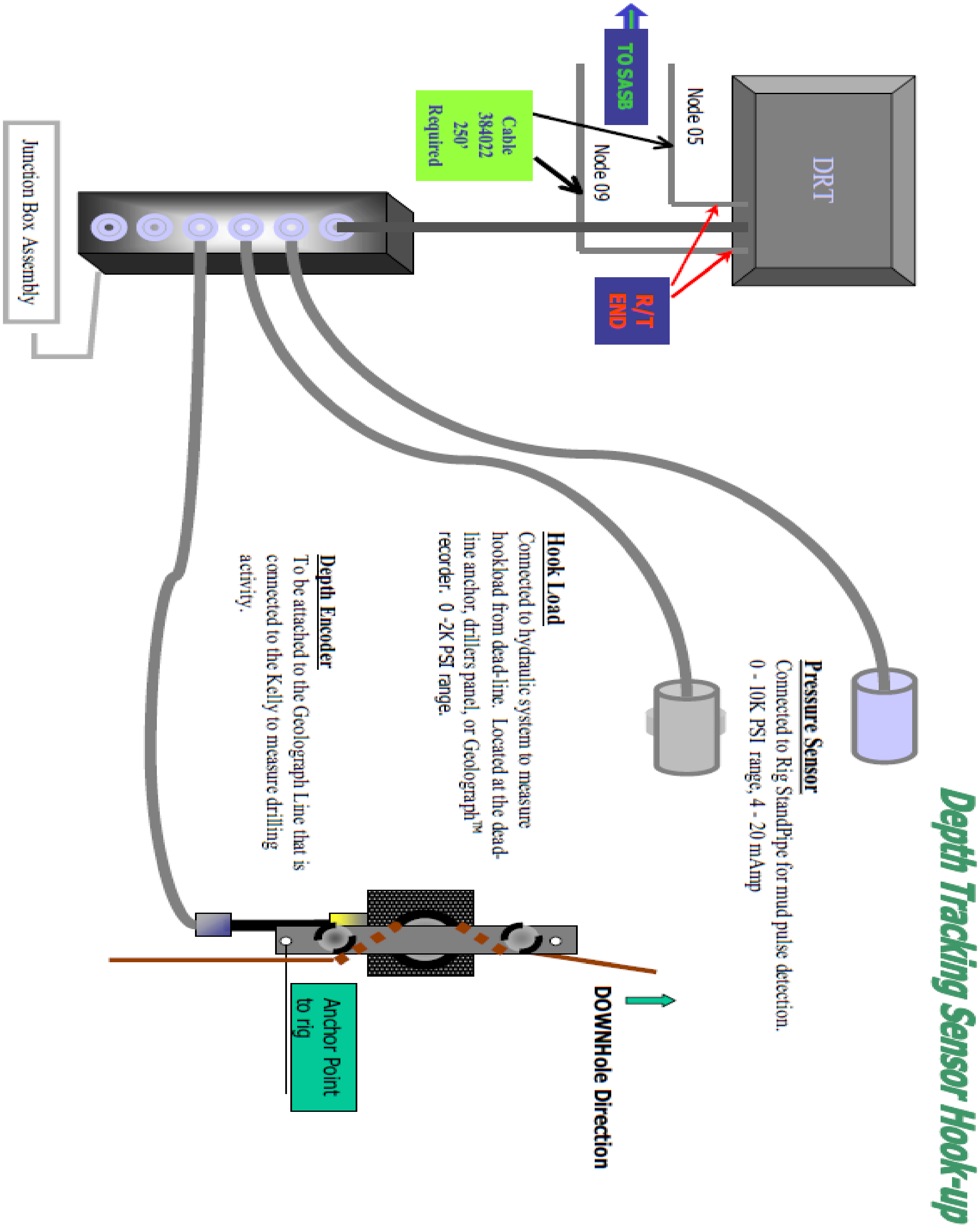
Poppet / Orifice Table
3 1/2 Tool String

Measured Depth	Flow Rate	SPP	Pulse Amplitude	Pulse Length	Orifice Size	Poppet Size	Mud Type	Mud Weight	Mud Vis	Solids %	Bit TFA	Hole Size	Drill Pipe	Collar ID	Job No.	County ST	Comments Closed Area
9200	140	2800	41	UK	1.200	1.122	GEL	11	19	16	0.75	4.75	2 7/8	2.25	SJ00078	Burleson	Horizontal
9300	150	3300	46	UK	1.200	1.122	GEL	10	19	16	0.75	4.75	2 7/8	2.25	SJ00078	Burleson	Horizontal
9400	150	3300	46	UK	1.200	1.122	GEL	10	19	16	0.75	4.75	2 7/8	2.25	SJ00078	Burleson	Horizontal
9500	UK	1950	33	UK	1.200	1.122	GEL	10	19	16	0.75	4.75	2 7/8	2.25	SJ00078	Burleson	Horizontal
10000	UK	2000	27	UK	1.200	1.122	GEL	10	19	16	0.75	4.75	2 7/8	2.25	SJ00078	Burleson	Horizontal
10400	UK	3000	27	UK	1.200	1.122	GEL	8.4	19	16	0.75	4.75	2 7/8	2.25	SJ00078	Burleson	Horizontal
10600	150	3200	35	UK	1.200	1.122	GEL	8.4	19	16	0.75	4.75	2 7/8	2.25	SJ00078	Burleson	Horizontal
10800	150	3200	35	UK	1.200	1.122	GEL	8.4	19	16	0.75	4.75	2 7/8	2.25	SJ00078	Burleson	Horizontal
11000	150	3200	35	UK	1.200	1.122	GEL	8.4	19	16	0.75	4.75	2 7/8	2.25	SJ00078	Burleson	Horizontal
11100	150	3200	35	UK	1.200	1.122	GEL	8.4	19	16	0.75	4.75	2 7/8	2.25	SJ00078	Burleson	Horizontal
11228	150	3200	35	UK	1.200	1.122	GEL	8.4	19	16	0.75	4.75	2 7/8	2.25	SJ00078	Burleson	Horizontal
11500	150	3200	35	UK	1.200	1.122	GEL	8.4	19	16	0.75	4.75	2 7/8	2.25	SJ00078	Burleson	Horizontal
11900	UK	3000	60	UK	1.200	1.122	GEL	8.4	19	16	0.75	4.75	2 7/8	2.25	SJ00078	Burleson	Horizontal
12000	UK	3100	40	UK	1.200	1.122	GEL	8.4	19	16	0.75	4.75	2 7/8	2.25	SJ00078	Burleson	Horizontal
12200	UK	2700	31	UK	1.200	1.122	GEL	8.4	19	16	0.75	4.75	2 7/8	2.25	SJ00078	Burleson	Horizontal
12400	UK	2900	30	UK	1.200	1.122	GEL	8.4	19	16	0.75	4.75	2 7/8	2.25	SJ00078	Burleson	Horizontal
12600	UK	2600	29	UK	1.200	1.122	GEL	8.4	19	16	0.75	4.75	2 7/8	2.25	SJ00078	Burleson	Horizontal

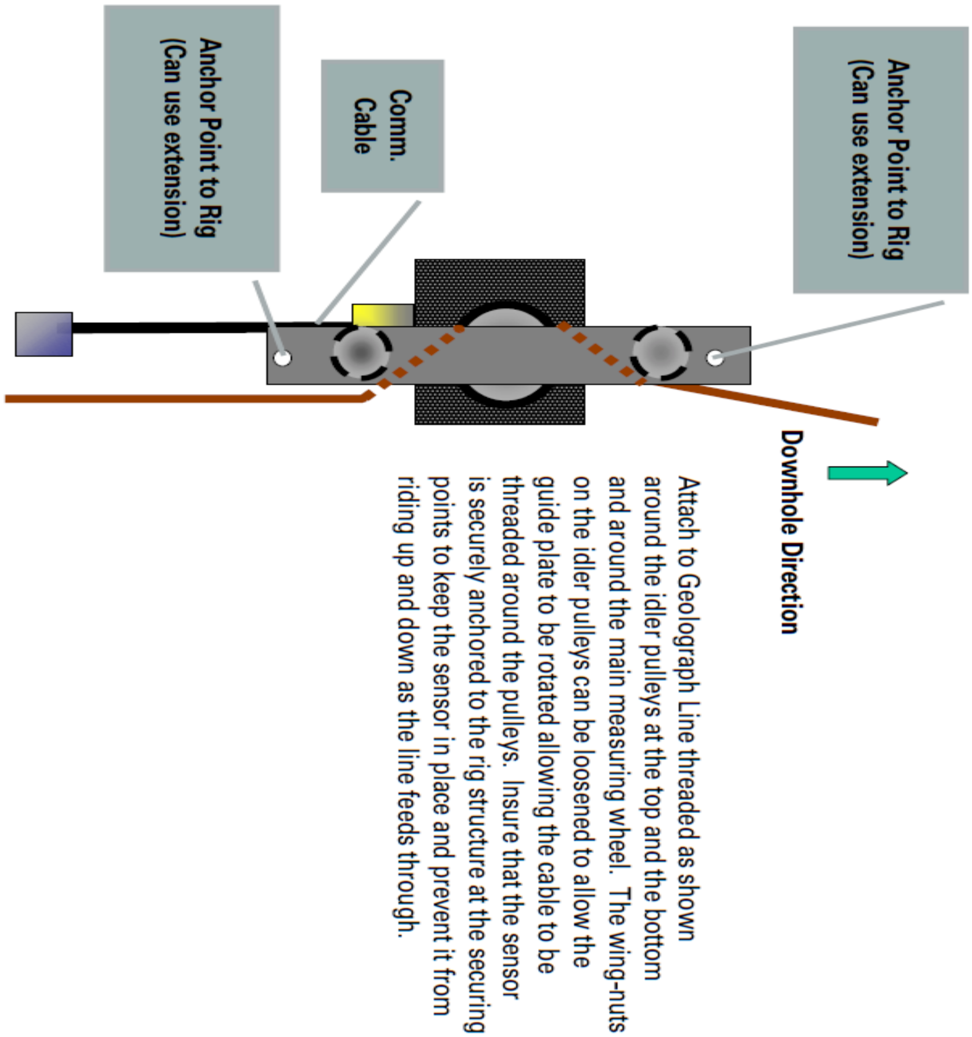
H. 3 MWD SURFACE GEAR SETUP (DIAGRAM)



H.4 DEPTH TRACKING SENSOR HOOKUP



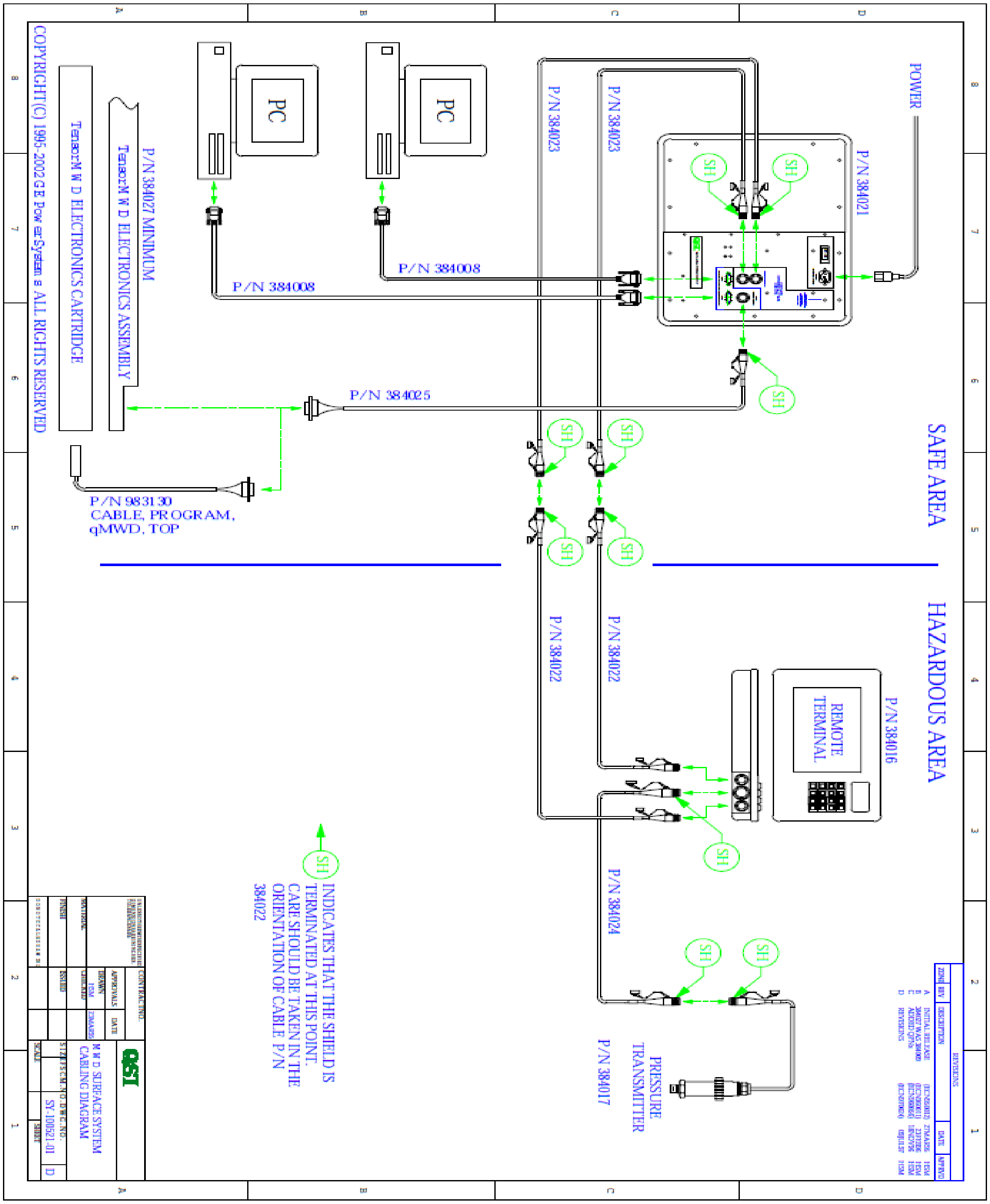
Deadline Hookload Sensor



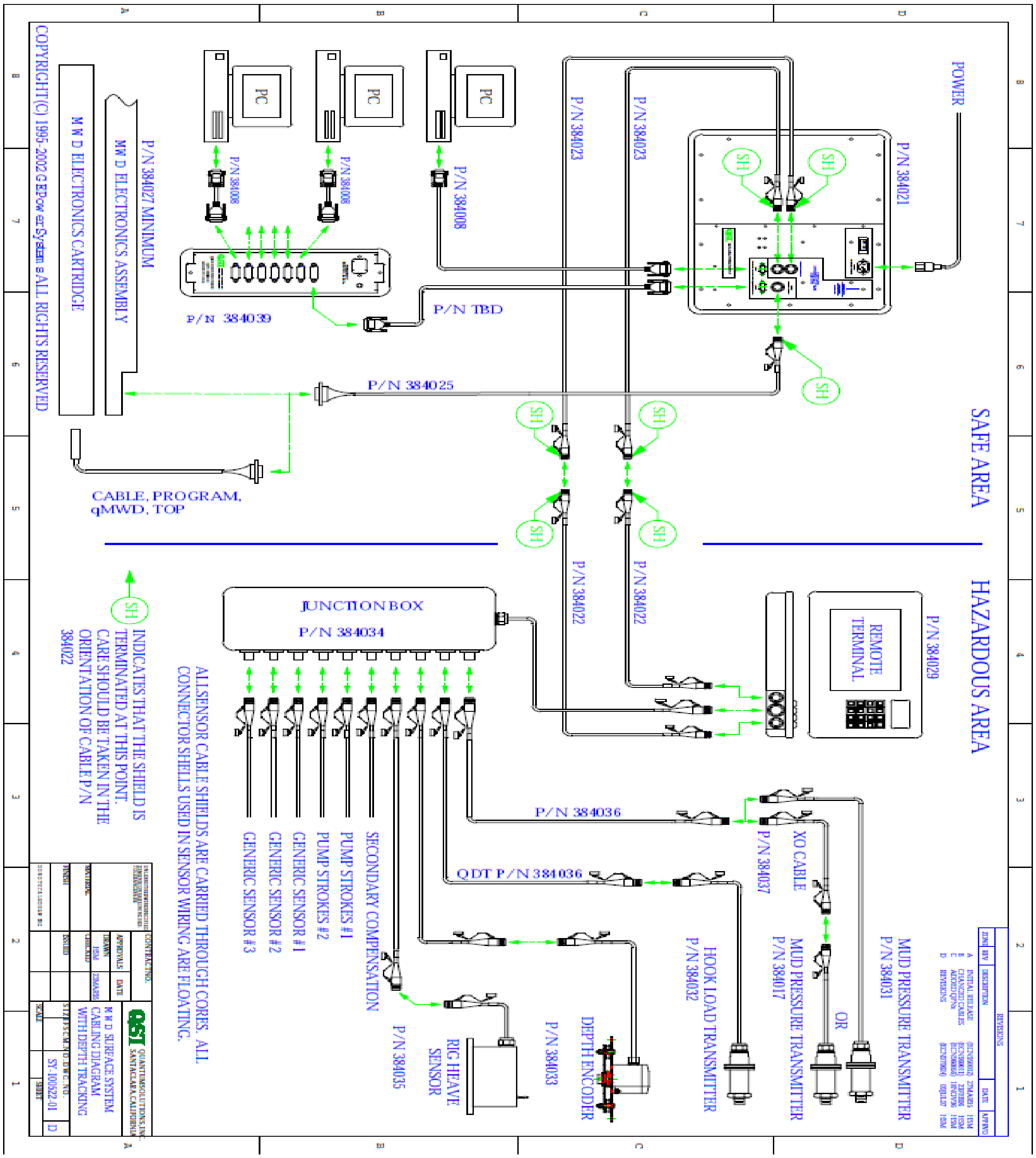
Shaft Encoder

Standpipe Pressure Transducer

H.5 SURFACE SYSTEM CABLING DIAGRAM



H.6 CABLING DIAGRAM W/DEPTH TRACKING



I. GAMMA MODULE - 201950

I.1 GAMMA MODULE ASSEMBLY PROCEDURES

GAMMA MODULE ASSEMBLY PROCEDURES

1. Lower End
1.1. Grease O-rings and install onto Intermodule End [201514] as shown below. Tape threads to prevent damage to O-rings.

Note: Leave protective caps (not shown) on electrical connectors to guard against damage.

1.2. Assemble the Gamma Snubber Pigtail [201955] and Gamma Snubber Shock [201953] as shown below. Use Loctite 243 on the MDM connector screws (2-56 x 1/4 Pan [100030]). Do not over-tighten.

Note: Make sure the pigtail wires lay flat in the wire groove on the bottom of the Snubber.

1.3. Pass the 4-pin/6-socket connector through the Intermodule End as shown. Using Loctite, attach Snubber to Intermodule End using four 6-32 x ½ Screws [103180] (not shown). Replace protective cap.

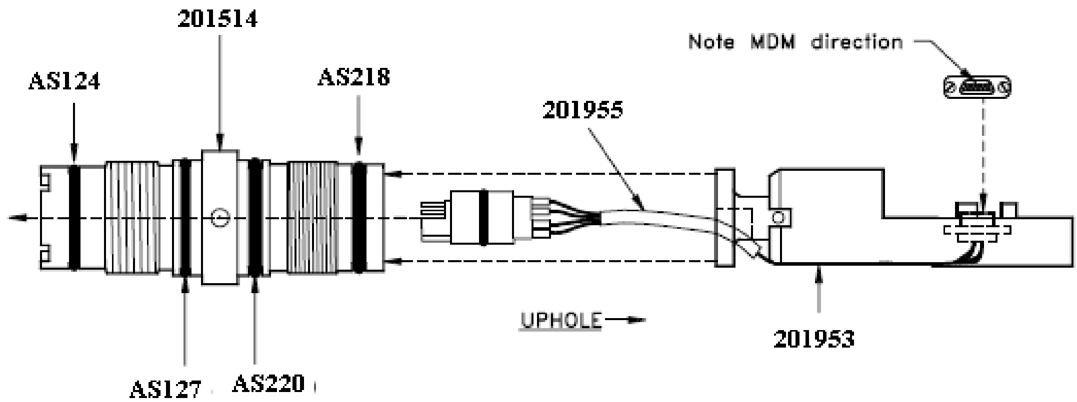


Figure 1

Steps 1.4 - 1.7: Refer to Drawing D-201950-02

1.4. **Gamma Sensor Installation:**
Install three pairs **Split Ring [972124]** and O-rings to the selected **Gamma Sensor [384000, 384030]** as shown. Attach the MDM connector on the lower end of the Sensor to the MDM on the Snubber Shock. Fasten the Snubber Shock and Gamma Sensor together using four **10-32 x**

3/4 SHC screws [105430] and Loctite 243.
1.5. Install O-rings (2) on **Gamma End [201888]** as shown.
Fasten the MDM on the Pigtail, Gamma End [201954] to the Gamma End MDM as shown, using screws (2-56 x 1/4 Pan [100030]) as shown. Fasten Gamma End to Gamma Sensor using four **10-32 x 7/16 screws [105430]** and Loctite 243.

1.6. Wrap the following areas of the assembly with Kapton tape using a 1/8" overlap:
1.6.1. Snubber Shock/Gamma Sensor connection
1.6.2. Gamma Sensor/Gamma End connection including *entire Gamma End*.
1.7. Carefully slide the assembly into the **Battery/Gamma Housing [201635]**, grease the O-rings, and screw Intermodule End and Housing together.

1.8. Grease O-rings and install onto **Bottom Bulkhead Retainer [201521]** as shown below. Grease O-rings on the pigtail 10-pin connector. Install **Split Shell [201506]** halves into the recess in the Intermodule End as shown.
Align the key on the 10-pin connector with the groove in the Bulkhead Retainer and install the retainer as shown.
Fasten the Retainer in place using (2) **4-40 x 1/4 screws [102010]** (not shown) and Loctite 243.

Note: These screws should be barely snug to allow the Bulkhead Retainer to "self-align" when installing the Interconnect Housing (next step).

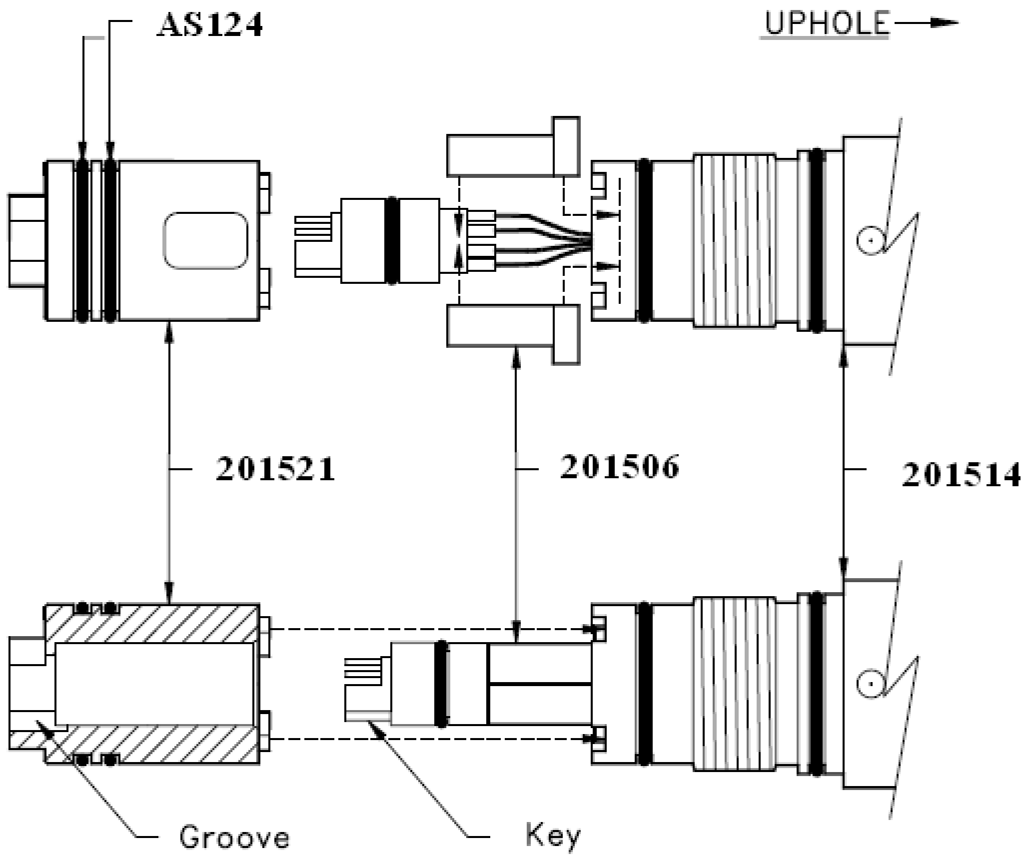


Figure 2

1.9. Grease O-rings, thread **Interconnect Housing [201509]** in place as shown. Grease O-ring and install **Thread Protector [201845]** (not shown) into open end of Interconnect Housing.

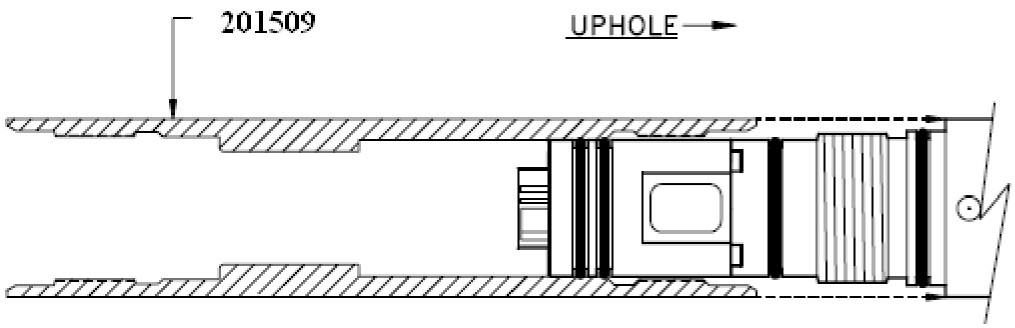


Figure 3

2. Upper End
2.1. Grease and install O-rings on **Gamma Intermodule End [201632]** as shown below. Tape threads to prevent damage to O-rings. Grease the Orings, feed the 10-pin connector into the Gamma Intermodule End, and thread the Intermodule End into the Pressure Housing as shown.

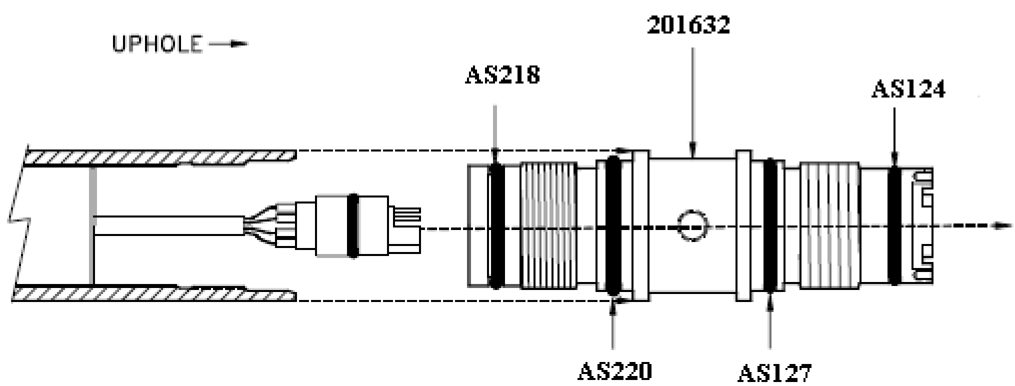


Figure 4

2.2. Grease O-rings and install onto **Top Bulkhead Retainer [201505]** as shown below. Grease O-rings on the pigtail 10-pin connector. Install Split Shell halves into the recess in the Gamma Intermodule End as shown. Align the key on the 10-pin connector with the groove in the Bulkhead Retainer and install the retainer as shown. Fasten the Retainer in place using (2) 4-40 x 1/4 screws (not shown) and Loctite 243.

Note: These screws should be barely snug to allow the Bulkhead Retainer
to “self-align” when installing the Interconnect Housing (next step).

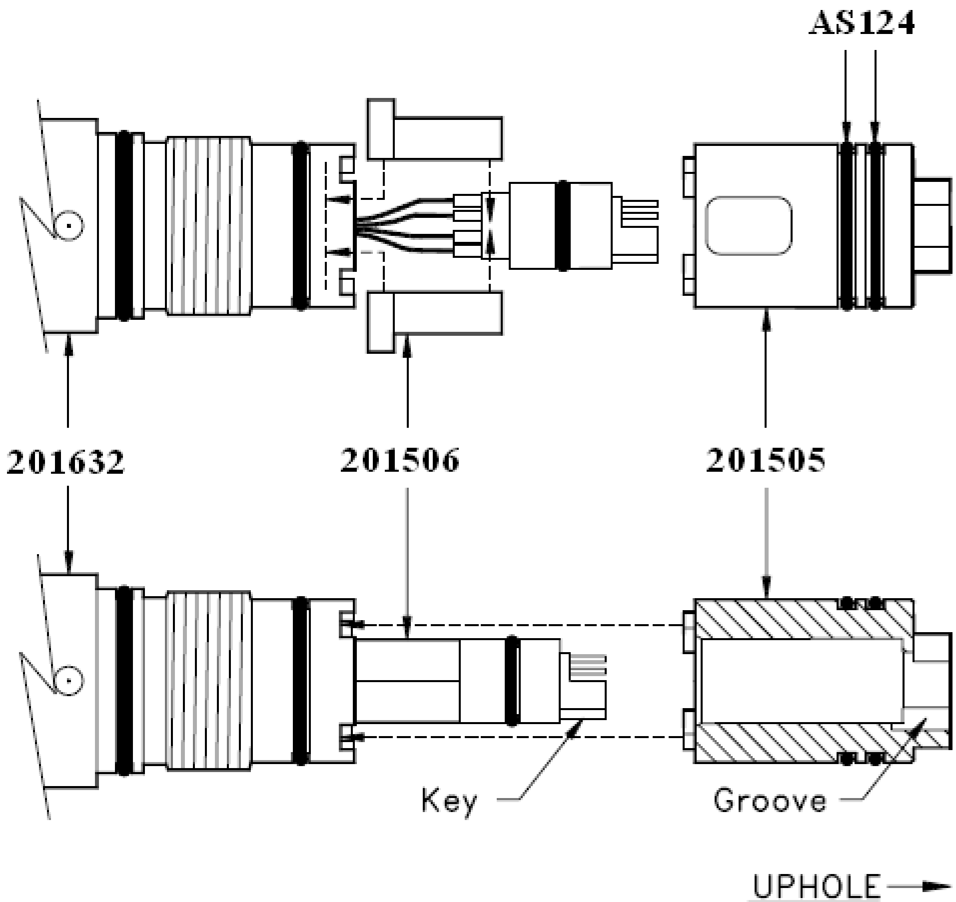


Figure 5

2.3. Grease O-rings, and thread Interconnect Housing in place as shown.

Grease O-ring and install Thread Protector (not shown) into open end of Interconnect Housing.

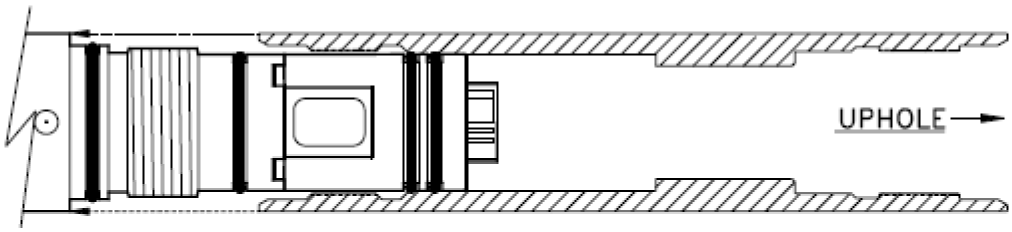


Figure 6

3. **Continuity Check**

Measure resistance. Do not use audible alarm. Verify continuity between connector pins at opposite barrel ends as listed in Table 1, below.

Pin #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	**<.9 ohm**	OC	OC	25-50 K ohm	OC	OC	OC	25-50 K ohm	OC	OC
2		**<.9 ohm**	OC	OC	OC	OC	OC	OC	OC	OC
3			**<.9 ohm**	OC	OC	OC	OC	OC	OC	OC
4				**<.9 ohm**	OC	OC	OC	20-30 K ohm	OC	OC
5					**<.9 ohm**	OC	OC	OC	OC	OC
6						**<.9 ohm**	OC	OC	OC	OC
7							**<.9 ohm**	OC	OC	OC
8								**<.9 ohm**	OC	OC
9									**<.9 ohm**	OC
10										**<.9 ohm**
Barrel	OC	OC	OC	OC	OC	OC	OC	OC	OC	OC

Table 1

I.2 BOM – GAMMA

BOM: Gamma Module (G.E.Tensor)

Asset

Part Number	Size	Product Line	Description
201949	1-7/8"	MWD	Gamma Module, 175° C

Serialized Part

Part Number	Size	Product Line	Description
201949S	1-7/8"	MWD	Gamma Module, 175° C
201948	Common	MWD	Gamma Sensor, 175° C

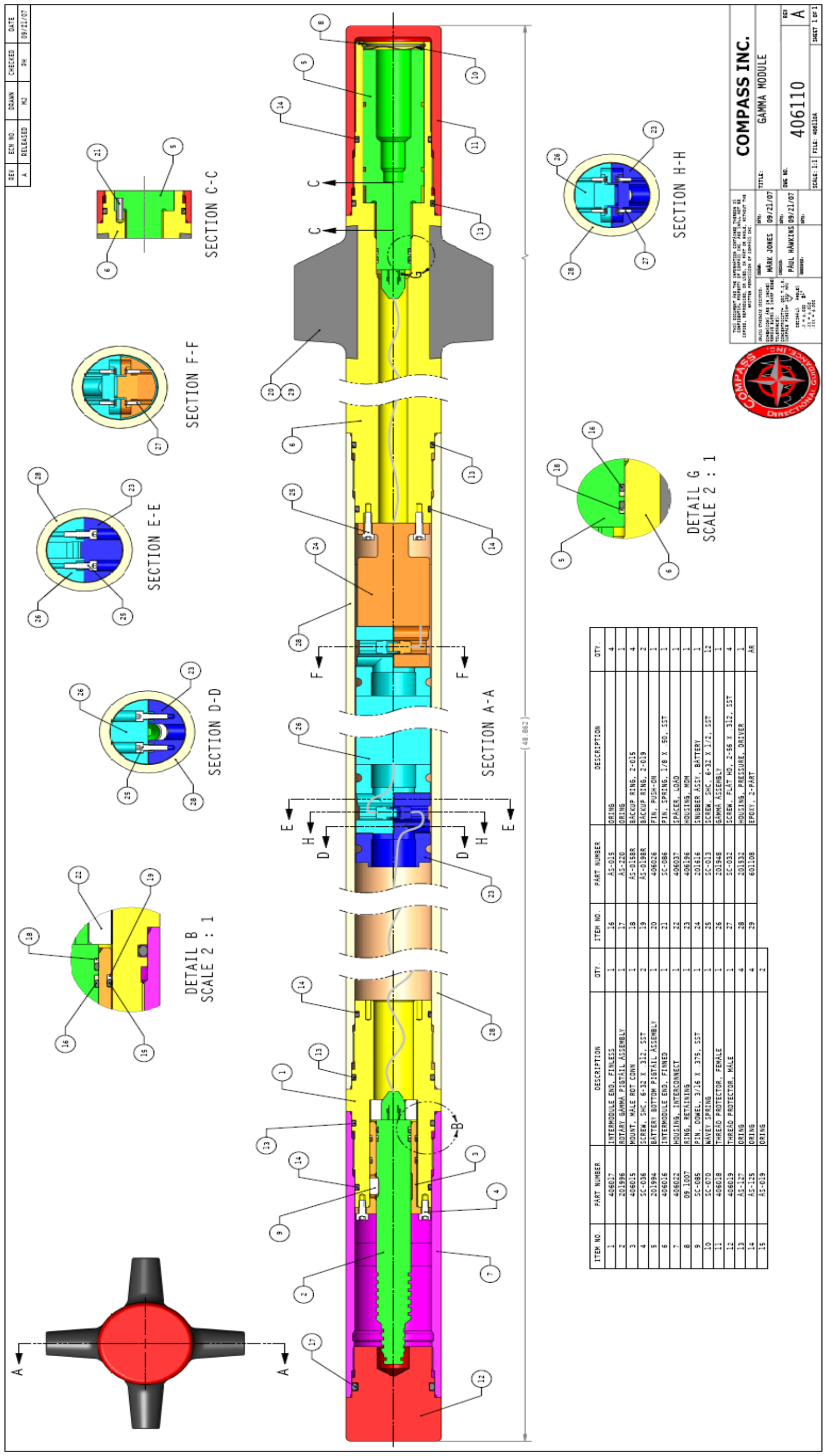
Non-Serialized Part

Part Number	Size	Product Line	Description	Quantity
201509	1-7/8"	MWD	Housing, Interconnect	2.00
201514	1-7/8"	MWD	Intermodule End	2.00
201532	1-7/8"	MWD	Housing, Pulser Driver	1.00
201845	1-7/8"	MWD	Thread Protector, Male	2.00
120001	Common	MWD	Temp Tab "B"	1.00
120002	Common	MWD	Temp Tab "C"	1.00
201505	Common	MWD	Bulkhead Retainer, Top (90 Degree)	1.00
201506	Common	MWD	Split Shell	2.00
201521	Common	MWD	Bulkhead Retainer, Bottom (45 Degree)	1.00
201617	Common	MWD	Snubber Assembly, Battery	1.00
201951	Common	MWD	CBG Short Gamma Extension	1.00
201991	Common	MWD	Pigtail, Battery	1.00
AS-124	Common	MWD	AS-124 O-Ring, Viton	2.00
AS-127	Common	MWD	AS-127 O-Ring, Viton	2.00
AS-217	Common	MWD	AS-217 O-Ring, Viton	4.00
AS-218	Common	MWD	AS-218 O-Ring, Viton	2.00
AS-220	Common	MWD	AS-220 O-Ring, Viton	2.00
SC-013	Common	MWD	Screw, 6-32 x 1/2" SHCS, SS	4.00
SC-014	Common	MWD	Screw, 6-32 x 3/4" SHCS, SS	8.00

Non-Serialized Part

Part Number	Size	Product Line	Description	Quantity
SC-015	Common	MWD	Screw, 4-40 x 1/4" SHCS, SS	4.00

I.3 FOCUSED GAMMA (DRAWING & BOM)



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	406017	INTERMODULE END, FINLESS	1
2	201996	ROTARY GAMMA PIGTAIL ASSEMBLY	1
3	406015	MOUNT, MALE ROT CONN	1
4	SC-036	SCREW, SHC, 6-32 X .312, SST	2
5	201994	BATTERY BOTTOM PIGTAIL ASSEMBLY	1
6	406016	INTERMODULE END, FINNED	1
7	406022	HOUSING, INTERCONNECT	1
8	09.1007	RING, RETAINING	1
9	SC-085	PIN, DOWEL, 3/16 X .375, SST	1
10	SC-070	WAVEY SPRING	1
11	406018	THREAD PROTECTOR, FEMALE	1
12	406019	THREAD PROTECTOR, MALE	1
13	AS-127	ORING	4
14	AS-125	ORING	4
15	AS-019	ORING	2

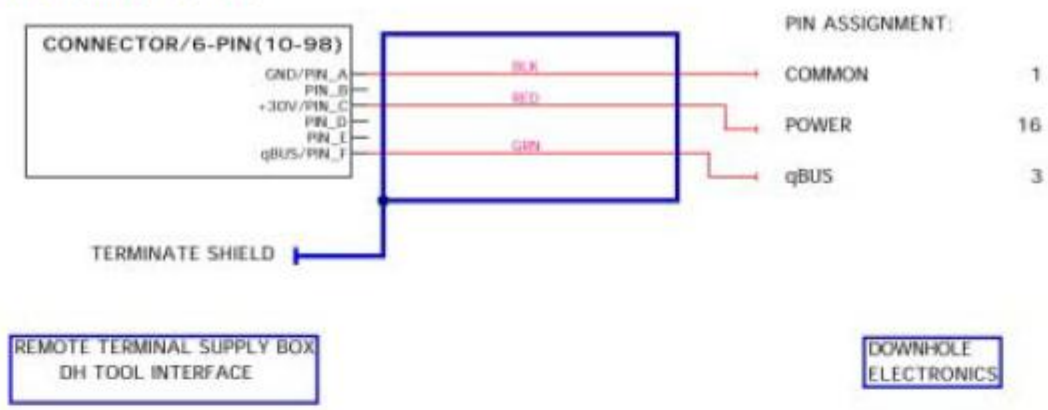
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
16	AS-015	ORING	4
17	AS-220	ORING	1
18	AS-015BR	BACKUP RING, 2-015	4
19	AS-019BR	BACKUP RING, 2-019	2
20	406026	FIN, PUSH-ON	1
21	SC-086	PIN, SPRING, 1/8 X .50, SST	1
22	406037	SPACER, LOAD	1
23	406196	HOUSING, MDM	1
24	201616	SNUBBER ASSY, BATTERY	1
25	SC-013	SCREW, SHC, 6-32 X 1/2, SST	12
26	201948	GAMMA ASSEMBLY	1
27	SC-032	SCREW, FLAT HD, 2-56 X .312, SST	4
28	201532	HOUSING, PRESSURE, DRIVER	1
29	601108	EPOXY, 2-PART	AR

G.E. TENSOR MWD SYSTEM CABLE PIN-OUTS

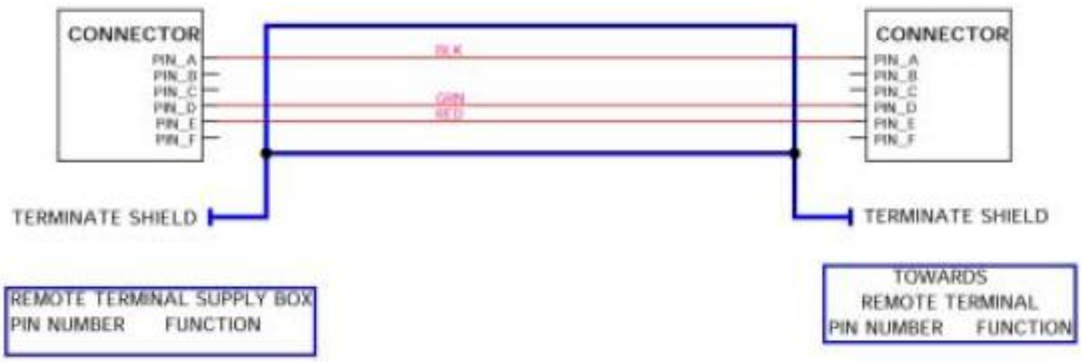
Main Cable: Drillers Remote Terminal to Safe Area Power Supply
Part Number 384022

Programming Cable: Safe Area Power Supply to Down Hole Tool

Part Number 384025

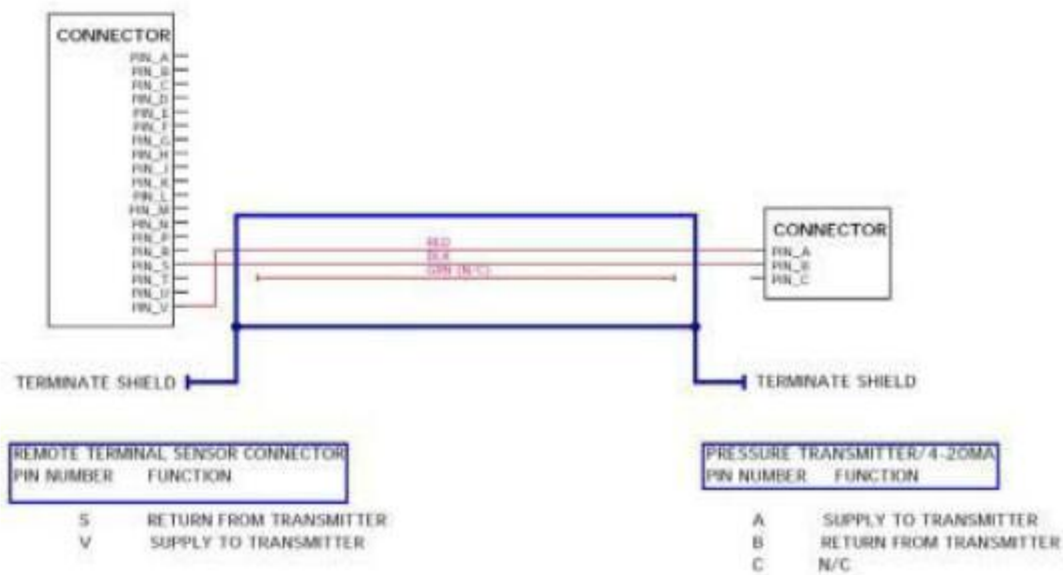


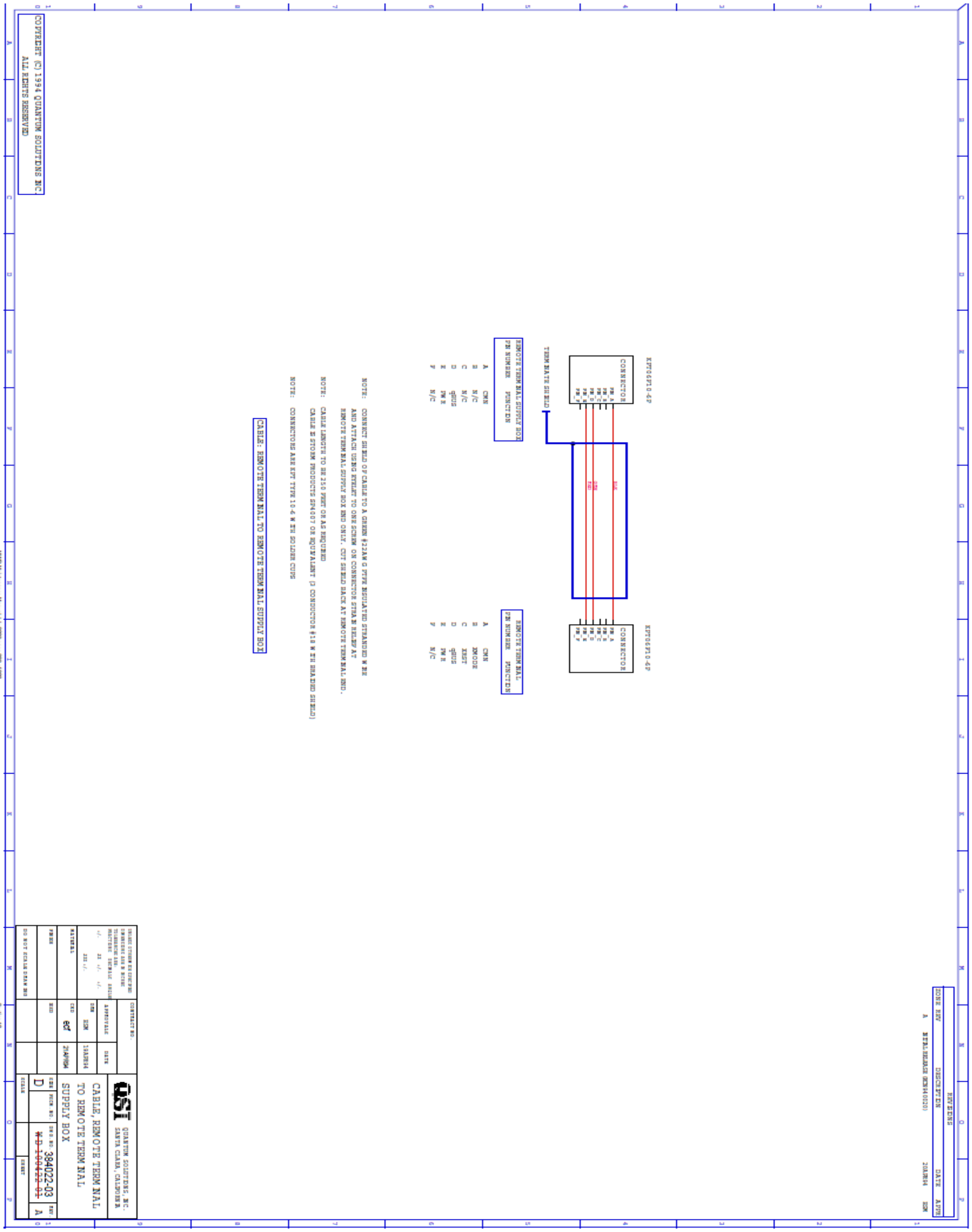
Extension Cable: Save Area Power Supply to Main Cable
Part Number 384023



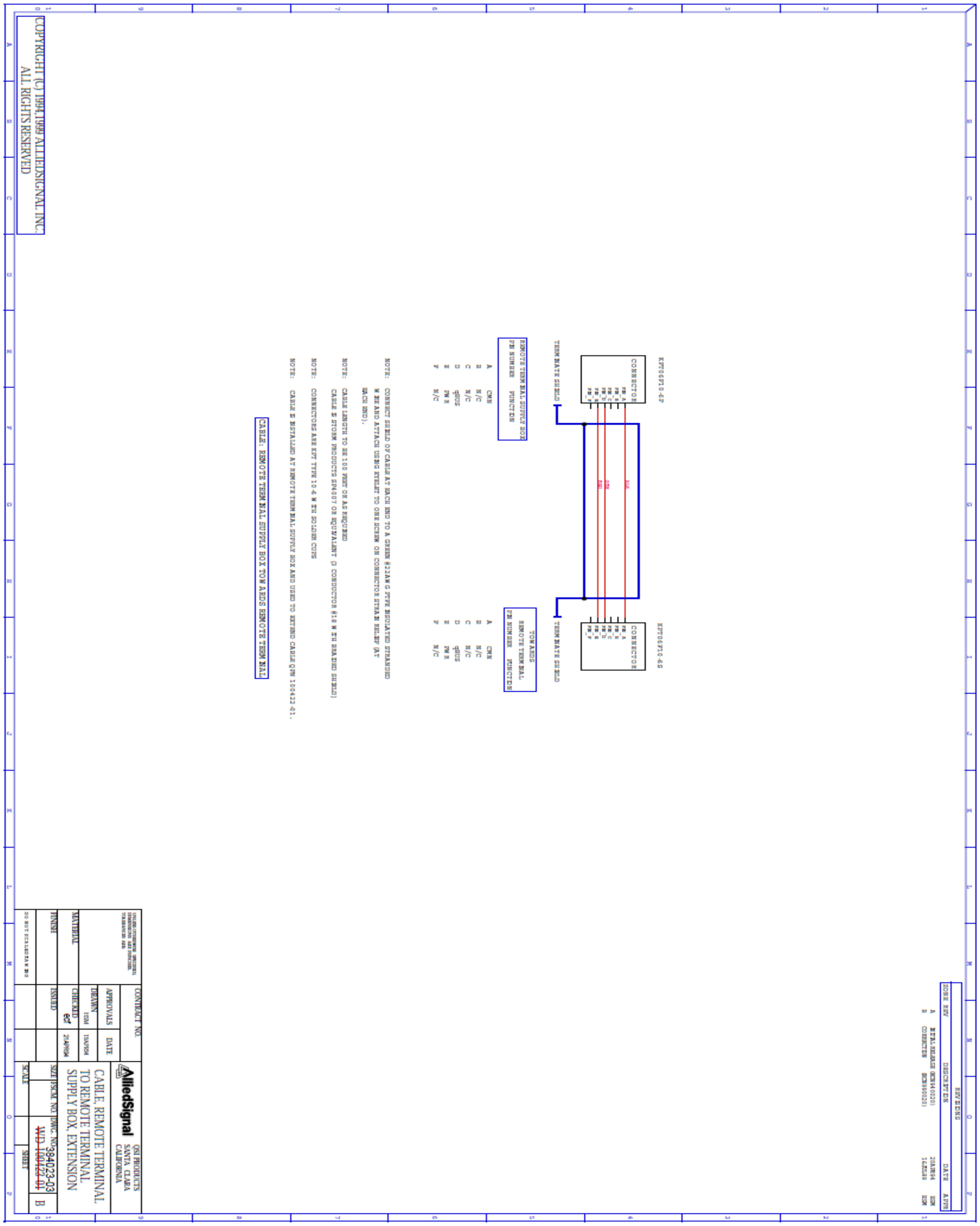
Transducer Cable: DRT to Pressure Transmitter/ 4-20 mA

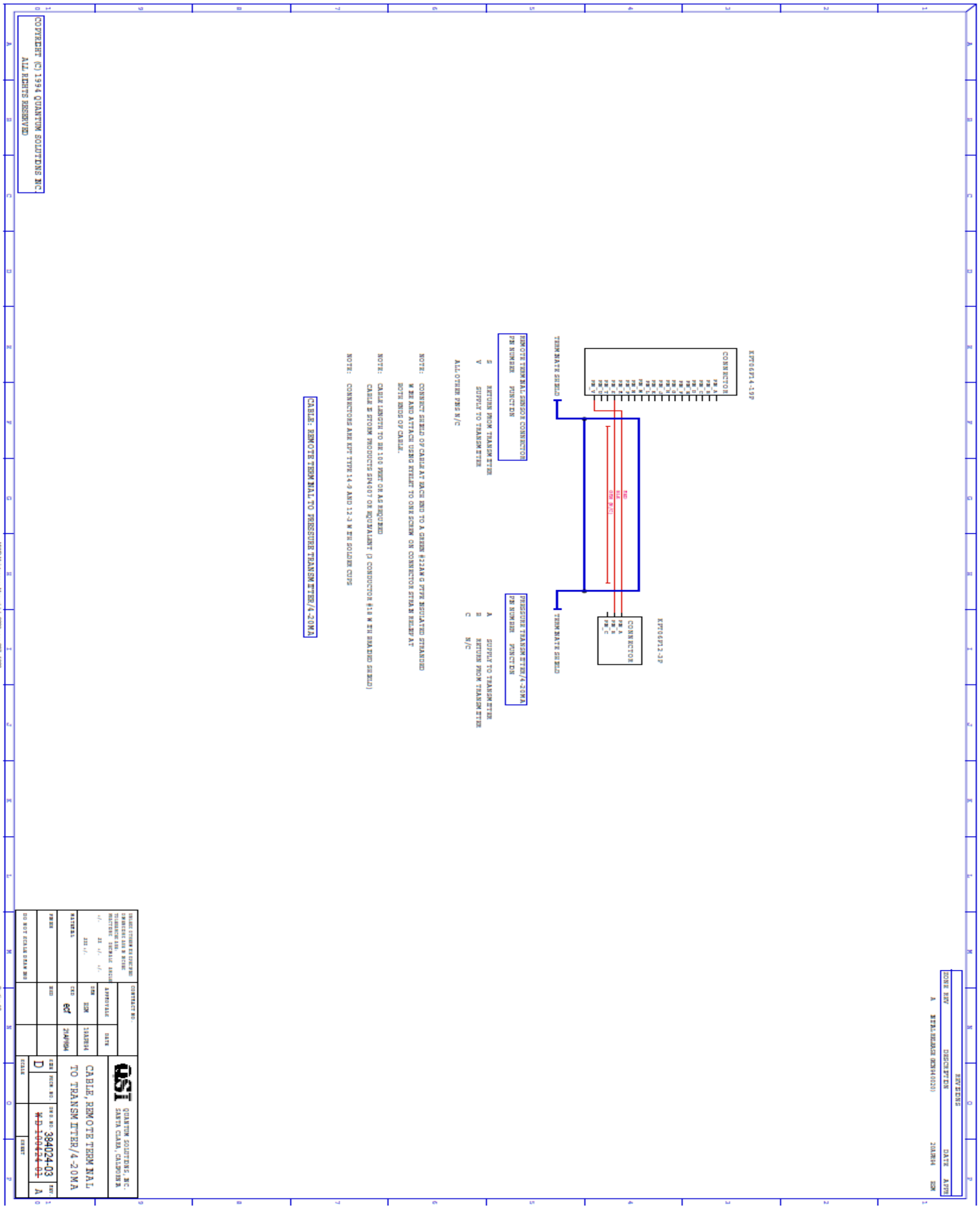
Part Number 384024

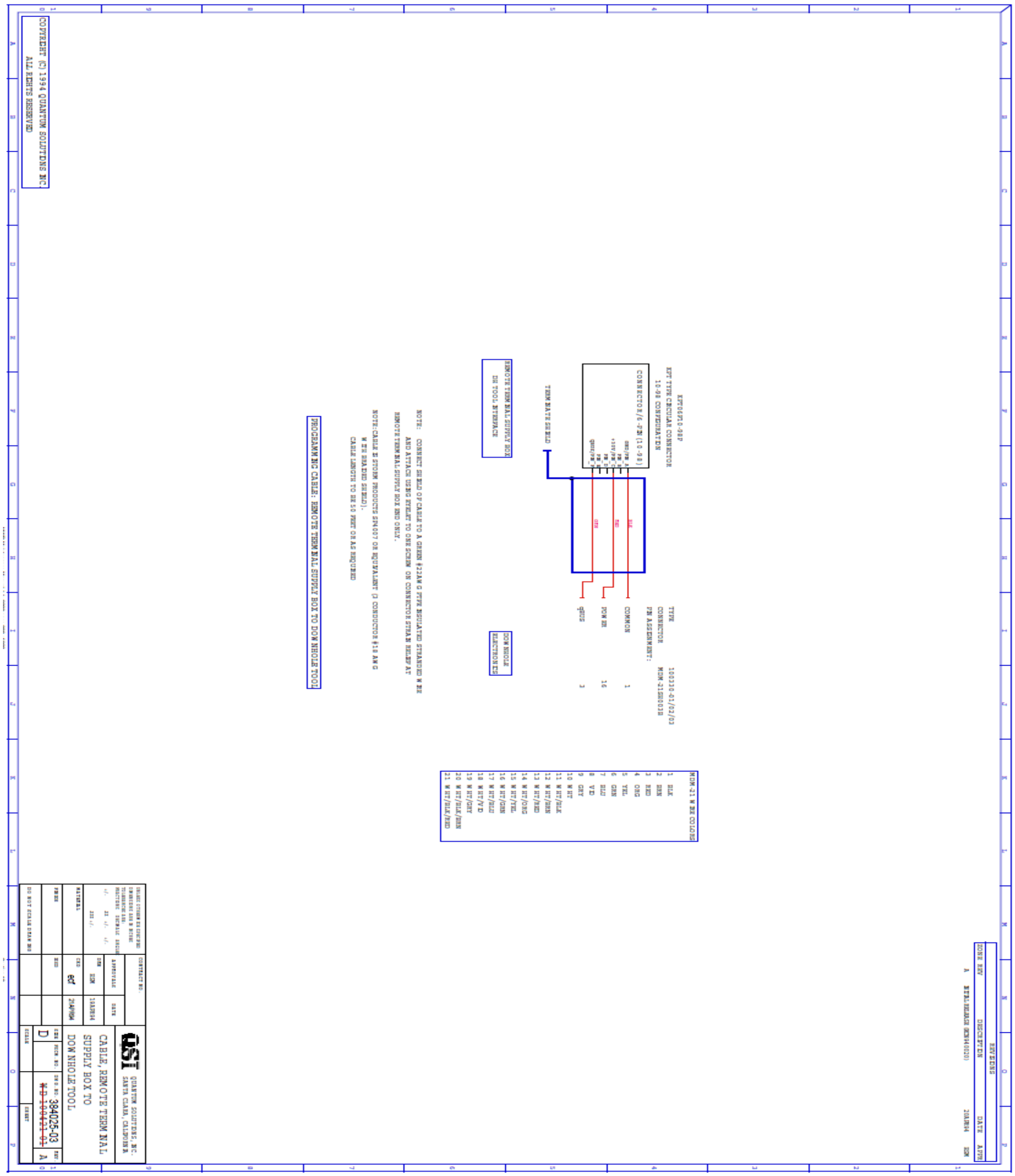


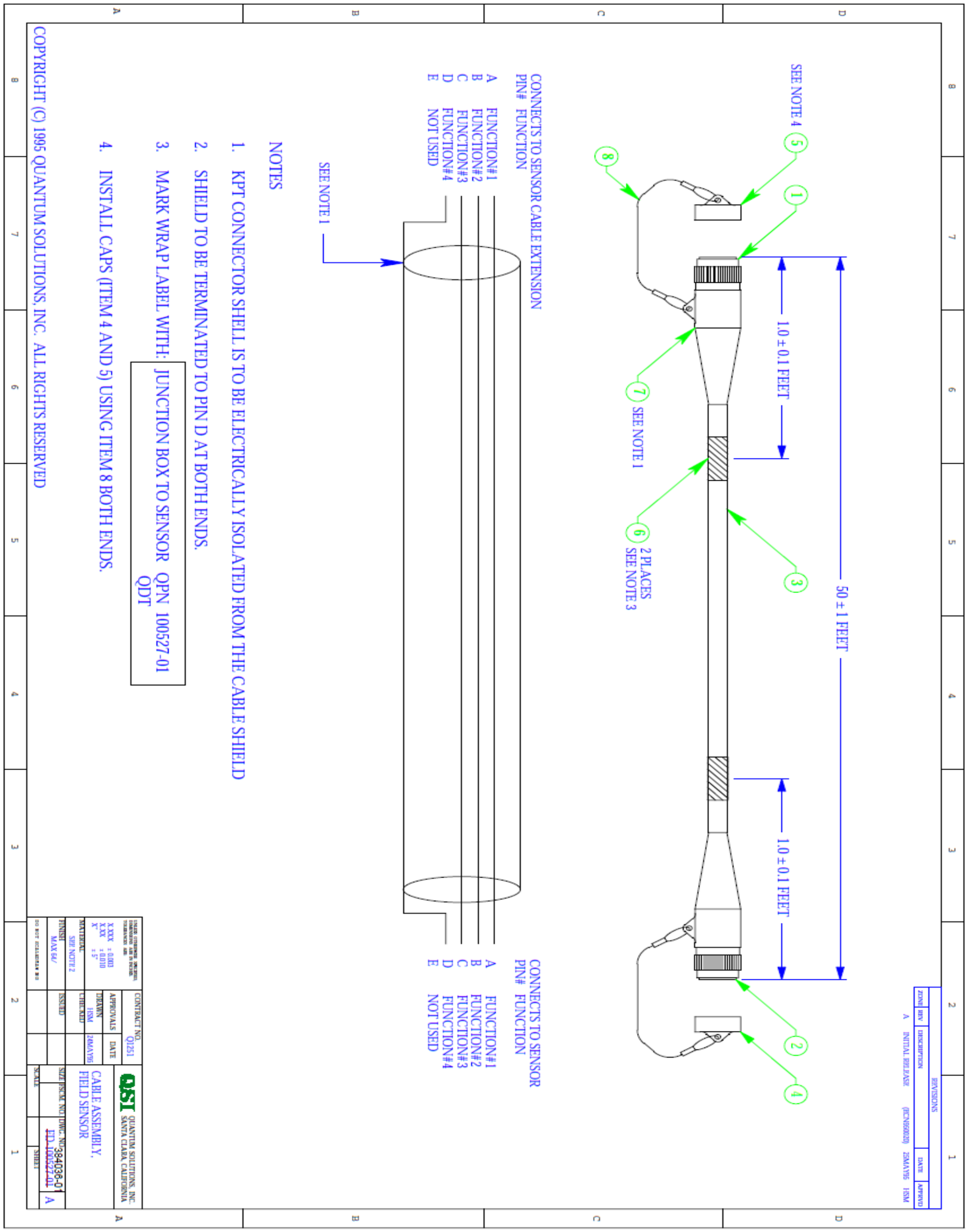


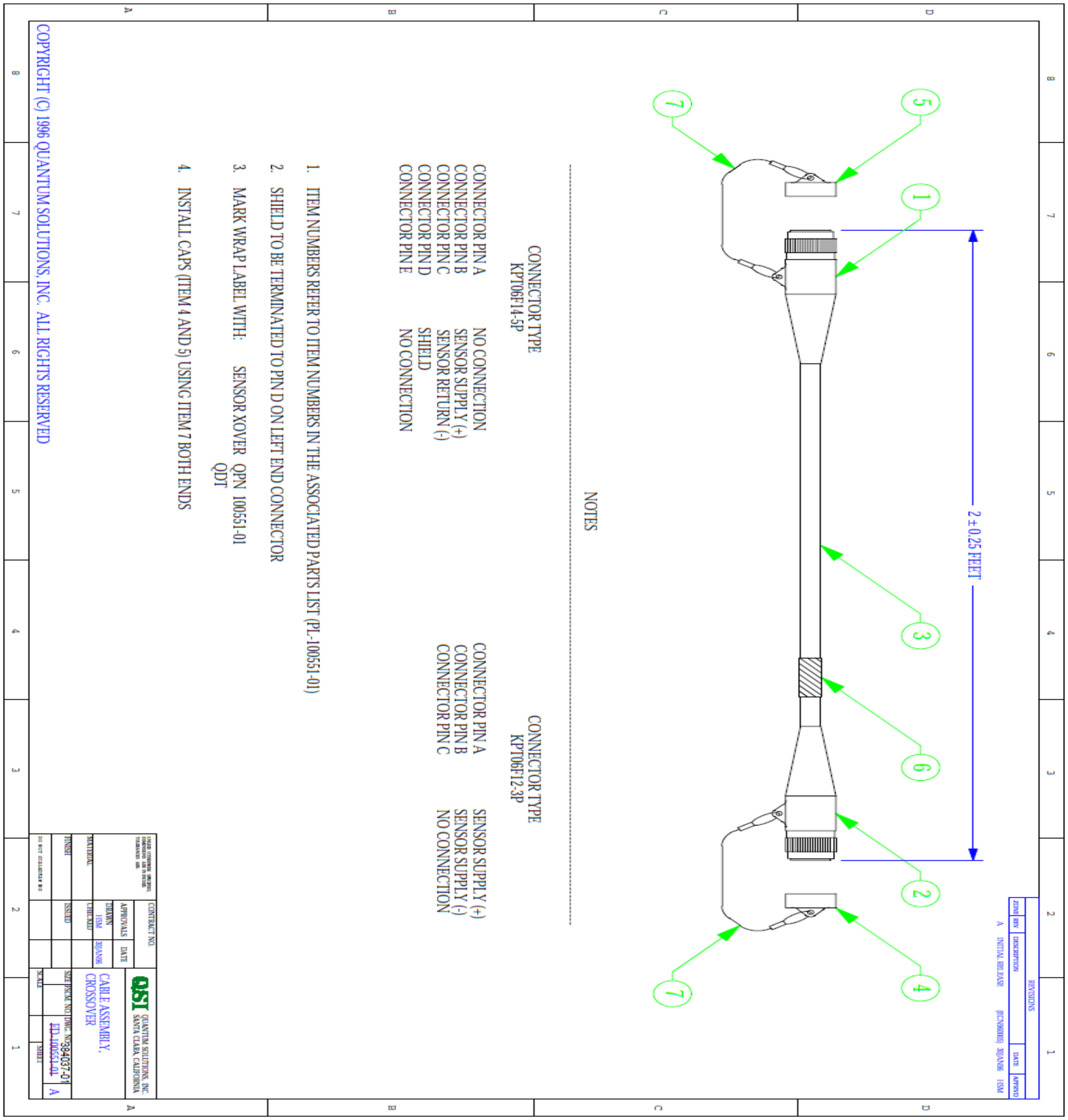
COPYRIGHT (C) 1994 QUANTUM SOLUTIONS INC
ALL RIGHTS RESERVED
KPT06F10-6P
CONNECTOR
TERMINATE SHIELD
REMOTE TERMINAL SUPPLY BOX
PIN NUMBER FUNCTION
A CMN
B N/C
C N/C
D +BUS
E PWR
F N/C
REMOTE TERMINAL
PIN NUMBER FUNCTION
A CMN
B XMODE
C XRST
D +BUS
E PWR
F N/C
NOTE: CONNECT SHIELD OF CABLE TO A GREEN #22AWG TYPE INSULATED STRANDED WIRE AND ATTACH USING EYELET TO ONE SCREW ON CONNECTOR STRAIN RELIEF AT REMOTE TERMINAL SUPPLY BOX END ONLY. CUT SHIELD BACK AT REMOTE TERMINAL END.
NOTE: CABLE LENGTH TO BE 250 FEET OR AS REQUIRED
CABLE IS STORM PRODUCTS SP4007 OR EQUIVALENT (3 CONDUCTOR #18 WITH BRAIDED SHIELD)
NOTE: CONNECTORS ARE KPT TYPE 10-6 WITH SOLDER CUPS
CABLE: REMOTE TERMINAL TO REMOTE TERMINAL SUPPLY BOX
QSI QUANTUM SOLUTIONS, INC.
SANTA CLARA, CALIFORNIA
CABLE, REMOTE TERMINAL TO REMOTE TERMINAL SUPPLY BOX
DO NOT SCALE DRAWING
CONTRACT NO.
APPROVALS
DATE
DRN
KDM
19APR94
CKD
21APR94
SIZE
D
DWG. NO.
384022-03
~~WD 100422-01~~
REV
A
SCALE
SHEET


COPYRIGHT (C) 1994,1999 ALLIEDSIGNAL INC.
ALL RIGHTS RESERVED
AlliedSignal
CABLE, REMOTE TERMINAL TO REMOTE TERMINAL SUPPLY BOX, EXTENSION
CABLE: REMOTE TERMINAL SUPPLY BOX TOWARDS REMOTE TERMINAL


COPYRIGHT (C) 1994 QUANTUM SOLUTIONS INC.
ALL RIGHTS RESERVED
CABLE- REMOTE TERMINAL TO PRESSURE TRANSMITTER/4-20MA
CABLE, REMOTE TERMINAL
TO TRANSMITTER/4-20MA
QSI
38404-03

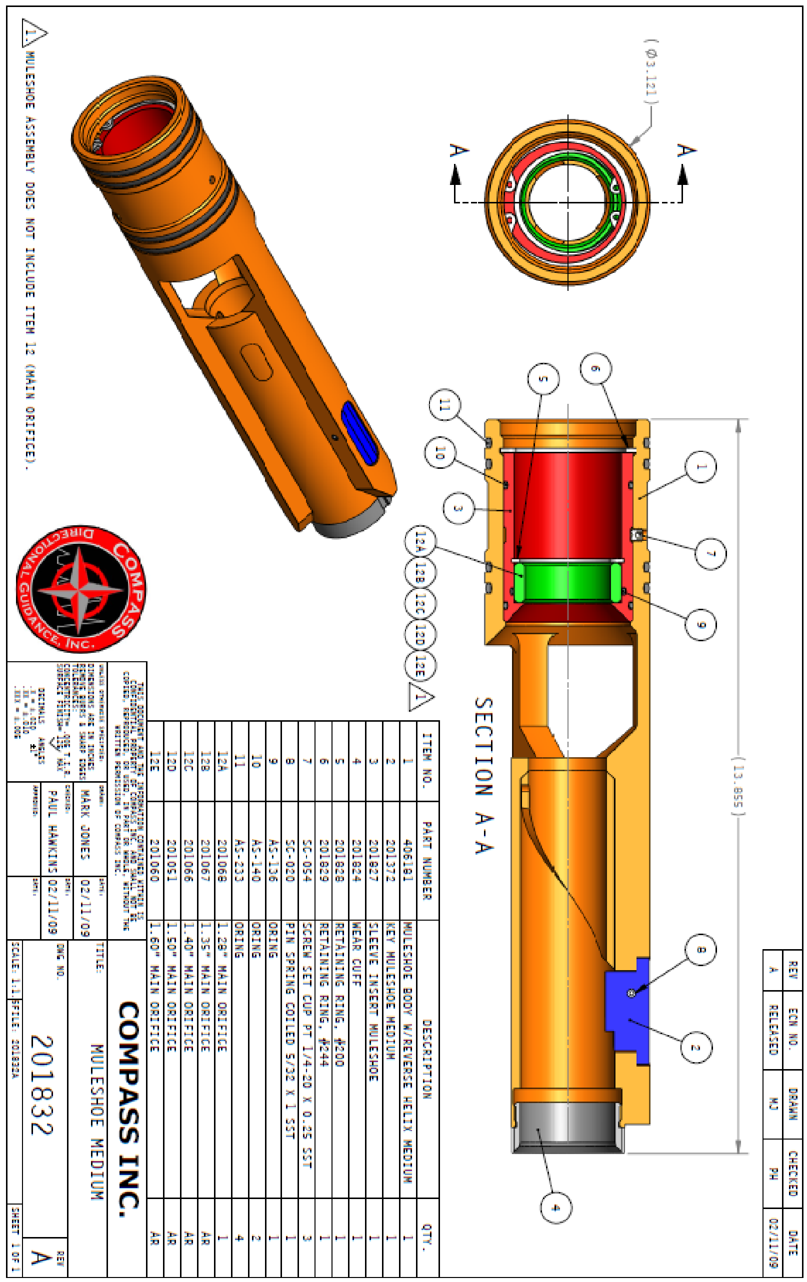

COPYRIGHT (C) 1994 QUANTUM SOLUTIONS INC
ALL RIGHTS RESERVED
PROGRAMMING CABLE: REMOTE THERMINAL SUPPLY BOX TO DOWNHOLE TOOL
DOWNHOLE ELECTRONICS
QSI
QUANTUM SOLUTIONS, INC.
SANTA CLARA, CALIFORNIA
CABLE, REMOTE THERMINAL SUPPLY BOX TO DOWNHOLE TOOL
384025-03

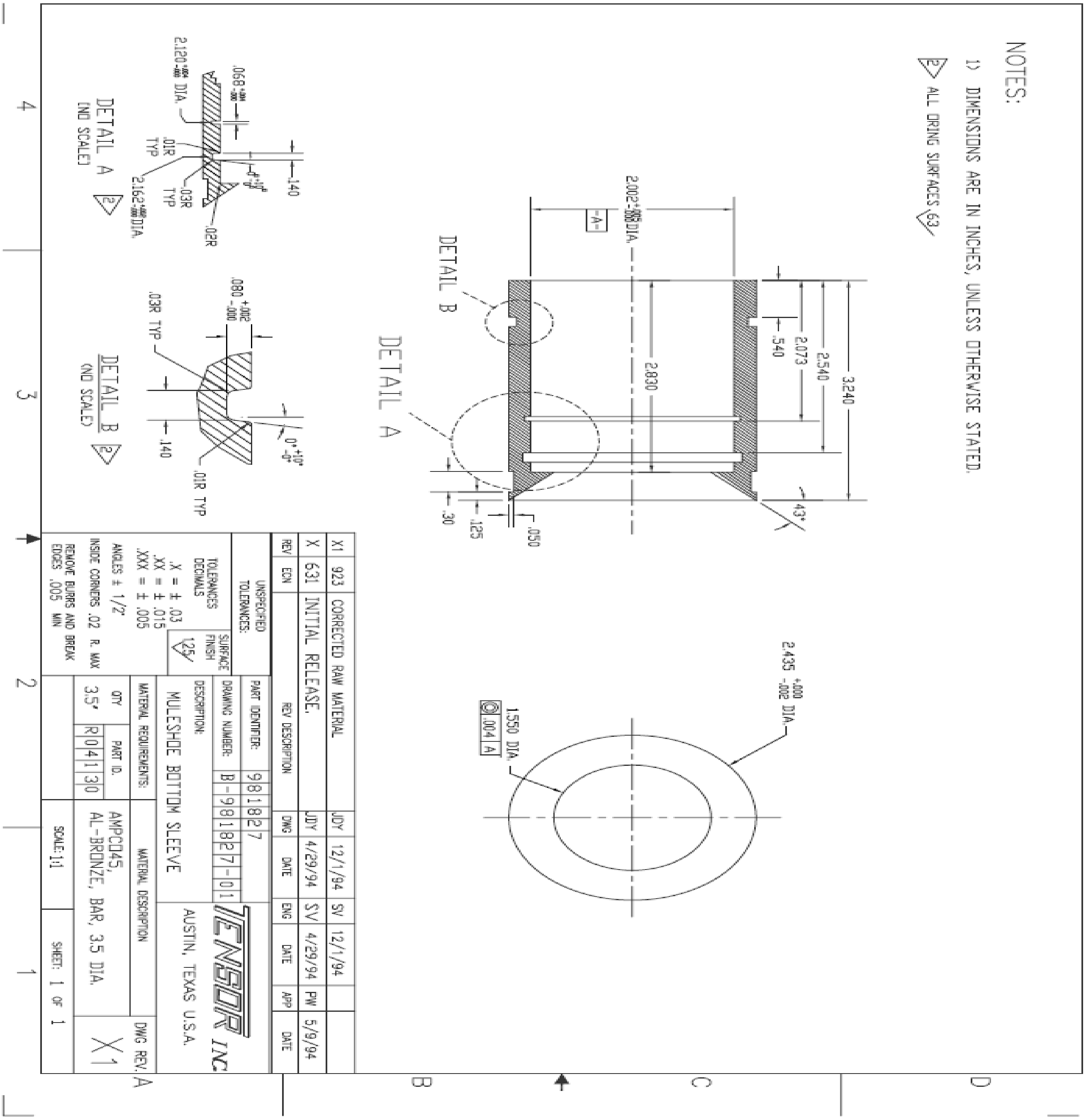

SEE NOTE 4
1.0 ± 0.1 FEET
50 ± 1 FEET
SEE NOTE 1
2 PLACES
SEE NOTE 3
CONNECTS TO SENSOR CABLE EXTENSION
PIN# FUNCTION
A FUNCTION#1
B FUNCTION#2
C FUNCTION#3
D FUNCTION#4
E NOT USED
CONNECTS TO SENSOR
PIN# FUNCTION
A FUNCTION#1
B FUNCTION#2
C FUNCTION#3
D FUNCTION#4
E NOT USED
NOTES
1. KPT CONNECTOR SHELL IS TO BE ELECTRICALLY ISOLATED FROM THE CABLE SHIELD
2. SHIELD TO BE TERMINATED TO PIN D AT BOTH ENDS.
3. MARK WRAP LABEL WITH: JUNCTION BOX TO SENSOR QPN 100527-01 QDT
4. INSTALL CAPS (ITEM 4 AND 5) USING ITEM 8 BOTH ENDS.
COPYRIGHT (C) 1995 QUANTUM SOLUTIONS, INC. ALL RIGHTS RESERVED
REVISIONS
INITIAL RELEASE
QSI
QUANTUM SOLUTIONS, INC.
SANTA CLARA, CALIFORNIA
CABLE ASSEMBLY,
FIELD SENSOR
CONTRACT NO.
APPROVALS
DRAWN
DATE
MATERIAL
SEE NOTE 2
FINISH
ISSUED
SCALE
SHEET


REVISIONS
ZONE | REV | DESCRIPTION | DATE | APPRVD
A | INITIAL RELEASE | (ECN960005) 30JAN96 | HSM
2 ± 0.25 FEET
1
2
3
4
5
6
7
7
NOTES
CONNECTOR TYPE
KPT06F14-5P
CONNECTOR PIN A NO CONNECTION
CONNECTOR PIN B SENSOR SUPPLY (+)
CONNECTOR PIN C SENSOR RETURN (-)
CONNECTOR PIN D SHIELD
CONNECTOR PIN E NO CONNECTION
CONNECTOR TYPE
KPT06F12-3P
CONNECTOR PIN A SENSOR SUPPLY (+)
CONNECTOR PIN B SENSOR SUPPLY (-)
CONNECTOR PIN C NO CONNECTION
1. ITEM NUMBERS REFER TO ITEM NUMBERS IN THE ASSOCIATED PARTS LIST (PL-100551-01)
2. SHIELD TO BE TERMINATED TO PIN D ON LEFT END CONNECTOR
3. MARK WRAP LABEL WITH: SENSOR XOVER QPN 100551-01
QDT
4. INSTALL CAPS (ITEM 4 AND 5) USING ITEM 7 BOTH ENDS
CONTRACT NO.
APPROVALS DATE
DRAWN HSM 30JAN96
CHECKED
MATERIAL
FINISH
ISSUED
QSI QUANTUM SOLUTIONS, INC. SANTA CLARA, CALIFORNIA
CABLE ASSEMBLY,
CROSSOVER
SIZE FSCM NO. DWG. NO 384037-01
FD-100551-01
A
SCALE SHEET
COPYRIGHT (C) 1996 QUANTUM SOLUTIONS, INC. ALL RIGHTS RESERVED

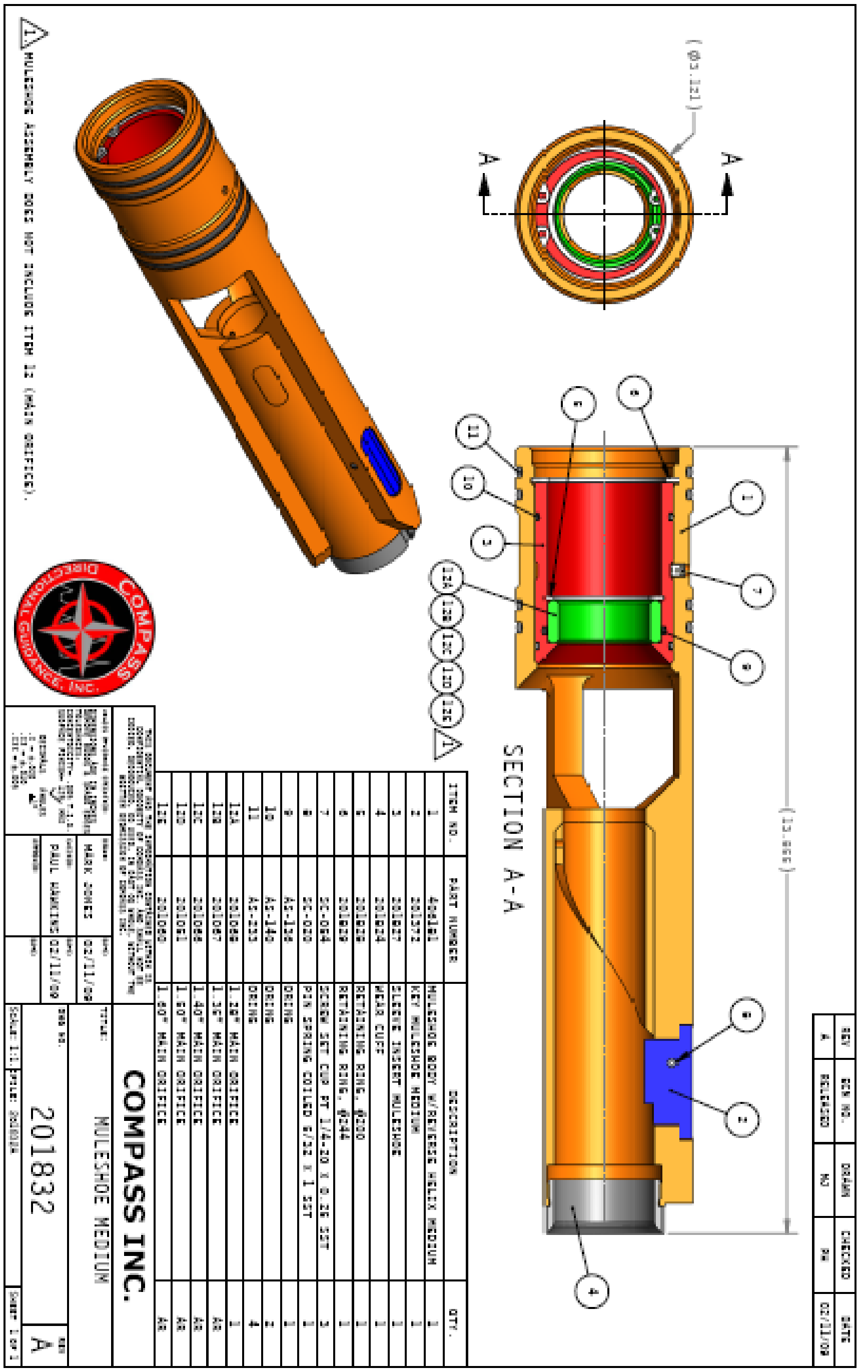
I.4 UBHO SUBS

MULE SHOE and LANDING SUBS

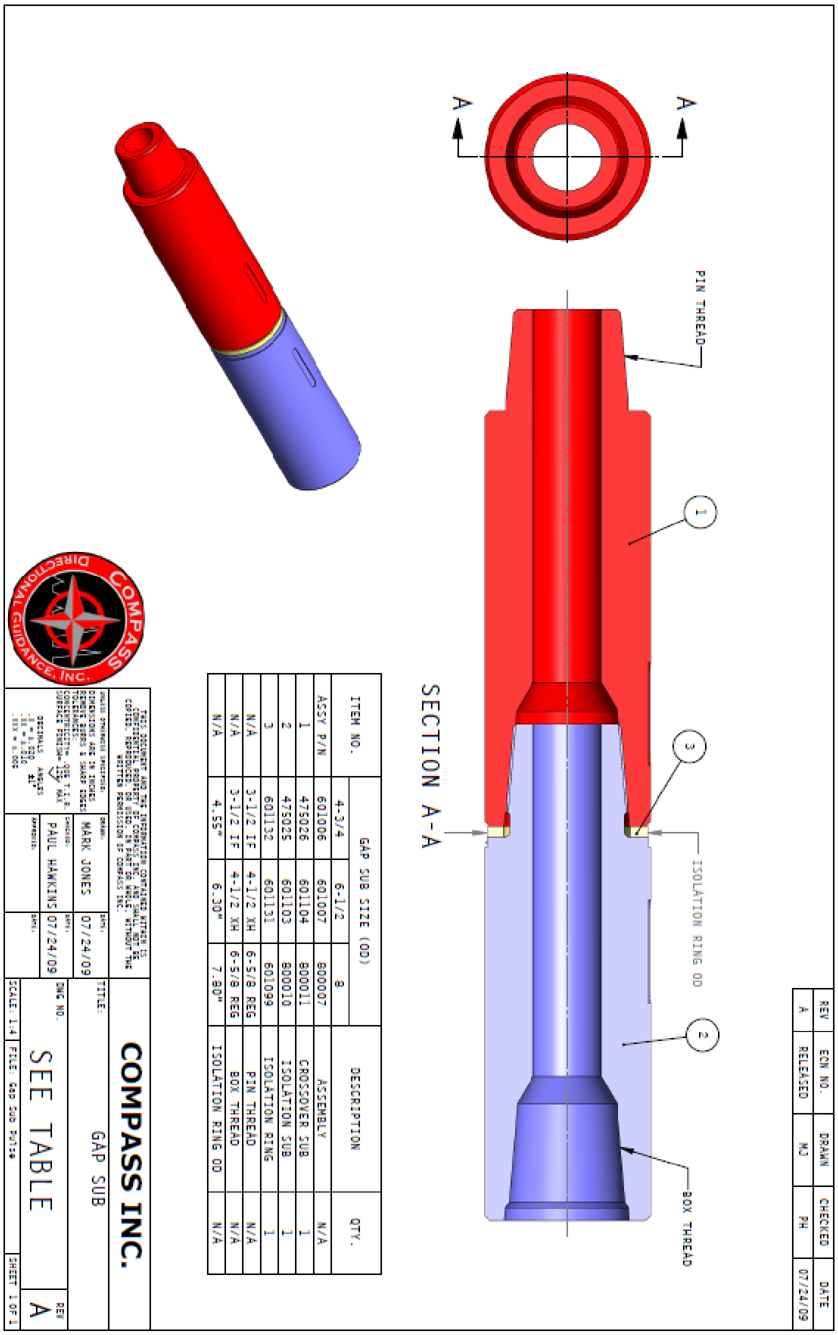



NOTES:
1) DIMENSIONS ARE IN INCHES, UNLESS OTHERWISE STATED.
ALL ORING SURFACES 63
DETAIL A
DETAIL B
DETAIL A (NO SCALE)
DETAIL B (NO SCALE)
X1 923 CORRECTED RAW MATERIAL JDY 12/1/94 SV 12/1/94
X 631 INITIAL RELEASE. JDY 4/29/94 SV 4/29/94 PW 5/9/94
REV ECN REV DESCRIPTION DWG DATE ENG DATE APP DATE
UNSPECIFIED TOLERANCES:
TOLERANCES DECIMALS
.X = ± .03
.XX = ± .015
.XXX = ± .005
ANGLES ± 1/2°
INSIDE CORNERS .02 R. MAX
REMOVE BURRS AND BREAK EDGES .005 MIN
SURFACE FINISH 125
PART IDENTIFIER: 981827
DRAWING NUMBER: B-981827-01
DESCRIPTION: MULESHOE BOTTOM SLEEVE
TENSOR INC.
AUSTIN, TEXAS U.S.A.
MATERIAL REQUIREMENTS:
MATERIAL DESCRIPTION
QTY 3.5'
PART ID. R041130
AMPCO45, AL-BRONZE, BAR, 3.5 DIA.
DWG REV. X1
SCALE: 1:1
SHEET: 1 OF 1

I. 5 MS SLEEVES



I. 6 GAP SUBS


A
A
PIN THREAD
1
3
ISOLATION RING OD
2
BOX THREAD
SECTION A-A
ITEM NO. | GAP SUB SIZE (OD) 4-3/4 | 6-1/2 | 8 | DESCRIPTION | QTY.
ASSY P/N | 601006 | 601007 | 800007 | ASSEMBLY | N/A
1 | 475026 | 601104 | 800011 | CROSSOVER SUB | 1
2 | 475025 | 601103 | 800010 | ISOLATION SUB | 1
3 | 601132 | 601131 | 601099 | ISOLATION RING | 1
N/A | 3-1/2 IF | 4-1/2 XH | 6-5/8 REG | PIN THREAD | N/A
N/A | 3-1/2 IF | 4-1/2 XH | 6-5/8 REG | BOX THREAD | N/A
N/A | 4.55" | 6.30" | 7.80" | ISOLATION RING OD | N/A
REV | ECN NO. | DRAWN | CHECKED | DATE
A | RELEASED | MJ | PH | 07/24/09
COMPASS INC.
TITLE: GAP SUB
DWG NO. SEE TABLE
REV A
MARK JONES 07/24/09
PAUL HAWKINS 07/24/09
SHEET 1 OF 1

NOTES

CHAPTER 5 OPERATIONS MANUAL

A. MUD PULSE
B. EM
C.MWD Tool Pickup And Lay Down Procedures & Torque Guide

SECTION A MUD PULSE

A.1 MECHANICAL & SOFTWARE/PROGRAMMING & TROUBLESHOOTING

ARRIVING ON LOCATION

Once on location, introduce yourself to the company representative as soon as practical. In addition, notify the office once all of our company personnel have arrived, or if someone is missing, and the contact phone numbers at the site should be given to the coordinator.

The job is expected to be set up and equipment tested as soon as possible upon arrival.

1. Confirm hole size to be drilled and the services required (Directional, Gamma).
2. Conduct a quick inventory to determine if all of the required subs and tubulars are present.
3. Confirm the non-magnetic drill collar I.D. for MWD fin selection.
4. Unpack and proceed to conduct an inventory of MWD equipment.
5. Notify the Directional Driller of the services to be run (i.e., D & I or Gamma)
6. Review and verify the Declination, Dip angle, Magnetic fields, with the well plots

SURFACE GEAR AND SOFTWARE TROUBLESHOOTING PROCEDURES

Grounding: It is ALWAYS required that all units be grounded properly. Insure that the Safe Area Interface (SAI) is always attached to a grounding cable firmly secured to the lug on the upper right hand portion of the box. Also, insure that the case of the Driller's Remote Terminal (DRT), is secured to a separate ground. Some locations run on very poor ground circuits, and if this is the case then it may be necessary to operate from a separate power source, such as a generator.

Intermittent Display screen on the DRT may be and is usually a result of improper grounding. All cable connections on the system must be dry and free from dirt and other debris. If any connections become wet or contaminated then they must be changed out with another set. The connections must be dried with isopropyl alcohol or solvent, then as a precaution, packed with silicon grease dirt or contamination to enter the connection. Caution **Intermittent Display**

System Power: It is STRONGLY recommended that an Uninterruptible Power Supply (UPS) be placed between all surface equipment and power sources. This practice will not only allow the system to run for a limited amount of time in the case of power outages, but it will and should supply clean conditioned power to the system. This will protect the valuable and expensive surface components from power fluctuations and spikes. All systems should be operated with at least a power conditioner on line. can resume.

No Reply Received from the Processor/Transmitter. This warning indicates that there is a communication breakdown between the PC to the DRT (MPRx

Node 05) or the DOWNhole Directional Module (MPTx Node 20). To remedy this problem the operator should:

1. Check the Device addresses specified in the Setup Configuration Screen.

2. Check the qBUS connection between the PC and the processors.

3. Check whether the PC or the processors can be communicated with another PC running the qTalk program.

4. Check to insure that the PC and processors are communicating on the same BAUD rate.

5. Check to insure that the processors are in the qMIX mode as opposed to the qChat mode.

6. Can the configurations be downloaded but not stored. There may be a hardware problem.

7. Do the component processors possess the same software that is running in the PC and vice versa.

Storing Configuration w/ Flow On
In this situation you will receive a message warning you that you must turn flow off and wait for the FEVT or the PEVT time period to elapse. When the processors in the DRT and the Survey Electronics are operating, they will accept some data. Please note, some data will be transferred to the processor, but the complete storing process cannot be completed and this will result in a partial store and the warning. This can be hazardous to the operation of the system and the operator should be cautious in this procedure. When using the simulator, at times if the Invert Flow Sense is reversed for the DOWNhole operation mode, then it must be reversed. To overcome this problem store the configuration to the DRT first and then to the DOWNhole tool separately. This will allow you to fix the flow simulation switch to the OFF position for each unit separately to put in the non-flow position.

Inactive Screens: If an operator enters into a screen and it is not updating or is displaying only a file or no data, then check the position of the monitoring toggle switch and check to see if the highlight on the drag-down menu is highlighted. Both positions will lock up the screen and not allow viewing of current data or exit out of the system. In the System Setup under the drag down Menu, there is an option allowing you to activate a switch,that will remind the operator when a screen was previously exited with the monitoring mode deactivated.the Basic Software Package, it is possible to convert the system to 4800 Baud and overcome the increased capacitance problem. For clients using the Depth Tracking Software Package, the Baud Rate **MUST REMAIN** at 9600. The problems with the cable length must be addressed some other way, I.E. by shorting the cables to a usable length or switching to QSI manufactured cables.

Pre-Run Tool Assembly Check List For Compass MWD Hot Hole Directional Only

Select a level place on the ground and set out the jack stands or V-blocks. It is important that the assembly area be level to insure that the threads on the tool connections are not placed in a bind when they are assembled.

Standard Directional Only Configuration [Pulser, 1st Intermodule Battery, 2nd Intermodule, Directional Module, 3rd Intermodule , Spear Point]

Job No.______ MWD Run No.______ MWD Operator ________ Date

PLACE A □ IN FRONT OF EACH STEP TO INSURE THAT THE PROPER PROCEDURE IS FOLLOWED PRIOR TO EACH RUN INTO THE HOLE.

Record the Serial Number of the Pulser selected
S/N:_______

Record the Serial Number of the Battery Module and Battery selected.
S/N:_______

Attach the Intermodule Connector to the DOWNhole end of the Battery Module. Insure that the threaded ring connection is snug, and NOT over-torqued. (Note: 6 PINS point UPhole and 4 PINS point DOWNhole.)

Attach the Intermodule Connector and Battery assembly to the Uphole end of the Pulser module. Insure that the threaded ring connection is snug, and NOT over-torqued.

Record the serial number of the Directional Module selected.
S/N:_______

Attach the second Intermodule Connector to the DOWNhole end of the Directional Module. Insure that the threaded ring connection is snug, and NOT over-torqued (Note: 6 PINS point UPhole and 4 PINS point DOWNhole)

Attach the Intermodule Connector. and the Directional Module to the uphole end of the Battery Module. Insure that the threaded ring connection is snug, and NOT over-torqued.

SECURE the VENT PLUGS on the Battery Module.

Record the serial number of the Spear Point Assembly selected.
S/N:________

Attach the Intermod Conn to the Spear Point Assembly and place this module to the side for attachment later. Insure that the threaded ring connection is snug, and NOT over-torqued (Note: 6 PINS point UPhole and 4 PINS point DOWNhole)

Configure Tool for DOWNhole Operation

Attach the programming plug and cable to the uphole end of the survey electronics and connect the cable to the SAI.

Enter the qMWDCnfg Program on the PC and select the previously configured .MWD file from the directory and check the flow sense and insure that it is in the 'ON' position.
STORE the .MWD configuration to the DOWNhole Tool only.

Remove the programming plug from the top of the tool. This insures that the tool is operating on its own power.

INSPECT the tool and insure that the SERVO-POPPET is ACTUATING.

Re-attach the programming plug/cable to the top of the Directional

Module.

From the qMWDCnfg Program, select a previously configured 'Filename'.MWD file containing the proper variables to satisfy the tools DOWNhole environment and STORE the configuration to BOTH the DOWNhole Tool and the Driller's Remote Terminal. (In an attempt to change the configuration of a tool that is pulsing, the system may not accept the STORE on the first attempt, so try again by storing to BOTH systems until the configuration is accepted.) Name of Configuration File:__________.MWD

Align the key slot on the Helix in a straight up position and Zero the Toolface Offset Angle GTFA CORR.:_____□
Print the configuration from the PC and assign a '*FILENAME*'.PRN to the printout.

Down LOAD the configuration from the Surface Receiver and print the configuration and assign a file name *Rx*.PRN to the printout.

Down LOAD the configuration from the DOWNhole Tool and print the configuration and assign a file name *Tx*.PRN to the printout.

Compare the three printouts of the configuration on a light table for any discrepancies.

Insure that the configuration stored to both the tool and the surface receiver the same! Then continue.

Remove the programming plug from the tool and unplug the cable from the SAI.

Attach the Spear Point Assembly with the third Intermod Conn. to the uphole end of the Directional Module. Insure that the threaded ring connection is snug, and NOT over-torqued (Note: 6 PINS point UPhole and 4 PINS point DOWNhole)

The DOWNhole tool is now ready to be loaded into the collar.

Extended Duration Gamma/Directional

Select a level place on the ground and set out the jack stands or V-blocks. It is important that the assembly area be level to insure that the threads on the tool connections are not placed in a bind when they are assembled.

Extended Duration Gamma/Directional Configuration [Pulser, 1st Intermodule Conn., Gamma Module, 2nd Intermodule Conn., Directional Module, 3rd Intermodule Conn., Battery Number TWO Module, 4th Intermodule Conn., Battery Number ONE Module, 5th Intermodule Conn., Spear Point Assembly]

Job No.______ MWD Run No.______ MWD Operator ________ Date

PLACE A □ IN FRONT OF EACH STEP AS IT IS COMPLETED TO INSURE THAT THE PROPER PROCEDURE IS FOLLOWED PRIOR TO EACH RUN IN THE HOLE.

Record the Serial Number of the Pulser selected
S/N:________

Record the Serial Number of the Gamma Module.
S/N:________

Record the Serial Number of the 1st Intermodule Connector selected.
S/N:________

Attach the Intermod. Conn. to the DOWNhole end of the Gamma Module. Insure that the threaded ring connection is snug, and NOT over-torqued. (Note: 6 PINS point UPhole and 4 PINS point DOWNhole.)

Attach the Intermod Conn and Gamma Module assembly to the Uphole end of the Pulser module. Insure that the threaded ring connection is snug, and NOT over-torqued (Note: 6 PINS point UPhole and 4 PINS point DOWNhole.)

Record the serial number of the Survey Electronics selected.
S/N:________

Attach the second Intermodule Connector to the DOWNhole end of the Directional Module. Insure that the threaded ring connection is snug, and NOT over-torqued (Note: 6 PINS point UPhole and 4 PINS point DOWNhole)

Attach the Intermod Conn. and the Directional Module to the uphole end of the Gamma Module. Insure that the threaded ring connection is snug, and NOT over-torqued (Note: 6 PINS point UPhole and 4 PINS point DOWNhole)

Record the Serial Number of the Number 2 Battery Module and Battery selected.
S/N:_______

Attach the third Intermod. Conn. to the DOWNhole End of the Number 2 Battery Module. Insure that the threaded ring connection is snug, and NOT over-torqued (Note: 6 PINS point UPhole and 4 PINS point DOWNhole)

SECURE the VENT PLUGS on the Battery Number 2 Module.

Attach the Number 2 Battery Module and 3rd Intermod. Conn. to the Uphole end of the Survey Electronics. Insure that the threaded ring connection is snug, and NOT over-torqued (Note: 6 PINS point UPhole and 4 PINS point DOWNhole)

Record the Serial Number of the Number 1 Battery Module and Battery selected.
S/N:_______

Attach the fourth Attach the second Intermodule Connector to the DOWNhole end of the Directional Module. Insure that the threaded ring connection is snug, and NOT over-torqued (Note: 6 PINS point UPhole and 4 PINS point DOWNhole)
to the DOWNhole End of the Number 1 Battery Module. Insure that the threaded ring connection is snug, and NOT over-torqued (Note: 6 PINS point UPhole and 4 PINS point DOWNhole)

SECURE the VENT PLUGS on the Battery Number 2 Module.

Attach the Number 1 Battery Module and 4th Intermod. Conn. to the Uphole end of the Number 2 Battery Module. Insure that the threaded ring connection is snug, and NOT over-torqued (Note: 6 PINS point UPhole and 4 PINS point DOWNhole)

Record the serial number of the Spear Point and Mode Plug Assembly selected.
S/N:_______
Attach the 5th Intermod Conn to the Spear Point Assembly and place this module to the side for attachment later. Insure that the threaded ring connection is snug, and NOT over-torqued (Note: 6 PINS point UPhole and 4 PINS point DOWNhole)

No Pulses

Look at these possible causes for no pulses at the surface during the surface test..

1. Is there power to the Driller's Remote Terminal (DRT)?

2. Is the Transducer connected properly to the DRT?

3. Are all valves open to the Transducer?

4. Is the mud line on the manifold clear to the transducer?

5. Is the 'Pumps On' threshold low enough to activate the processor, in the DRT, to look for pulses? 'PUMPS ON'

6. Is the standpipe pressure accurately measured and displayed on the DRT? (±50 PSI)
   Different transducers used in the industry have different settings that may or may not activate at low pressures. The presence of mud pressure and no pulses indicates that the tool is not creating any pulses or they are being absorbed in the surface system or below the tool.

7. Is the BHA open-ended or does it have a bit on the end?

8. Is the tool seated in the mule shoe?

9. Is the flow adequate and is the Poppet/Orifice configuration tight enough to create a pulse at a lower flow?

10. Is the Flow Switch (INVF) switch set to 'Off' for a conventional flow switch

Failure to Decode Pulse

Start pumps and wait for tool to start pulsing. After TxDT time has elapsed...

1 Are pulses present on DRT? (Caution to distinguish between noise and pulses.)
   Yes - go to step 3.
   No - go to step 2.
2 Are pulses present on standpipe gauge and/or choke manifold?
   Yes - go to step 4.
   No - go to step 3.
3 Is the pump pressure accurately displayed on the DRT pulse wave-form screen?
   Yes - go to step 4.
   No - go to step 8.
4 Is the processor decoding the pulsed data correctly?
   Yes - tool is working properly.
   No - go to step 5.
5 Are the High Pulse Limit and Low Pulse Limit (HiPl/LoPl) adequate to decode the pulse data correctly?
   Yes - Go to step 6.
   No - Adjust the settings.
6 Are the DOWNhole tool and the Surface receiver configured correctly?
   Yes - Go to step 7
   No - Reconfigure
7 Are the Alert Pulse (4-1X Pulse) and the proper number of Synch pulses sent and are they decoded by the Surface Receiver?
   Yes - Go to step 8
   No - Pull the tool and check the components. (refer to Surface Check of DOWNhole Tool)
8 Is the transducer connected properly to the standpipe and the DRT?
   Yes - Go to step 9
   No - Correct the situation - Go to step 1

9 Do the values in the transducer settings match the type of transducer being used?

Yes - Go to Step 10

No - Correct the settings and retry.

10 Check for closed valves and plugged connections - are they open?

Yes - Change out the Transducer.

No - Open all valves to the transducer and remove any solids blocking the standpipe connectors. - Go to Step 1.

Pulser Troubleshooting Guide

Lower End Inspection

Condition of Signal Poppet Tip and Shaft Stop

Check these two parts for unusual damage and wear. If the poppet is chipped severe wash and erosion will result when it run DOWNhole. The shaft stop should be secure and not jammed with debris or eroded severely. Always check to insure that the tip is secure to the shaft.

Condition of Signal Poppet Shaft

The shaft should be free moving and not jammed with debris. Check for excessive wear that would allow for excessive wobble while in the pulsing motion. Should the Signal Poppet Shaft offer resistance when shoved upwards into the helix end, then remove the helix end and the shaft for inspection.

Condition of Piston Cap, Wiper, Poly-Pak and Orifice

The piston cap and wipers are subject to a tremendous amount wear and should be checked on every trip out of the hole, for damage and excessive wear. They can be easily changed when the lower end is inspected. This will allow for extended use Downhole provided the other parts of the pulser are operational. When new wipers are installed, the area between the wipers should be packed with a Silicon Lubricant, to prevent solids from entering the area between the wipers and causing damage.

Condition of Wear Sleeve

The Wear Sleeve provides a smooth surface for the wipers to slide against and should remain free of debris. The surface should be smooth and free of pitting

Condition of Main Spring

The Main Spring is made of steel and should endure a lifetime in excess of 2000 pulsing hours. It is perfectly matched to account for the forces involved in the pulser, so this should be reordered from the manufacturer.

Condition of Pulser Helix End, O-ring and Poppet Housing

The pulser helix end is very important to the orientation of the probe in the MWD collar. It endures extreme conditions of wear and abuse when repeatedly retrieved and landed in the mule shoe. This piece should be inspected every time it retrieved from DOWNhole. The abrasion ring needs constant attention to insure that the tool is not being subject to excess vibration DOWNhole. This will cause excess wear on the reverse helix in the mule shoe and the helix end of the pulser. As the abrasion ring is worn down, many events could occur that may cause unique operational abnormalities in the probe.

Condition of Screen Housing and Screens

Insure that the screens are intact and none are missing. Inspect for severe wear and erosion, and replace any screens that are damaged. Screens with oversized holes should be changed out with new or less worn screens.

Level of Silicone Oil

There three areas to check the oil level in-between runs. Look at the bellows and check for any leaking in and around the screen housing area. Push the bladder in with a BLUNT instrument (5/16 th Hex driver) in one of the two middle holes and feel for resistance. If the bladder feels like it collapses without any resistance, then check the third area. The third area to check is the oil fill plug. Removing this plug should only be done by a trained and experienced operator.

Oil Fill Plugs

The oil fill plugs should not be removed from the pulser in the field, unless an oil fill kit is available on location and the operator is proficient in the oil fill procedure. Should the operator decide not to run the pulser prior to returning to the shop, the plug can be opened for inspection. Keep this area clean from all debris. Clean the plug and screwdriver slot area completely prior to removal. If the pulser is cold the oil may not appear at the surface. If the pulser is warm or hot, then oil may well up and spill over the rim of the port

Pulser Driver Assembly

The pulser driver assembly is an electronic device. Field inspection should be kept to the minimum of a visual inspection to look for physical damage caused by excess vibration or fluid invasion. If there is any doubt to the integrity of the assembly, it should be returned to Compass. for inspection and possible repair.

Servo-poppet Actuation with Pulser Test Box

Actuation of the pulser with the Pulser Test Box will give a complete test of the pulser's electronic and mechanical parts. However, it is not capable of testing the flow switch. Should the pulser not actuate, then all of the connections from the box to the pulser and the power source should be checked.

Battery Troubleshooting Guide

Batteries can be checked for proper operation by using the Breakout Box (#203140) to check the unloaded voltage and continuity. By assembling a complete tool with the breakout box in line between any of the modules and placing the tool into the dry pulse mode, the loaded voltage can be monitored. Note, all unloaded batteries will read maximum after they have had time to recharge. However, after a load is placed on the system, the batteries will display the true operating voltage. The following instructions will guide the operator in the proper procedures to connect the system.

Battery Continuity and Unloaded Voltage Check

1. Lay the battery module flat and note the uphole and DOWNhole positions

1.1 WARNING: Insure that all of the switches on the breakout box are in the 'Break' position. This will prevent you from completing a circuit through the breakout box. Insert the plug marked Down (indicates DOWNhole orientation of the breakout box) on the box into the uphole end of the battery module (end nearest the vent plug). Insert the plug marked Up (indicates uphole orientation of the breakout box) on the box into the DOWNhole end of the battery module (end opposite the vent plug). With the voltmeter in the Ohms (resistance) position, place the black lead into the No. 1 position and the red lead into the opposite No. 1 position, you should observe a closed circuit (activate the audio alarm if available). With either of the leads (not both), insert one of the leads into the No. 2 socket and then into the No. 3 and so on to No. 10. Each time you should observe an open circuit (no sound). If a closed circuit is observed (heard), then a short is present between those two lines. Next place the lead that remained in socket No. 1 into socket No. 2 of the same color. Place the other lead into socket No. 2 of the opposite color. At this point you should observe an opened circuit (no audio alarm). This is O.K. Continue to socket No. 3 with the second lead and you should observe a closed circuit (audio alarm).

This is O.K. Continue to check the circuits by following the same routine to determine if any of the Bus lines are shorted to another Bus and the housing components. Refer to the battery pack wiring diagram and note that Bus 2 and Bus 3 cross paths through the length of the battery. This procedure allows for the switching from one battery to another when the tool is using the stacked configuration.

1.2 With the Breakout box and the tool in the same position place the black lead of the volt meter into socket No. 01 on the black lower row and place the red lead of the voltmeter into socket No. 03 on the red upper row. You should read a voltage of 29 DC (± .5 VDC). With only the black row plug (Down) inserted, voltage can be read from the black sockets Nos. 1 & 2. And with only the red row plug (Up) inserted, the voltage can be read from the red sockets Nos. 1 & 3. Do this only if you are going to do a voltage check and not a complete continuity test.

Loaded Voltage Battery Check

1.3 To perform a loaded battery voltage, it is currently advisable to place the Breakout Box in line with the system and configure the tool to pulse on the ground. (Refer to Dry Pulse Test) Monitor the battery voltage as above while the tool is pulsing. This will give the operator an indication of the voltage while the tool is operating with the load that the tool will see DOWNhole. Note that these voltages are measured at ambient temperature on the surface and that the batteries will possible deliver a slightly higher reading after the system is warmed up.

1.4 The importance of tracking the operating hours of the batteries and the on time hours cannot be stressed enough. The easiest way to do this is to record the time that the tool is made up and the time that the tool begins pulsing (start of drilling time) and then the time the tool stopped (end of drilling time) and the time that the batteries are disconnected. These time spans will give the operator the necessary data to compile a history battery usage. By combining this data with the other configurations of the tool (pulse width, directional only, or directional with gamma ray detector), the operator will be able to accurately determine and predict the potential life span of his battery packs and determine how to obtain the maximum amount of battery life without jeopardizing the operation.

Compass MWD Directional Module
Troubleshooting Guide

The Directional Module contains the Compass electronics package and the DOWNhole processor (Node 20). This module acquires all directional data and controls and commands the entire MWD tool and peripheral modules. This package is designed to withstand tremendous amounts of DOWNhole shock and vibration, but it must be noted that it contains numerous sensitive electronic devices that require care and attention when handled on the surface. If any problems are suspected to exist with this system, the operator should follow the prescribed procedures to assist in troubleshooting the module to determine the extent of, if any, damage.

Directional Module **Continuity Check**

Lay the module in a safe and secure position, and make note of the Uphole (6-pin connector) end and the DOWNhole (4-pin connector) end. Insure that all of the switches on the Breakout Box (PN# 203140) are in the 'Break" position. Insert the leads of the Breakout Box into the appropriate ends of the Survey Electronics module. With the leads of the test meter in the proper sockets, (black in COM, red in □), insert the black lead into the black sockets and the red lead into the red sockets of the Breakout Box, and check the module for continuity (1-1, 2-2, ..., 10-10) as instructed by the chart below and record the results on a copy of the blank form supplied.

For the subsequent test, place the black meter lead into the Bus 1 red socket of the Breakout Box and the red meter lead into the Bus 2 red socket and continue to check the module (1-2, 1-3, 1-4, ..., 1-10 and then 2-3, 2-4, ..., 2-10, and so on) according to the chart and record the results. It is best to use a test meter with an auto ranging feature and a digital readout. This will make the comparison of the results more accurate. Please note that different meters are calibrated differently and may result in variations of the results listed in the example. The technician should not be alarmed with slight differences, ±5% (10% range), in the readings. Only gross differences should be noted and then should the system be returned for further evaluation. Refer to Inspection of the Transorbs.

Inspection of the Transorbs

The transorbs are board mounted devices placed in line with the six Bus lines that are connected to the MPU. The board is encapsulated in a resin compound designed to fit snugly in the up hole end of the module at the bulk head assembly. The transorbs are voltage limiters designed to act as 'fuses' in the case of a long duration, high voltage spike caused by static discharge or a short in the bus lines from the battery. Should the operator measure an open line or other drastic differences in the continuity check of the module, this would be the next location to be checked prior to sending the system back for further investigation.

MWD Roll Test

Refer to the MWD Roll Procedure in the QDT MWD Training Manual for the proper procedure. This routine will activate the entire Survey Electronics and display the measured values of each individual sensor in the module. The Gamma Module can be attached and powered by the system to display the measured values for a simultaneous test of the Gamma module. By using this routine the operator can visually inspect the measured values of each component for potential problems. Perform a 25 point roll test according to the procedure and evaluate the measurements. The results should fall into the ranges prescribed on the printout. Should any of the results fall outside of the ranges, go through the following flow chart and check the results. This test should be performed before and after each job.

Accelerometers:

1. Is the g-total = 1.0000 ± 0.0004?

Yes - accelerometers are good.
No - go to Step 2.

2. Are any of the accelerometer readings remaining the same regardless of the orientation?

Yes - That particular accelerometer is damaged.
No - Possible loss of calibration - go to Step 3.

Magnetometers

3. Is the MAGF value equal to the prescribed value in the Site Environment Settings in the range of ±0.0035 Gauss?

Yes - Magnetometers are good.
No - go to Step 4.

4. Was the tool rolled in a non magnetic environment?

Yes - Remove the unit from the barrel for inspection or return the module for inspection at your shop or the manufacturer's.
No - Reroll the unit in a cleaner environment, go to Step 1.

If there are any problems with the system, i.e. failed roll test, failed continuity test or failed flow simulation test, the system should be returned to TENSOR, Inc. for inspection, evaluation and re-calibration.. Removing the system from the barrel will nullify the calibration and cause inaccuracies in the directional measurements. Proper calibration cannot be obtained without the complete survey system contained in the barrel.

Continuity Check for Interconnect Module/ Bow Spring/Fin Centralizer

The Interconnect Module/Centralizer is a simple wire-way for the bus lines through the tool. If one of these components is suspected of having a short or broken connection, then it should be checked for continuity, using an Ohm meter. Lay the module in a flat and secure position, and make note of the Uphole (6-pin connector) end and the DOWNhole (4-pin connector) end. Insure that all of the switches on the Breakout Box (PN# 203140) are in the 'Break" position. Insert the leads of the Breakout Box into the appropriate ends of the Interconnect module. With the leads of the test meter in the proper sockets, (black in COM, red in □), insert the black lead into the black sockets and the red lead into the red sockets of the Breakout Box, and check the module for continuity (B1-R1, B2-R2, ..., B10-R10) as instructed by the chart below and record the results on a copy of the blank form supplied. The value of the measurements should be 0.50 □ ±0.1□. It is best to use a test meter with an auto ranging feature and a digital readout. This will make the comparison of the results more accurate. Please note that different meters are calibrated differently and may result in variations of the results listed in the example. The technician should not be alarmed with slight differences, ±5% (10% range), in the readings. Gross differences should be noted and only then should the system be returned for further evaluation or broken down for rebuild..

To check the unit for shorts, place the black meter lead into the Bus 1 black socket of the Breakout Box and the red meter lead into the Bus 2 red socket and continue to check the module (B1-R2, B1-R3, B1-R4, ..., B1-R10, B1-Barrel and then B2-R3, B2-R4, ..., B2-R10, B2-Barrel and so on) according to the chart and record the results. All of these readings should measure OL. Should any reading other than OL. be measured, then the possibility of a short exist and the check should be rerun and the procedure be checked before breaking down the unit. If the test is consistent, then the unit has a short connection and requires rebuild by a qualified technician.

SECTION B - EM

B.1 MECHANICAL

PRE-JOB CHECKS

Well Information

Evaluate the job to select the best operating parameters

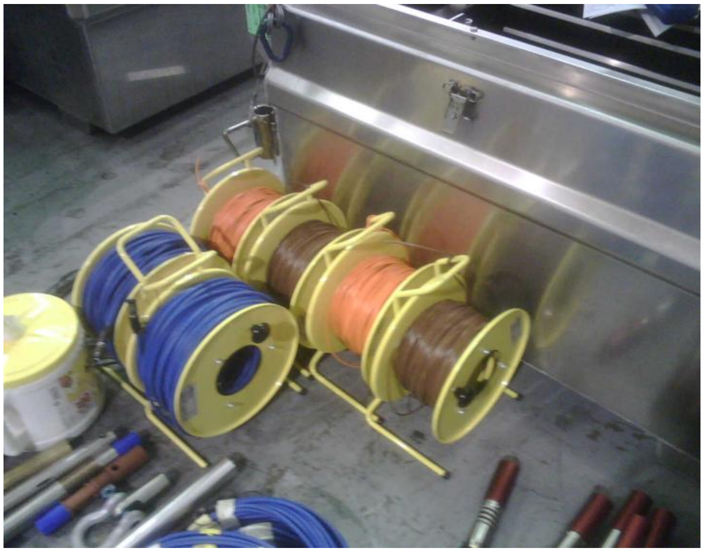
- Formations to be drilled (Resistivity logs)
- Depth of hole
- Casing depth
- Drilling fluids
- Select Power setting
- Select Pulse width

KIT REQUIREMENTS

The Compass EM requires these additional components along with the standard Compass MWD System:

Compass Transmitter Module, Isolation Sub, Extended Battery Module

CABLING



Power Supply Cable (ground prong removed), Antenna Cable, BOP Cable, BNC Cable, Transducer Pigtail Cable

TEST EQUIPMENT

Frequency Interface Receiver, Transmitter Test Box, Oscilloscope, Line Conditioner (optional), Power Bar (with the ground removed on the plug)

RUNNING GEAR

Antenna Rods, Clamps

COMPASS EM TOOL

The **Directional Module** accumulates data including INC and AZM, etc.

The **Centralizer/Interconnect Assembly** provides electrical connection between each module and contact to the drill string. **Bow springs should be tight so they make good contact to the drill collar**. Poor contact can cause weak or no signal.

The **Gamma Module** can be added to the tool string above the Transmitter Module and operated using the existing gamma software.

IMPORTANT: Before starting make sure there are no shorts from any lines to the housing of all modules except for the Compass Transmitter. This can be done by ringing out the modules with a break out box. Since we are making a dipole antenna with the tool string the EM signal may interfere with the operation of the tool.

Assemble the tool string with the normal MWD setup procedure. The Compass Transmitter Module is placed on the bottom of the tool string and should be assembled first.

Do not have the programming cable plugged in the tool string when tightening the tools or tap testing. It will turn the transmitter on and will lock up the Qbus (no communications) and if the programming cable is shielded, voltage may travel from the barrel to the surface equipment and may result in damage to the equipment.

Do not ground the SAI or any surface system.

Do not have the transducer cable connected to the FI Receiver when programming the tools. Connect the transducer cable from the FI Receiver to the Surface system once all programming is complete. Every time you change the tool programming, you are required to unplug the transducer cable.

SASP Surface System

Program the Remote Terminal first without the tool connected. Unplug the two main cables to program and high-side of the tool string. Reconnect the main cables to tap test the tool. When in operation, make sure the rig floor display is electrically isolated from the rig or electrical interference from the rig may interfere with the operation. This can be done by using a nonconductive case to hang the rig floor display on the rig.

CABLING

- Antenna Cable 600’ or 200m
- BOP Cable 300’ or 100m
- Transducer cable

ISOLATION SUB (GAP SUB)

The Isolation Sub is connected on top of the UBHO Sub in the BHA assembly. An Isolation Sub ohm measurement should be performed before picking up tools. This is done by putting the Isolation Sub on wooden blocks for insulation from ground and measuring across the gap with a multimeter set to ohms. This prevents any false reading from whatever the sub is lying on. A measurement of greater than 1000 ohms should be seen. If the reading is less, clear away any debris around the isolation area inside and out and measure again. It is normal to see the resistance climb slowly to an open circuit. **If the sub still reads under 1000 ohms, do not run it.**

Visually inspect the annular washer for any cracks or pitting. If cracks are observed, do not run the gap sub. If pitting has occurred, talk to your MWD coordinator for confirmation of running it.

Never torque the Isolation area of the sub.

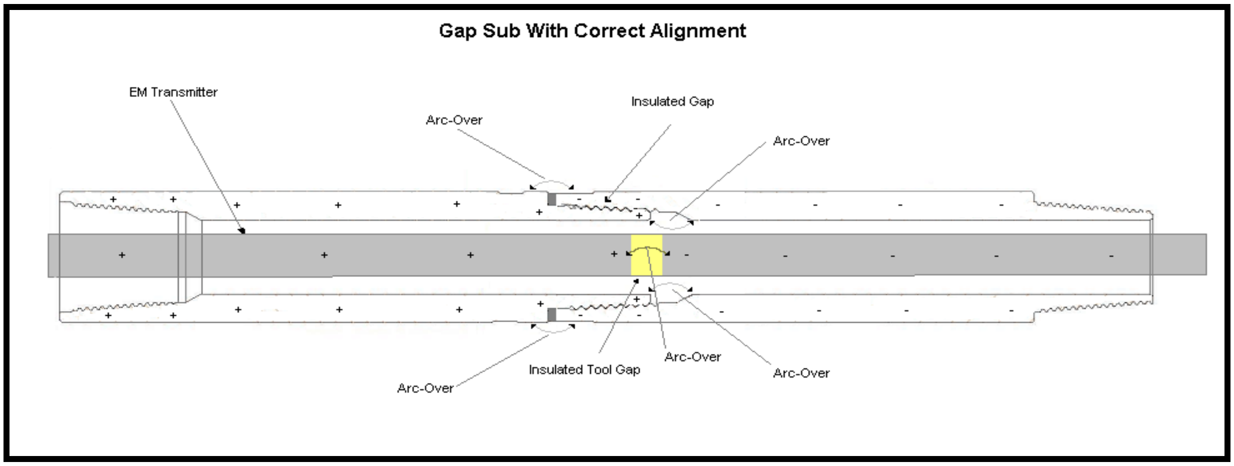
Make sure the tool gap lines up within 6 inches of the Isolation (Gap) Sub. To measure the distance of the tool alignment:

- ✓ Measure the inner shoulder of the UBHO Sub, e.g. 27”
- ✓ Measure Muleshoe sleeve up to the wear cuff, e.g. 14”
- ✓ Subtract the distance (27 – 14 = 13”)
- ✓ Measure the length of the face of the Gap Sub to the gap area, e.g. 20”
- ✓ Add the distance of gap from top of Muleshoe sleeve (13 + 20 = 33”)
- ✓ The Transmitter tool gap is 30” from the wear shoulder
- ✓ Subtract distance tool gap sits from Gap Sub (33 – 30 = 3”)

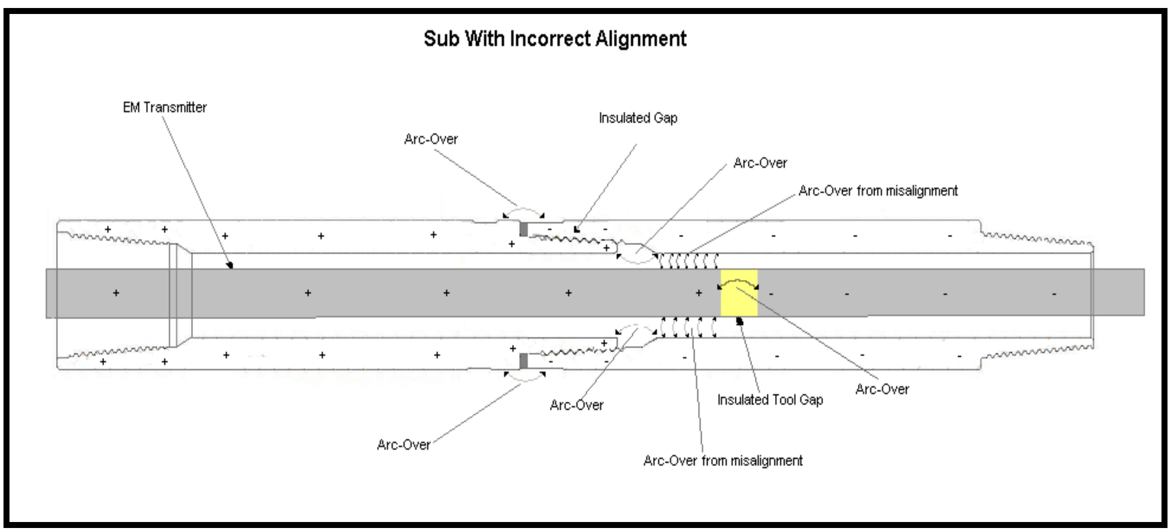
TOOL SPACING

ISOLATION SUB (GAP SUB) ALIGNMENT IS KEY

- **+ / - 6.0” alignment**
- **Arc over currents through mud**



- **Incorrect Alignment Degrades Signal & Wastes Battery Life**



ARRIVING ON LOCATION

Once on location, introduce yourself to the company representative as soon as practical. In addition, notify the office once all of our company personnel have arrived, or if someone is missing, and the contact phone numbers at the site should be given to the coordinator.

The job is expected to be set up and equipment tested as soon as possible upon arrival.

1. Confirm hole size to be drilled and the services required (Directional, EM, Gamma).
2. Conduct a quick inventory to determine if all of the required subs and tubulars are present.
3. Confirm the non-magnetic drill collar I.D. for MWD fin selection.
4. Unpack and proceed to conduct an inventory of EM MWD specific equipment.
5. Notify the Directional Driller of the services to be run (i.e., Gamma) and the tool mode that will be run.
6. Review and verify the Declination, Dip angle, Magnetic fields, with the DD and well plots supplied.
7. Review drilling program to check for conductive/resistive formations and their depth. If possible, obtain offset well log with resistivity data.

Battery life and power level transmission are the key items to consider. Maximum power setting will allow only 2-3 days of drilling, and will consume upwards of $1,000.00 per day in battery costs. It is imperative that the EM MWD operator selects power levels and power shifts properly to provide good detection while minimizing battery costs. We have seen that 1 watt of power can be detected at depths up to 1500m (5000ft).

RIG and ENVIROMENTAL NOISE

Rotary Noise, Top Drive Noise, Environmental Noise

- Permeates out from rig
- Properly ground floor motors, pumps, & light plants
- Move antenna stake further away from rig
- Formations can cause a noisy signal-signal may clean up once drilled through

SURFACE SYSTEM

The EM Directional surface system is relatively simple and easy to set up. The major components and their preferred locations are as follows:

GROUND RODS

Typically 2 ground stakes are utilized. One is clamped onto the rig's BOP while a second is driven into the ground as a reference. The deeper a ground rod, the better detection should be. Often a noisy rig may require 2 ground rods be used and not the Rig's BOP. Some alternative grounding (antenna) configurations are:

- Rig anchors (not connected to rig)
- Metal culverts
- Old well heads
- Steel fence posts

One cannot say for certain which works the best. However, operators will develop an innate understanding of what works effectively.

MAIN CABLE

The main cable is run from the rig floor junction box to the junction box located in the work shack. Each kit is supplied with two cables (75 m long) and a short jumper that can be used to connect them should the rig be located a significant distance from the working shack. The EM MWD utilizes the same cable as the standard Compass mud pulse systems. ***The main cable should be clearly marked with flagging tape, which hangs at least ½ a meter and spaced no more than 5 meters apart on the cable. All cables shall be run in a neat and tidy manner, out of harm's way!***

RIG FLOOR DISPLAY

The Rig Floor Display (RFD) is generally mounted in the Dog House. The rig floor junction box, if used, is also located in the Dog House. The RFD has a graphical and digital readout.

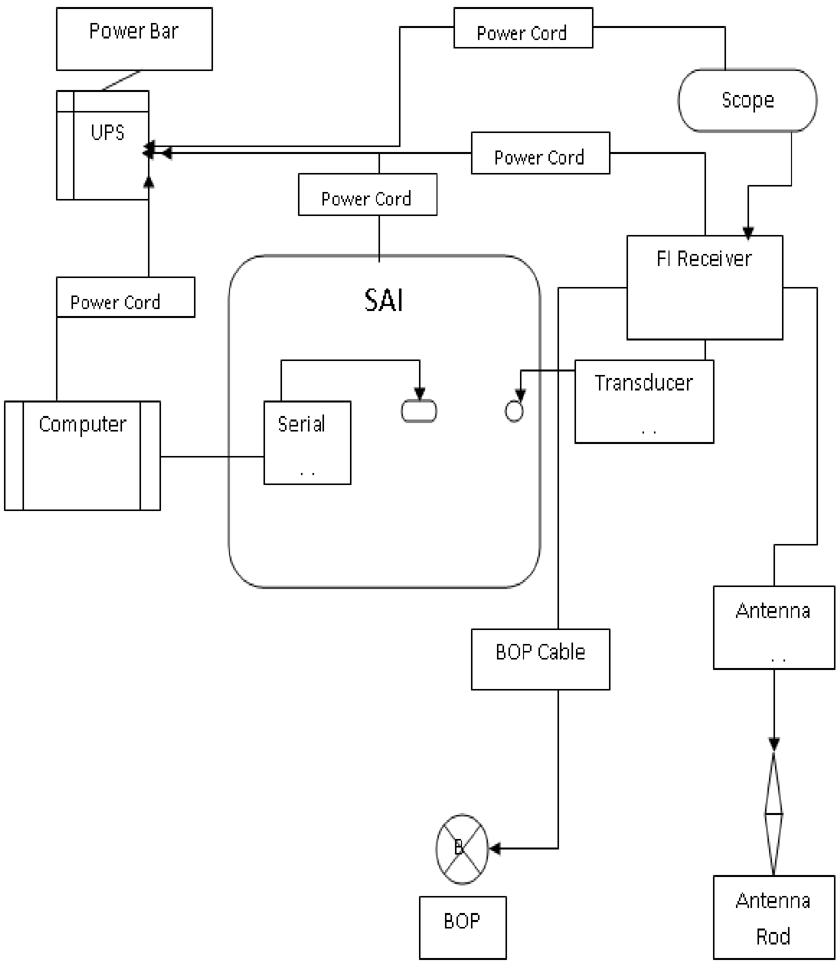
COMPUTER

The computer decodes the conditioned signal, applies offset and magnetic declination to the survey, sends calculated data to the RFD, and records a log of detection activity.

UPS

The Uninterrupted Power Supply (UPS) conditions the rig power to provide a steady output to the surface computers and receiver. Models may vary but the standard 650 KVA should allow the system to run 45 to 60 minutes on battery reserve. Ensure the proper power supply cable (heavy-duty) is used as light service cords may fail.

Compass Directional EM Surface Configuration

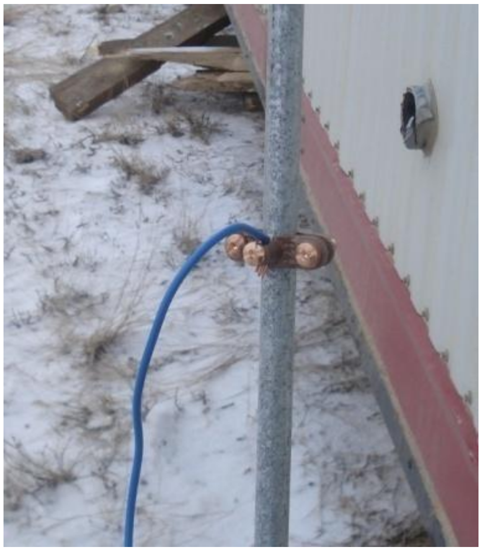


Make sure all the power cords do not have a third ground prong. If the ground line is present in the power cord, then you will not see pressure (pumps) on the software when the transducer pigtail cable is connected to the surface equipment. Any ground prong can cause a ground loop.

<u>Have all cables plugged in before powering up the FI Receiver.</u>

CABLE SETUP

The BOP cable should be connected to the BOP on the rig and run back to the FI Receiver. The antenna rod is pounded into the ground (at least 1 foot deep) away from the rig in a moist undisturbed area. Connect the antenna cable from the rod to the FI Receiver.



Important: Clean a BOP bolt with a wire brush and file to ensure good contact with clamp, make sure clamp is screwed down tight. Use vice grips to clamp down wire if there is no spot on the BOP.

An alternate place for the antenna cable is on a close by well head

CONFIGURING THE TOOL

SET UP

Connect the Power Supply cable, Antenna cable, BOP cable, BNC- BNC cable to the Oscilloscope. Leave the Transducer pigtail cable unplugged until the tool is programmed. Once the tool and SAI/BTRc/RT is programmed, connect the Transducer pigtail cable from the SAI to the FI Receiver. At this point, a base line pressure should appear on the QMWDPC /BENCHTREE software (approx 450 psi). The actual number will depend on what "PTFS, PTO, PTG" is set to.

GAIN SETTINGS

The gain settings are used to amplify the signal, located on the front of the FI Receiver. The gain can be set from 0 – 19, a good number to start with would be 6. Adjust the numbers by pressing the + / - buttons until you get a peak voltage of approximately 5 volts on the scope. Anything under 0.7V will not be detected by the software. Use the Gain Adj. dial to increase or decrease the gain by smaller increments. When gaining the signal up and down, adjust the scaling on the scope for a better view.

SATURATION

SAT Led are indicators of too high of gain and will flash red when the amps begin to saturate. When this happens, turn the gain down by pressing the gain +/- buttons until the SAT lights turn off. **Extended amplifier saturation will cause damage to the FI Receiver and will cause unwanted noise.**

PUMPS AUTO/OVERRIDE SWITCH

Always set the switch to Auto (default). This lets the system operate normally. Use the Override switch during surveys when there is noise causing the FI Receiver to think that the tool is turning on. The Override switch prevents the Receiver from cycling the pumps on/off because of noise. **Once the tool is in sync, switch back to auto. The pumps will not cycle off if the Override switch is on.**

LOW/HIGH WINDOW

The Low/High Window is used to increase or decrease the window that the FI Receiver uses to look for signal. Set to 1 and 6 (default). To decrease the window when there is noise, press one at a time. Do not adjust during slides as you may lose sync.

EM FREQUENCY INTERFACE RECEIVER (F.I. RECEIVER)

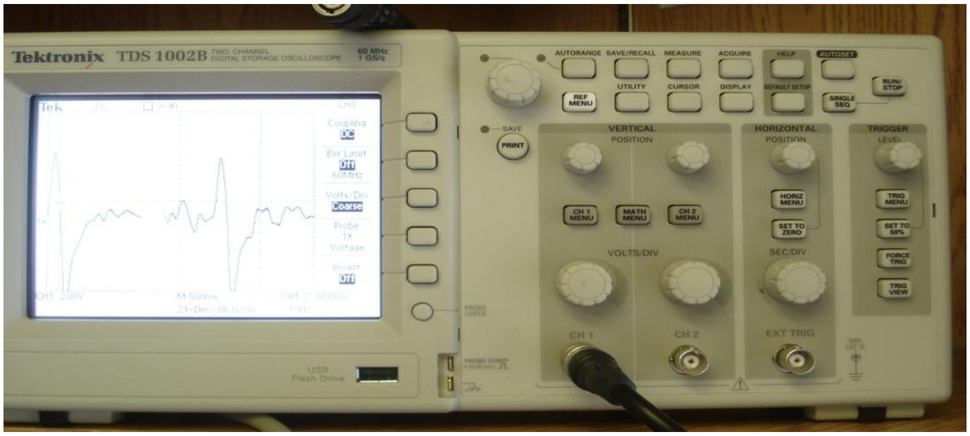
The Frequency Interface Receiver takes the signal transmitted from the tool, filters it, and sends the signal to the SAI or RT for decoding. The decoded signal is viewed and monitored on the QMWDPC/Benchtree software. The F.I. Receiver always looks for the tool to turn On/Off (transmitting) instead of looking for flow on/off. The pressure will now no longer affect the QMWDPC/Benchtree software because the tool will only see vibration. You will see the pressure "on" in the QMWDPC/Benchtree software until the tool stops transmitting, then pumps will read "off" for 8 sec and "pumps on" will start counting again.

Front

Back

EM OSCILLOSCOPE SET-UP

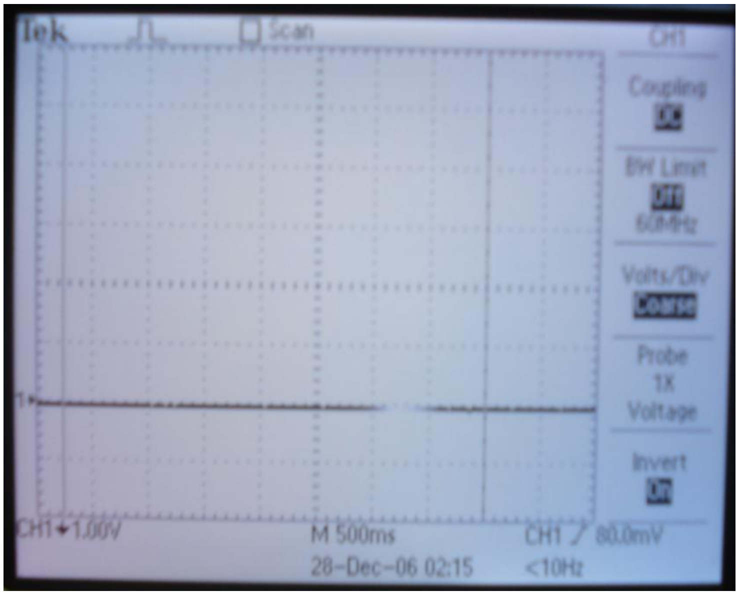
The Oscilloscope is used for monitoring and troubleshooting. It will not interfere with the operation of the system. The signal on the Oscilloscope corresponds to the pulses on the QMWD PC/Benchtree software. The view can be adjusted by scaling on the Oscilloscope.



Turn the Oscilloscope on (power button on top) to view the Main Menu screen. Make sure the base line is running across the screen. If it is not, press the “RUN/STOP” button on the top right-hand corner.

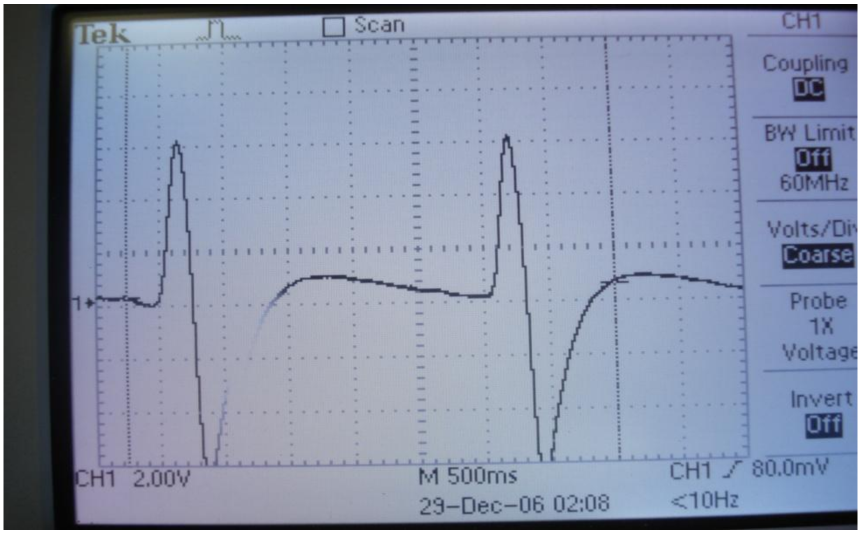
Press the CH1 button where the BNC cable is connected on the front of the Oscilloscope. On the screen, set the following by pressing the button next to the screen.

- ✓ Coupling DC
- ✓ BW Limit Off 60Mhz
- ✓ Volts/Div Coarse
- ✓ Probe 1X
- ✓ Invert Off



Where the BNC cable is connected, press the CH 1 Menu button. Vertical scaling is adjusted using the Volts/Div knob. You can see it in the lower left corner. Set CH1 to 1 or 2V. This represents each square on the Oscilloscope as 1 or 2 volts. You can count the number of squares to determine the volt peak.

Set the Sec/Div knob to M500ms (found on the bottom). The baseline position can be adjusted using the Vertical Position knob. Set to the middle of the screen for a better view. Make sure the peak on the Oscilloscope is above 1V. Do not gain above 10V peak.



Tool working with good signal.

QMWD PC/ BENCHTREE SET-UP

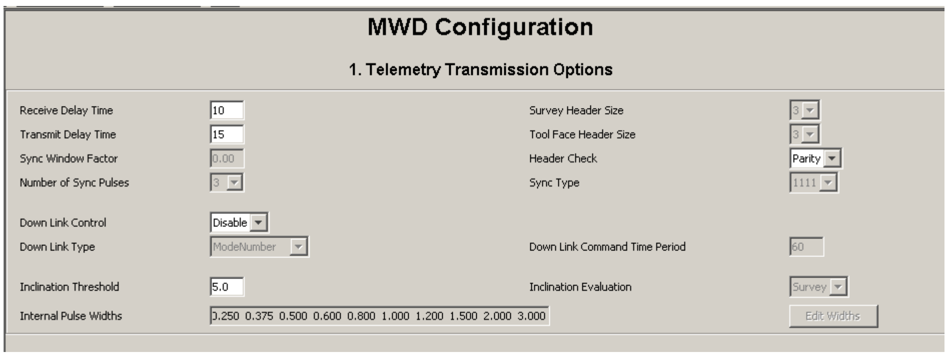
Open the QMWDPC/Benchtree software. Once the tool is transmitting and it is visible on the Oscilloscope, adjust the “HIPL” and the “LOPL” to correspond with the pulse amplitude on the software. If the pulses are above the 640psi scale, adjust the PTG to a decimal value to attenuate the signal to greater than one to gain the signal. “PTFS” can also be adjusted to either attenuate or gain the signal. “FBWF” like on a mud pulse tool will also help to filter out noise. Adjust it like you would for a mud pulse tool. Start with **FBWF: 0.5** and adjust accordingly. Operator preference will determine the pulse height to run.

GAMMA SETUP

Make sure the Gamma computer also has the ground prong removed. If there is a ground loop problem, the SAI pressure will read zero when the Qbus cable is plugged in. Make sure the Wits computer also has the ground prong removed.

CONFIGURATION SET-UP

1. Telemetry Transmission Options



Receive Delay Time = 10 seconds
Transmit Delay Time = 15 seconds
When you click close a screen will pop up saying
"The values you have set for TxDt and RxDt may prevent sync decoding you either need to increase TxDt by 10 Sec or decrease RxDt by 10 sec. Do you wish to make these changes now?" Click "*NO*." **For Underbalanced Wells (re-sync option "mode 4"), the Receive Delay time must be 15 seconds apart from Transmit Delay time.**

"Downlink Commands" only enable if the operator has experience with Downlinking.

To prevent the tool from downlinking accidentally, set the "Command Time Period" to the maximum setting of 90 seconds. This keeps the driller from accidentally downlinking the tool during connections.

Make sure "Sync Word Type Format" is set to "1111."

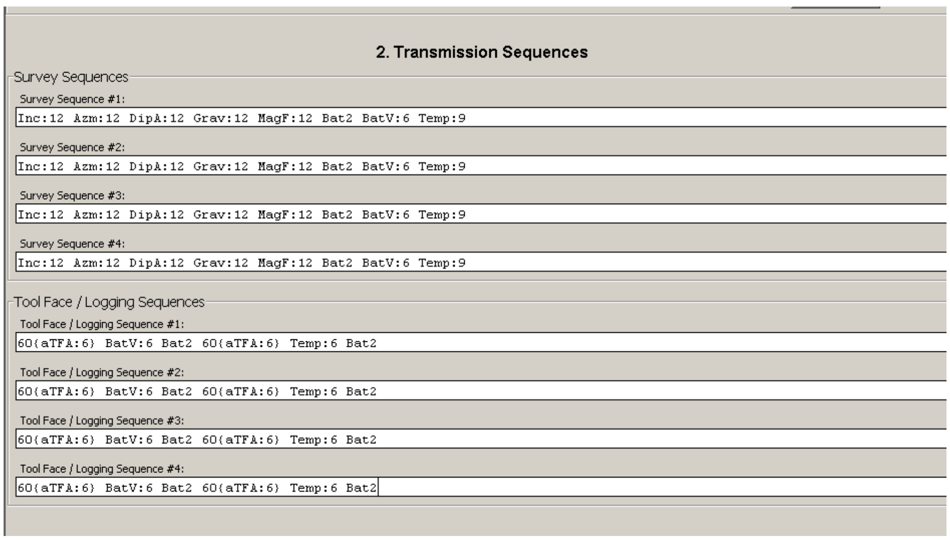
***Do not set to "3111" because the triple wide pulse uses a different frequency and will not sync up.**

2. Transmission Sequences

Survey Sequences

Survey Sequence should be the same on all sequence numbers. Copy and paste the sequence. Annular pressure abbreviation is GV1; the minimum bits should be set to 13 or higher. These values transmitted are in pounds per square inch (PSI).

Example: GV1:13Parity
This can be added to the Survey Sequence or Toolface Sequence.



Tool face /Logging Sequences

Tool face sequences should all be the same in all the sequence numbers. Copy and Paste the sequence.

Annular pressure abbreviation is GV1, with the minimum bits set to 13 or higher. These values are transmitted in pounds per square inch (PSI). Example: GV1:13Parity. This can be added to the Survey Sequence or Toolface Sequence.

3. Mode Control Settings

3. Mode Settings

Current Mode Number: 1

Mode #	Pulse Width	Survey Seq. #	Tool Face Seq. #	Acq. Time	T/L Transmit
1	0.600	1	2	10	0
2	0.600	2	2	10	0
3	0.600	3	2	10	0
4	0.600	4	2	10	0

Each mode number represents a different power selection.
Low Volt:
Mode 1 = 8 Amp
Mode 2 = 5 Amp
Mode 3 = 3 Amp
Mode 4 = 3 Amp Re-sync Option (for underbalanced situations when the flow switch stays on) Tool will re-sync after 16 minutes.

High Volt:
Mode 1 = 4 Amp
Mode 2 = 2.5 Amp
Mode 3 = 1 Amp
Mode 4 = mud pulse telemetry

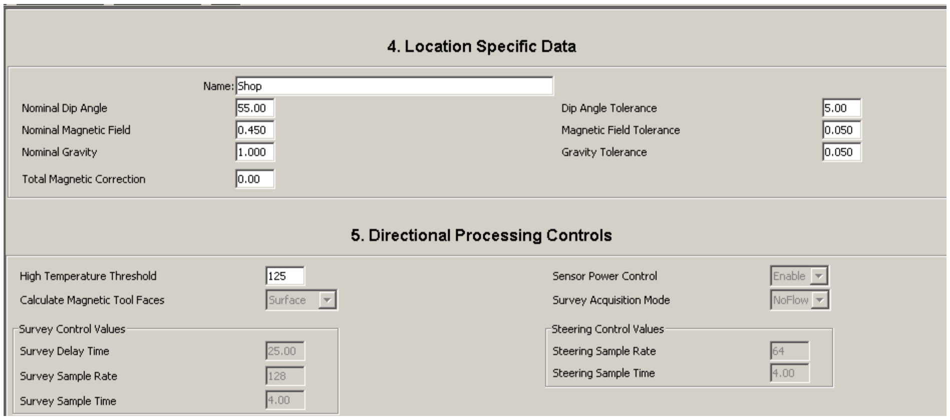
Multi Frequency Settings are selected by the Toolface logging sequence:
T/L Sequence 1 = 0.370 Default
T/L Sequence 2 = 0.250
T/L Sequence 3 = 0.125
T/L Sequence 4 = 0.78 (Do not use - still under development.)

Select the "Mode Number" to match the required power. Leave the Survey Sequence # corresponding to the mode # per example above. This helps indicate which mode you are in when downlinking is enabled. **Do not run mode 1 or 2 (8 or 5 Amp) with the standard batteries, it will blow the fuse. Only run the 8 and 5 Amp with the EM batteries.**

Pulse Width:
DO NOT USE any pulse width greater than 0.6. This will adversely affect the pulse definition and decoding.

4. Location Specific Data

Input all required fields. This Information should be furnished by the client



5. Directional Processing Controls

High Temperature threshold should be set to the maximum expected downhole temperature expected.
This is a switch, the tool will power down when this temperature is detected.

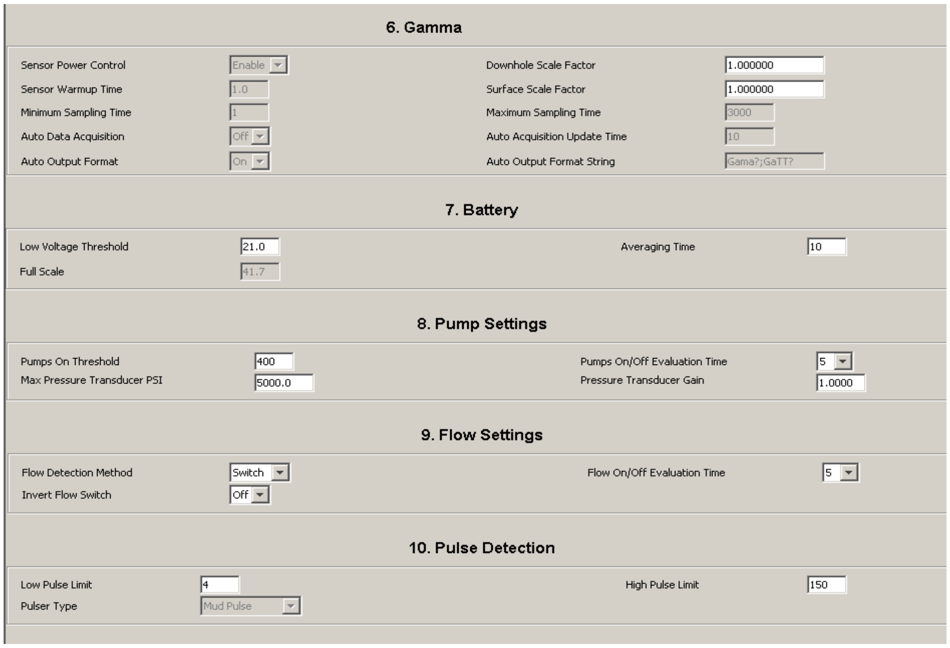
6. Gamma

If the rotary switch is installed, the “Gamma Sensor Power Control” enables or disables the RFS.

Gamma Sensor Power Control: Enabled. - Turns off the RFS and it acts like a normal vibration switch.
Gamma Sensor Power Control: Disabled – Turns on the RFS and flow will go off after 2 minutes and 15 seconds of continuous rotation.

7. Battery: New version software where the "Battery Full Scale" option is available, BFS Default is 41.7 for standard batteries. Set to 44.5 when using the 22 V Compass Battery.

The "Low Battery Voltage" switchover should be set to 18.5V for the Compass extended battery cell. Leave standard cells as per normal operation.



8.Pump Settings

"Pump on Threshold" set to 200 PSI

"Pressure Transducer Rating" set to less than 5000 PSI

"Pressure Transducer Gain" Set to 1

9. Flow Settings

"Flow On/Off Evaluation Time" Set to 5 second

These values can be adjusted during drilling**.**

Do not turn INVF: "ON"

Once the Configuration is completed Run the Tool face Offset Program and high side the tool.

10. Pulse detection: set low pulse limit to 4.

TAP TESTING

Connect the transmitter test box to the isolation ring area on the Compass Transmitter Module. The red clamp should be placed on the top of the transmitter body and the black clamp should be on the bottom of the transmitter body (down hole end).

Note: The isolation ring isolates the top transmitter body from the lower transmitter body. Make sure that there is not a tool stand under the isolation ring that can cause a short across the tool isolation when measuring the output voltage. Connect the transmitter test box to the BOP connector and to the Antenna connector on the back of the FI Receiver box. Power up the Receiver, connect the transducer cable to the SAI, and set gain to 7.

Do not tap test the tool string with the programming cable connected to the tool and SAI. Incorrect operations could possibly cause damage to the SAI.

Tap test the tool and watch the LED flash on the transmitter test box, indicating that the tool string is transmitting. Tap test the tool for approximately 2 minutes to get a complete survey on the computer screen. A pulse signal at approximately 4 Volts should appear on the Oscilloscope. This indicates that the tool is functioning properly.

PICKING UP TOOL

When carrying the tool string across the lease to the catwalk, the tool can turn on because of vibration and transmit and receive delay time is set too low. Place the bottom area of the transmitter in rags or blocks of wood when lying on catwalk. Do not drag the tool across the catwalk as this can cause it to spark and blow a fuse. Use an extended J-Latch assembly to seat the tool. Because of the Isolation Sub, the tool string sits deeper into the drill collar. Fill the helix end key slot with chalk and run the tool string in without any o-rings or springs. Mark the J-Latch at the top of the drill collar when the tool is properly seated. Pull the tool string back up and install the contact springs and o-ring, run back down and make sure tool seats to the same spot. Do not put a pipe wrench on the J-Latch and apply torque to the tool. **The tool gap is an insulated connection and failure may occur if torque is applied.**

SHALLOW/ SURFACE TEST

Make sure that the isolation subs are completely out of the casing before doing a shallow test. Adjust gain to get a proper signal. Monitor the Oscilloscope to see if there is any noise over 1Volt. Anything over 1V may be registering as a pulse. Use the gain to adjust this and filter out the noise. Increase the gain to increase the signal. You will notice the pulse Amplitude increase with the gain increase. Pay attention to the formation being drilled through. Certain formations may give you more noise until it is drilled through.

SURVEYS

The survey procedure is similar to standard mud pulse procedure. The operator must note that the FI Receiver will not sense flow off/on. It can only sense if the transmitter is turned on/off (transmitting). When pumps are off with no vibration, the tool will shut off. You will notice "*pumps down*" for 8 seconds and then the "*pumps on*" clock will start up again. The Driller will watch the "*pumps on*" time on the rig floor display for one minute, and then should turn the flow on. The "*pumps on*" time will continue counting and the survey data should start coming up as per normal. Because the Receiver will not sense flow (as a transducer), you will not notice "*pumps on/off*" when the flow is turned on/off.

If the software does not cycle pumps off, turn the gain down or unplug the transducer pigtail cable from the SAI. There is noise that the Receiver is seeing as if the tool is transmitting.

Switch the pumps to override if the tool is not synced up but you see sync pulses coming up on the QMWDPC. Switch back to Auto once you have sync. The FI Receiver is seeing some noise as transmitting signal and cycles on/off when the noise disappears. This will cause the Receiver to miss the timing when the sync pulse is actually transmitting.

"Pumps off" survey sequence, as above when pumps are off with no vibration, the tool will shut off. You will notice "*pumps down*" for 8 second and then the "*pumps on*" clock will start up again and the survey will begin transmitting while the pumps are still off. When the survey is received the transmitter will idle until the pumps come back on then will go directly to Toolface logging sequence.

TRIP OUT OF HOLE

Turn the gain down or unplug the power to the FI Receiver when you trip out of the hole. Too high of gain can cause damage to the FI Receiver.

- Ideal voltage on scope is 4-6 Volts maintained.
- Write down Gain vs. Depths vs. Volts on scope.
- Watch formation being drilled through.
- Adjust gain accordingly.
- Trip out of the hole.
- Turn off or turn down receiver.

UPON PERFORMING ANY SHALLOW EM TEST

Although theory says that EM should not work in casing, one typically will receive surveys to a depth of 500 to 1200 feet, depending upon power levels, ground stake placements, etc.

The EM operator should be looking for signs of detection while running in hole and comparing transmitted data to known parameters. (i.e. inclination).

Once in open hole, a survey should be taken while stationary to verify G Total and B Total, etc.

Tie on Survey-

Edit a tie on survey to use as a starting point on the well. It is important that this survey be the same as directional and coordinates throughout the course of the well are the same.

Surveying in hole-

While running in hole, surveys are frequently obtained to determined accurate coordinates at kick off. The requirements for survey intervals vary with inclination, but assuming the wells are vertical, the interval should be no more than 200' or 70m.

COMMON PROBLEMS

Tool would not shut off-

Check to see if well has circulation, inspect pumps to determine if there is any flow, bleed lines.
Run INC and AZM in tool logging sequence (re-sync option)

Noise While Rotating-

Move ground stake, check cables, clean all connections, and lubricate ground stake.

Tool would not catch sync-

Switch the Automatic/Manual switch to MANUAL

Tool flat lined-

Remove the bottom to determine if the Gap Sub failed

TROUBLESHOOTING

Always start by isolating the GE/Benchtree equipment from the EM equipment by unplugging the Transducer Pigtail cable. You should still be able to see the tool transmitting with the Oscilloscope. If this doesn't cure the problem, change out the complete surface system.

Always keep in mind that EM is formation-dependent so when an incident occurs, see if you have drilled through a different formation that may have caused the problem. Pull back into a formation where you know the signal was working.

NOISE OR LOST SIGNAL

Adjust gains on the FI Receiver to amplify the signal. Use the Oscilloscope to monitor the signal. Adjust the High/Low window to eliminate the noise out of the window area. If you are experiencing a lot of noise, try running off UPS battery power to eliminate the rig power.

When experiencing noise or loss of signal, place the antenna rod as far away from the rig as possible. Pour water around the antenna rod to dampen the ground for better contact. Find a moist conductive material to plant the antenna rod in. Pound the antenna rod deeper. If there is a well nearby, try tying the cable to the wellhead.

Check to ensure all cables and ground clamps are clean and secure. Run new cables. Notice if there are any changes between on-bottom signal versus off-bottom signal. This may indicate Isolation Sub failure.
Make sure the pump house and light plant are properly grounded.

- ✓ Isolate Surface system from EM receiver.
- ✓ Unplug scope for transducer cable.
- ✓ Monitor scope for signal.
- ✓ Check if you have drilled onto another formation.
- ✓ Adjust Gain on Receiver to amplify signal.
- ✓ Adjust High/Low Window to narrow the signal.
- ✓ Run off UPS power supply to see if signal cleans up.
- ✓ Inspect all cable connections (clean and secure or move if necessary)
- ✓ Place antenna cable as far away from the rig as possible.
- ✓ Check signal off bottom.
- ✓ Check grounding around rig.
- ✓ Always monitor the scope to see if there is a signal.

TROUBLESHOOTING DOWNHOLE TOOL

Troubleshooting Picking up Tools

Problem		Resolution
No communication	1	Check cables
	2	Assuming battery or connection: Unplug sensor and batteries.
	3	Check alignment of battery pins to key, and inspect alignment and condition of pins on driver coupler.
	4	Source another battery and harness (no barrel). Plug stave directly into the driver ensuring contact if there is no activity, change out the transmitter.
Tool transmitting but low output voltage across gap	1	Check connection of fluke leads to the 1 ohm resistor and to body of gap sub. A shortened resistor or short will reduce output voltage.
	2	Check to ensure the upper and lower end of Gap Sub is not shorted through the rig. Either the top must not be touching blocks, etc., or the lower end hanging free from the Monel is in the stump.
	3	Disassemble tool and check resistance across gap. Change out if less than 190 ohms. Ensure sub is lying on wood, etc., so that there is no short.

DETECTION TROUBLESHOOTING

Problem		Resolution
No Detection	1	Was tool transmitting on the rig floor? (See above)
	2	Inside casing? Detection inside Casing is not reliable, but we have detected to 600-700m, (1000-1500ft).
	3	Signal observed on oscilloscope.
	4	Antenna on BOP or behind shack OK? Check all surface-receiving antenna wiring. You should be able to see a signal on the fluke meter when checking the antennas. Run more antennas.
	5	Gain set OK? Go back to 1x gain and try detection again.
Poor Detection	1	Drilling by another casing string? This can greatly attenuate the signal, which will improve as the Downhole transmitter gets further away from the adjacent casing.
	2	If signal is weak (1mV) or noise is high, try reducing the bandwidth in detect > configure. If you do this, the frequency must be spot (set when signal is strong).
	3	Noise from the rig? Try unplugging the UPS to isolate shuttle and top end box from the rig's power. Signal looks better? May need a generator. Is there noise from adjacent pumps on wellheads? Get the company man to shut them down.

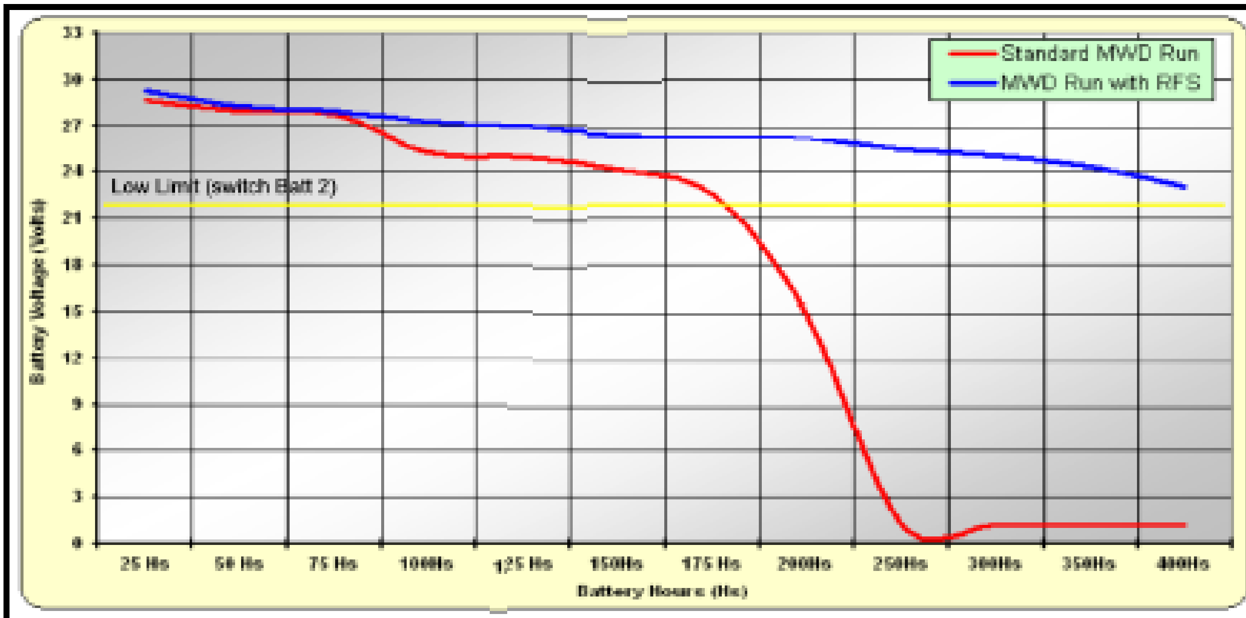
ROTARY FLOW SWITCH

BATTERY LIFE CONSUMPTION TABLE

	TYPE OF WELL (Profile)	Run Time	Battery Consumption	% Save
Standard MWD Tool MWD Tool with RFS	Horizontal Well (no gamma)	200 Hs 200 Hs	100% 90%	10%
Standard MWD Tool MWD Tool with RFS	Directional ("S" Type)	200 Hs 200 Hs	100% 48%	52%
Standard MWD Tool MWD Tool with RFS	Directional ("Build & Hold" Type)	200 Hs 200 Hs	100% 37%	63%
Standard MWD Tool MWD Tool with RFS	Straight Hole (KOP)	200 Hs 200 Hs	100% 28%	72%

Note : This Table is base on field information.

BATTERY LIFE COMPARISON CHART



Note : This Chart is base on the information of a Directional "S" Type WELL.

C.MWD Tool Pickup And Lay – Down Procedures & Torque Guide

COMPASS MWD
Tool Pickup and Lay - Down Procedures

THIS IS THE MOST CRITICAL TIME FOR HANDLING THE MWD TOOL!

MWD TOOL EXPOSURE TO DAMAGE THAT CAN BE CONTROLLED IS AT ITS HIGHEST.

UTMOST CARE AND ATTENTION TO HANDLING DETAILS MUST BE OBSERVED AND FOLLOWED!

THE MWD OPERATOR IS ULTIMATELY IN CHARGE OF ALL ASPECTS OF MWD TOOL HANDLING.

THE MWD OPERATOR WILL TAKE CHARGE OF ALL ASPECTS INVOLVING THE HANDLING OF THE MWD PROBE, THE UBHO AND THE MULESHOE SLEEVE.

ANY QUESTION TO THIS AUTHORITY SHOULD BE DIRECTED TO THE MWD MANAGER OR SUPERVISOR ON-CALL.

1. MWD Tool Pickup Procedure

a. Meet with the rig crew and explain the pickup procedure to insure that the tool is picked up in a safe and secure manner to protect all personnel and the tool during the pickup procedure. Use a minimum of three (**3**) persons to move the tool from the build area to the rig and back.

b. The tool will be completely assembled and carried by three (**3**) persons to the open side of the V-door between the rig and the pipe rack. (Refer to Figure 3) Place the top of the tool (spear point) closest to the rig. Lay the tool on the ground or on one or two jack-stands. DO NOT pickup from the catwalk through the V-Door!

c. Attach the lifting-bale to the top of the spear-point with the pin fully inserted into the latch device, from the top of the slots, (Refer to Figure 1). Insure the lifting-bale is secure.

d. The pick-up line (air hoist or cathead) should be passed through the loop of the bale assembly connecting to the two cable slings, and tied with a double knot with the hook latched to the line.

e. Instruct the hoist operator to follow your instructions and begin picking up the tool in a steady, smooth, and continuous action. Use the poppet-tip protector provided and do not drag the tool on the ground. Insure that the tool does not contact the rig structure by holding the lower end off the ground and pulling the tool away from the rig structure. Walk the tool in to the rig as the top of the tool is lifted to vertical. Have someone keep the tool away from the rig structure by keeping it pushed away with open hands.

f. Carefully guide the tool over the railing towards the NMDC. Pay attention to the pickup cable position in the derrick to avoid tangles.

g. Remove the poppet protector from the bottom of the tool.

h. With the tool suspended away from the collar tool joint, test the Main Signal Poppet again, by depressing it upward into the Poppet housing, several times.

I. Perform another tap test on the rig floor. (Refer to Tap Test Procedure)

j. Apply a generous amount of lubricant (DC 111 or pipe dope) to the lower helix end and the o-ring and abrasion ring.

k. Carefully align the MWD tool above the box end of the non-Mag collar and have the hoist operator slowly lower the tool down until the lifting bale rests gently on the top of the NMDC. Give the tool one last visual inspection as it is lowered into the collar. Carefully inspect the latching device to insure that it is secure.

L. Slowly rest the lifting bale arms on the top of the collar and slack off on the hoist line. Take extreme care not to damage the shoulder of the NMDC.

m. Release the hoist line from the sling of the lifting bale assembly and attach the hoist line to the top shackle of J-latch assembly. If the shackle is damaged or missing the rope socket may be used attached to the rigs slickline Insure the proper amount of spacer bars between the J-latch and the shackle assembly, to lower the tool to the Mule Shoe.

n. Attach the J-latch onto the pins of the spear-point of the MWD tool and secure the pins in the J-latch by pushing down and turning the J-latch counter-clockwise.

o. Direct the hoist operators to slowly lift the tool assembly connected to the J-latch and lift the tool about one foot and remove the lifting bale assembly. Be acutely aware of possible pinch-points and keep hands and fingers clear!

p. Contact the Directional Supervisor to witness the next operation. This is a requirement! Instruct the hoist operator to gently lower the tool down into the collar until the tool contacts the Muleshoe sleeve. DO NOT run the tool in hard! Severe contact of the point of the helix to the Muleshoe Key can damage one or the other or both. CLOSELY observe the tool for rotation as it enters the Muleshoe sleeve and seats. Have the hoist operator gently lift the tool up approximately 3 feet and rotate the tool 180 degrees counter-clockwise then slowly lower the MWD tool assembly back into the Muleshoe sleeve. Again, CLOSELY observe the tool for rotation as it enters the Muleshoe sleeve. With a pipe wrench, grip the spacer bar and attempt to rotate the tool, clockwise looking down hole. A strong resistance to turn will indicate that the tool is seated. The MWD operator and the Directional Supervisor <u>MUST</u> observe the tool's rotation before proceeding.

q. Disconnect the J-latch from the spear point by pushing down on the spacer bar and lifting the assembly off the tool.

r. Pickup the lifting and seating tools and clean them completely and place them back in the kit box. Keep them clean and free from rust by painting them.

2. MWD Tool lay-down Procedures

a. Meet with the rig crew and carefully explain the lay-down procedure to insure that the tool is laid down in a safe and secure manner to protect all personnel and the tool during the lay down procedure.

b. Attach J-latch to top of tool. Slowly pick up the tool to slots on spear point for attaching pick-up bale. Attach the bale to the MWD tool and insert the locking pin <u>from the bottom</u> (Refer to Figure 2). Be acutely aware of possible pinch-points and keep hands and fingers clear! Stay in communication with the hoist line operator. Then lower the tool to allow bale to rest on top of NMDC. Be aware not to damage the shoulder of the NMDC.

c. Remove J-latch and transfer pick-up line to bale sling.

d. Make contact with the hoist operator and slowly pick-up tool while spraying with water wipe down tool with rags and inspect all parts of the tool for wear. If the tool failed, do not wash down tool – only wipe with rag. Make note of any irregularities or excessive wash on the tool string. Make a report of the condition of the tool on the run report.

e. Stop at the screen housing inlet screens. Wash out the servo-poppet area behind the screen, thoroughly. Continue to pick-up tool, slowly.

f. Ease the tool over the edge of the collar and instruct the hoist operator to hold the tool steady and securely. Then manually push the signal poppet up and down. Movement should be firm but smooth. Spray water up through the opening at the bottom of the signal poppet. Manually push the poppet/shaft up and down to force out all mud and water. Do this until fluid is clean.

g. Attach the poppet protector to the bottom of the tool.

h. Carefully guide the tool over to the railing next to the V-door and carefully lower the tool down. Guide the tool down and do not allow the tool to drag or bump the sidewall.

I. Grab the lower end of the pulser and quickly walk away from the rig and have the tool slowly and steadily lowered to the ground. You will need assistance to insure that the tool does not contact the ground with excess force or contact the rig structure. Sidewall impacts on the tool can cause severe damage.

j. Gently lay the tool down and disconnect the bale assembly from the pickup line and the tool.

k. Return to the rig floor and break the set screws on the Muleshoe for removal. Remove the Muleshoe sleeve as soon as possible. It is best to do this when the UBHO is just out of the hole

l. Three people will then carry the MWD tool to a secure place. Inspect and break down the tool and perform maintenance on the parts.

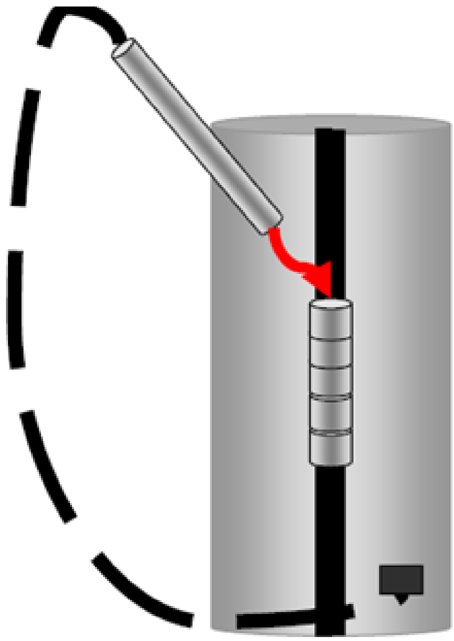


Figure 1

Insert pin from top, when preparing to Pickup tool to the rig floor and load into the NMDC.

Load Pin from the bottom when unloading tool from NMDC and preparing to lower to the ground. Note if Pin is broken, secure device used as pin to prevent cup from expanding and dropping tool. Order replacement bail assembly ASAP.

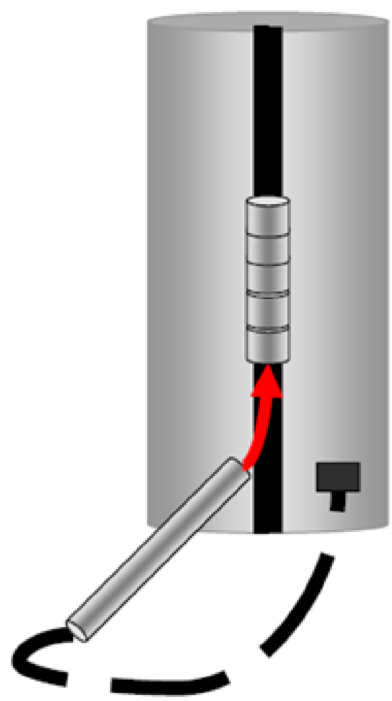


Figure 2

Note: Position on rig to Pick-up and Laydown MWD tool. Do not pickup or laydown MWD tool through V-door and down ramp. Always pickup and laydown MWD at position on rig as indicated in sketch. Note: Pickup and lay-down

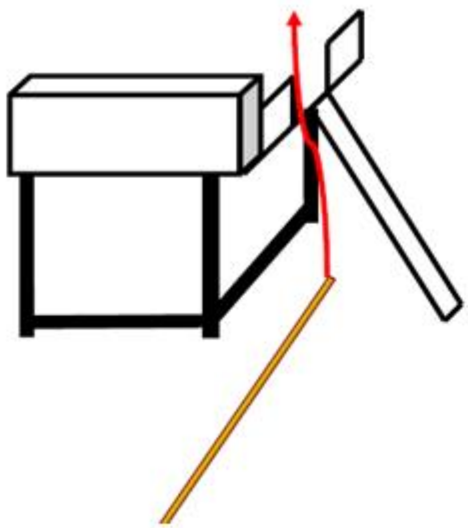


Figure 3

Carrying Tool w/3 Personnel 1

DRILL PIPE & DRILL COLLAR CONNECTIONS AND TORQUE GUIDE

Drill Collar Connections

O.D. (inches)	Pin I.D. (inches)	Connection Size & Type	Recommended Torque (ft/lbs) Min	- Max	Weak Member
6¾	2	4 ½ Full Hole	25,700	28,200	PIN
6¾	2¼	4 ½ Full Hole	23,800	26,100	PIN
6¾	2½	4 ½ Full Hole	21,700	23,800	PIN
6¾	2 13/16	4 ½ Full Hole	18,800	20,700	PIN
6¾	2	4 ½ Reg.	22,200	24,500	PIN
6¾	2¼	4 ½ Reg.	20,500	22,600	PIN
6¾	2½	4 ½ Reg.	18,400	20,300	PIN
6¾	2 13/16	4 ½ Reg.	15,400	16,900	PIN
6¾	2¼	4 ½ IF	34,200	37,600	BOX
6¾	2½	4 ½ IF	33,700	37,100	PIN
6¾	2 13/16	4 ½ IF	30,400	33,400	PIN
6¾	3	4 ½ IF	28,500	31,400	PIN
6¾	3¼	4 ½ IF	25,200	27,700	PIN
6¾	2¼	4 ½ H-90	27,100	29,800	PIN
6¾	2½	4 ½ H-90	24,700	27,200	PIN
6¾	2 13/16	4 ½ H-90	21,900	24,000	PIN
6¾	3	4 ½ H-90	20,000	21,900	PIN
6¾	2¼	5 H-90	33,300	36,600	PIN
6¾	2½	5 H-90	31,400	34,500	PIN
6¾	2 13/16	5 H-90	28,000	30,800	PIN
6¾	3	5 H-90	25,700	28,200	PIN
7¾	2½	6⅝ REG.	52,300	57,500	BOX
7¾	2 13/16	6⅝ REG.	50,400	55,400	PIN
7¾	3	6⅝ REG.	47,500	52,300	PIN
7¾	3¼	6⅝ REG.	44,700	49,100	PIN
7¾	2½	6⅝ H-90	52,300	57,500	BOX
7¾	2 13/16	6⅝ H-90	52,300	57,500	BOX
7¾	3	6⅝ H-90	50,400	55,400	PIN
7¾	3¼	6⅝ H-90	47,000	51,700	PIN
8¼	2½	6⅝ REG.	54,200	59,600	PIN
8¼	2 13/16	6⅝ REG.	50,400	55,400	PIN
8¼	3	6⅝ REG.	47,500	52,300	PIN
8¼	3¼	6⅝ REG.	44,700	49,100	PIN
8¼	2½	6⅝ H-90	56,500	62,200	PIN
8¼	2 13/16	6⅝ H-90	53,200	58,500	PIN
8¼	3	6⅝ H-90	50,400	55,400	PIN
8¼	3¼	6⅝ H-90	44,000	51,700	PIN

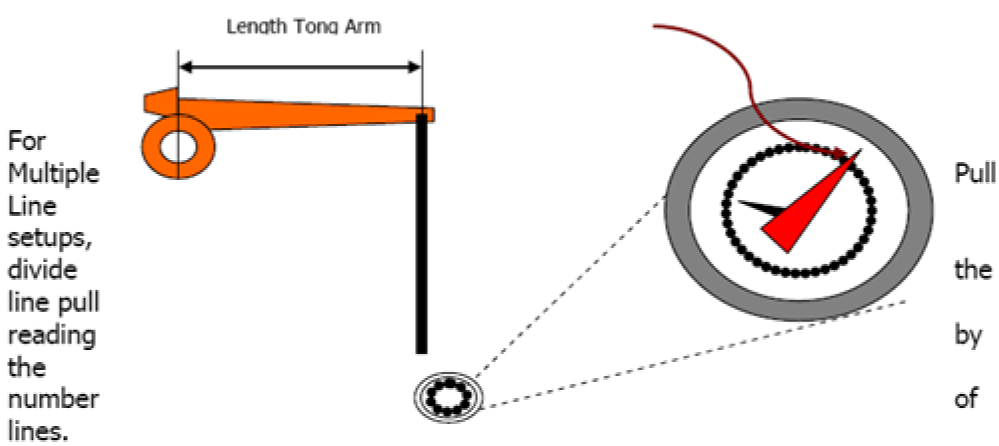
O.D. (inches)	Pin I.D. (inches)	Connection Size & Type	(ft/lbs) Min	- Max	Weak Member
9½	3	7⅝ REG.	83,600	92,000	PIN
9½	3¼	7⅝ REG.	78,900	86,700	PIN
9½	3½	7⅝ REG.	75,100	82,600	PIN
9½	3¾	7⅝ REG.	70,300	77,300	PIN
9½	3	7⅝ H-90	93,100	102,400	BOX
9½	3¼	7⅝ H-90	93,100	102,400	BOX
9½	3½	7⅝ H-90	93,100	102,400	BOX
9½	3¾	7⅝ H-90	90,700	99,800	PIN
9½	3	7⅝ REG.	80,800	88,800	BOX
9½	3¼	7⅝ REG.	80,800	88,800	BOX
9½	3½	7⅝ REG.	77,900	85,700	PIN
9½	3¾	7⅝ REG.	73,200	80,500	PIN

ALWAYS convert Torque (ft/lbs) to line pull. Convert Tong Length to decimal feet. Single Line Pull Algorithm:

Effective Tong-
Arm Length / 12 => 50 (inches) / 12 (inches) = 4.2 Feet

Example 6 3/4 "ID X 2 **13/16**" OD, 4 ½" IF, Rec. Trq, 30,400 – 33,400 Ft/lbs

33,400 / 4.2" = **7,950 ft/lbs Line Pull.**



Drill Pipe Connections

OD (Inches)	Nominal Weight (Lb/Ft)	Conn.	Tool Joint ID (Inches)	Equivalent ID (Inches)
2 ⅜	4.85			2.00
2 ⅜	6.65		1 ¾	1.82
2 ⅞	6.5	IF	2 ⅛	2.25
2 ⅞	10.4	XH	1 ⅞	2.14
2 ⅞	10.4	IF	2 ⅛	2.15
3 ½	13.3	FH & XH	2 7/16	2.74
3 ½	13.3	IF	2 11/16	2.76
3 ½	15.5	IF	2 9/16	2.60
4	14	FH	2 13/16	3.29
4	14	IF	3 ¼	3.34
4	15.7	FH	2 11/16	3.18
4	15.7	IF	3 ¼	3.24
4 ½	16.6	FH	3	3.76
4 ½	16.6	FH	3 5/32	3.79
4 ½	16.6	XH	3 ¼	3.78
4 ½	16.6	IF	3 ¾	3.82
4 ½	20	FH & XH	3	3.56
4 ½	20	IF	3 ⅝	3.64
5	19.5	XH	3 ¾	4.23
5	25.6	XH	3 ½	3.97
5 ½	21.9	REG	2 ¾	4.40
5 ½	21.9	FH	3 13/16	4.60
5 ½	21.9	FH	4	4.75
5 ½	21.9	IF	4 13/16	4.80
5 ½	24.7	FH	4	4.60
6 ⅝	25.2	REG	3 ½	5.52
6 ⅝	25.2	FH	5	5.88
6 ⅝	25.2	IF	5 29/32	5.96

Tool Joint Specifications 1

TOOL JOINTS THAT ARE EQUIVALENTS AND INTERCHANGEABLE CONNECTIONS

2 ⅜ IF	=	2 ⅞ SH	=	NC#26				
2 ⅞ IF	=	3 ½ SH	=	NC #31				
2 ⅞ XH	=	3 ½ DSL						
3 ½ IF	=	4 ½ SH	=	API #38				
3 ½ XH	=	4 SH	=	3 ½ SIF				
4 FH	=	4 ½ DSL	=	API #40				
4 ½ XH	=	4 ½ SIF	=	4 IF	=	5 DSL	=	API #46
4 ½ IF	=	5 XH	=	5 SIF	=	5 ½ DSL	=	API #50

IF = INTERNAL FLUSH
SH = SLIM HOLE
XH = EXTRA HOLE (EH)
FH = FULL HOLE
DSL = DOUBLE STREAMLINE
SIF = SLIM INTERNAL FLUSH
API = AMERICAN PETROLEUM INSTITUE
NC = NUMBERED CONNECTION
EF = EXTERNAL FLUSH

Approximate Weight (lbs) of Non-Magnetic Drill Collars

Collar OD/ID	Length (ft)	Weight (lbs)
3 ½"	20	410
4 ⅛"	**10**	**372**
4 ⅛"	**30**	**981**
4 ¾" / 2 ¼"	10	427
4 ¾" / 2 ¼"	30	1280
5"	**10**	**544**
5"	**30**	**1632**
5 ¼"	10	615
5 ¼"	30	1845
5 ¾"	**10**	**688**
5 ¾"	**30**	**2065**
6"	10	797
6"	30	2390
6 ¼"	**10**	**860**
6 ¼"	**30**	**2580**
6 ½"	10	945
6 ½"	30	2835
6 ¾"	**10**	**1051**
6 ¾"	**30**	**3154**
7"	10	1153
7"	30	3460
7 ¼"	**10**	**1221**
7 ¼"	**30**	**3662**
7 ¾"	10	1411
7 ¾"	30	4232
8"	**10**	**1533**
8"	**30**	**4600**
9"	10	1998
9"	30	5994
9 ½"	**10**	**2251**
9 ½"	**30**	**6753**
10"	10	2518
10"	30	7553

Good Drill Pipe/Collar Handling Practices

All MWD operators should observe some of the practices on the rig when tripping. Not following the practices listed below can alert operators that there may be problems down the road due to lax handling practices.

Initial Make-up

Proper initial make-up is probably the most important factor affecting the life of the tool joint connections. Here are some recommendations to follow:

1. Proper make-up torque is determined by the connection type, size, OD and ID and may be found in torque tables.

2. Make-up connections slowly, preferably using chain tongs. (High speed Kelly spinners or the spinning chain used on initial make-up can cause galling of the threads.)

3. Tong them up to the predetermined torque using a properly working calibrated torque gauge to measure the required line-pull.

4. Breakout, clean, visually inspect, redope and (repeat 1-3). Always use the backup tongs to make and break connections.

5. Stagger breaks on each trip so that each connection can be checked, redoped and made up every second or third trip, depending on the length of drill pipe and size rig.

Drill pipe deserves good surface, handling equipment and tools. Check slips and master bushings before damage occurs to the tube.

Do not stop the downward movement of the drill stem with the slips. This can cause crushing or necking down of the drill pipe tube. The drill pipe can also be damaged by allowing the slips to ride on the pipe during trips out of the hole.

Always use back-up tongs to make and break connections and rotate breaks when tripping.

Good rig practices will help eliminate time consuming trips in the future, looking for washouts or fishing for drill pipe lost in the hole.

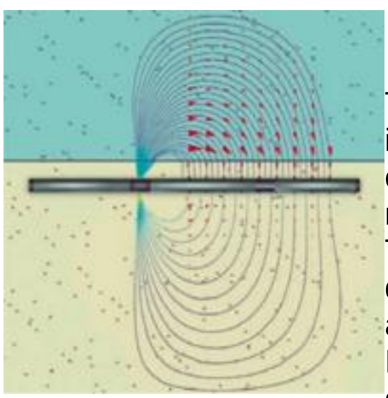
NOTES

CHAPTER 6 RESISTIVITY

A: GRT Resistivity
B: Gen II Resistivity

GEOSTEERING RESISTIVITY TOOL

Most MWD Resistivity tools are of the “Wave Propagation” type, and can accurately measure the average rock-formation resistivity.
However, this type of tool may be difficult to use in horizontal drilling because it requires complex interpretation of phase and attenuation logs to see an adjacent bed-boundary. It is easy to mistake curve separations due to other effects such as anisotropy or invasion, resulting in drilling through a bed-boundary, and then having to backtrack.
CBG Corporation has invented and patented (US patent #6,064,210) and UK patent 2,353,596, a method for measuring resistivity as a vector quantity.
For example, up to one meter before mistakenly drilling out of a reservoir, advance indication of the distance and direction to a nearby shale bed is available so that corrective action can be taken.
The addition of directional information to the resistivity reading provides a new enabling technology for geosteering, at a price that is affordable for directional-drilling companies.

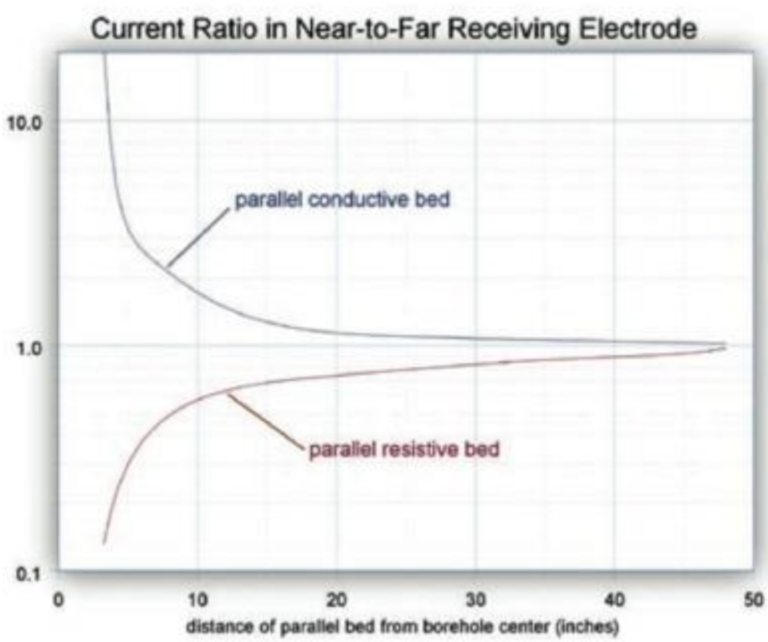


The GRT is an advanced imaging laterolog device, incorporating four independent receiving electrodes to create an azimuthally-sensitive resistivity measurement.
This capability allows the GRT to detect a nearby bed, determine whether it is conductive or resistive, and ascertain its direction and distance.
In the diagram at left (from a computer model), the electric current density is higher in the upper conductive rock region (e.g. a shale), so the upper electrode receives a bigger current.
Unlike competing tools, it is not necessary to rotate the GRT to obtain directionally-sensitive resistivity measurements.

Directional resistivity data from the GRT can be graphically presented on a surface display (patents pending) in an enhanced version of the familiar compass rose drillers display typically employed in directional drilling. A continuously-updated borehole image showing the distance and direction to conductive/resistive anomalies enables the operator to intelligently direct the drilling process, without having to study resistivity logs.

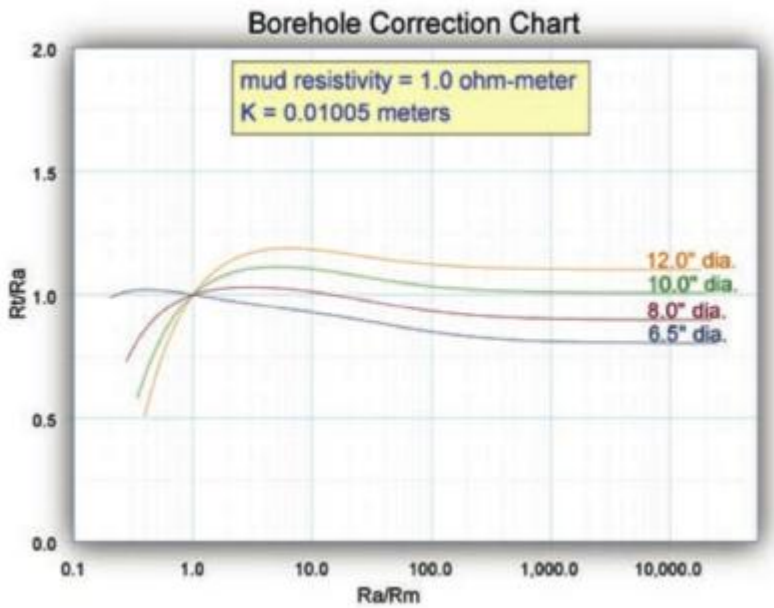
ADVANCED COST-EFFECTIVE DESIGN

State-of-the-art techniques were applied in creating the GRT. For example, FEMLAB 3D Finite-Element-Analysis modeling was used to optimize mechanical and electrical parameters. A graph (at right) from the model of the GRT illustrates how the ratio of current received by a pair of electrodes can be used to distinguish a parallel conductive bed from a resistive bed, and determine the distance to the boundary.

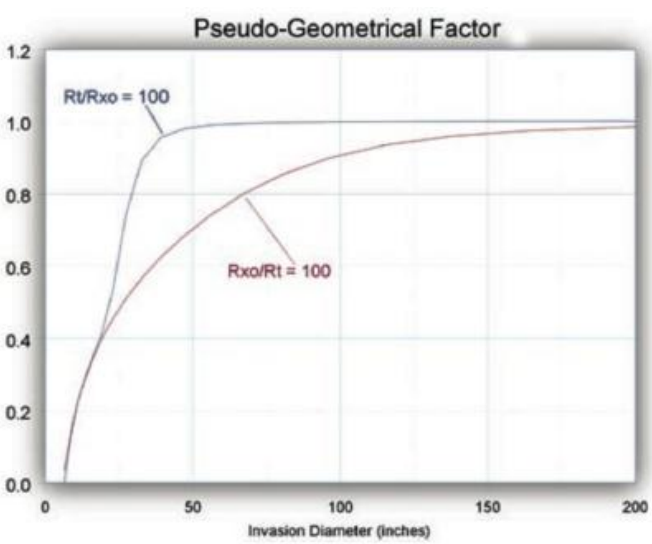


Benefiting from its innovative electronic and mechanical design, the GRT provides accurate and reliable operation, combined with low cost and serviceability. Sophisticated self-calibrating measurement circuitry ensures that stability and precision are maintained across the full range of operating conditions. Should it be necessary to service or repair the GRT, its rugged, probe-based construction makes disassembly and reassembly quick and easy. The GRT does not employ any third-party proprietary technology so there are no licensing fees required.

LOGGING WHILE DRILLING



Of course, in addition to its application in directional drilling, the GRT performs exceptionally as a conventional LWD resistivity tool. In the graph at left, the 4.75 inch diameter tool is shown capable of very accurate measurements in a 6.5 inch diameter hole whatever the mud resistivity. Even in severe washouts up to 12 inches in diameter, the tool retains acceptable accuracy. A complete log is saved in the GRT internal memory and can be subsequently downloaded through a high-speed link to a PC when the GRT is retrieved from the well. Click to see actual log of a GTI Catoosa test well. It is not necessary to remove the tool from the BHA to download data. Furthermore, the GRT can include an internal Gamma-Ray tool (standard or directional), providing directional capability that is unique in the industry.The GRT can be provided as a stand-alone tool, or part of a complete LWD resistivity system, including a surface display, display software, and data communications/control electronics. A mud Pulser can be mounted above or below due to the full 10-wire bus passing through the tool. The GRT is available compatible with Tensor-type systems, and can be readily integrated into other industry-standard tool strings. A built-in



Muleshoe helix at the top end of the tool ensures that the Directional Sensor package is always correctly oriented with the GRT sensors.

Since the GRT is a laterolog-type tool, it will not give accurate results in oil-based muds if there is a significant amount of emulsion breakdown. However, in high resistivity formations operation at reduced accuracy is still possible.

Laterolog tools excel in very high-resistivity formations, where it may be necessary to distinguish between oil and fresh water. An example is the heavy-oil Orinoco Basin of Venezuela, where the wave-propagation tools have been found unusable. Another example is in fresh-water injection well situations, such as in Saudi Arabia. Wave-propagation tools are not accurate in resistivities above about 200 ohm.meters.

The GRT has another advantage over other directional types of resistivity tools. As the graph below indicates, the detection distance for an adjacent contrasting rock formation is dependant only on resistivity contrast, and not on the actual resistivities. Detection distance is constant for a wide range of resistivities,

GEN II RESISTIVITY TOOL

Introduction

The Gen II resistivity tool uses low frequency waves that permeate into the formation. As they travel into the formation the amplitude of the wave is attenuated. The amplitude of the received wave corresponds how resistive the formation is. The amount of current required to generate this wave between the transmitter and receiver is also measured and is used to determine the resistivity of the formation. This tool as been put together to be fully retrievable and Tensor compatible.

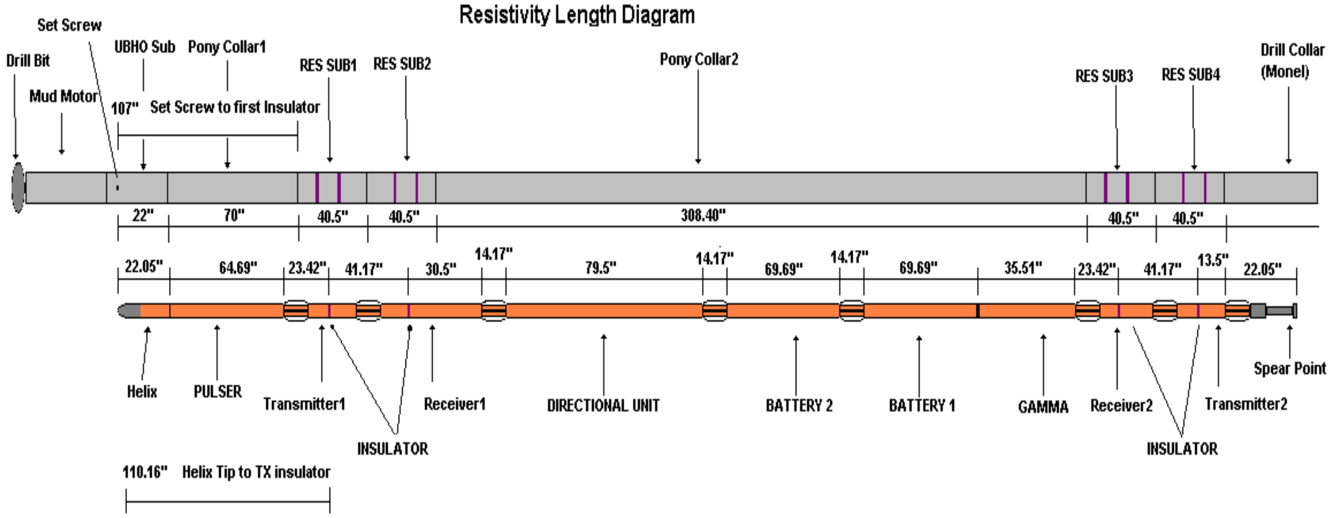
Key Requirements

Key components that are required to run a job but do not include the Tensor compatible mud pulse system.

- 2 Resistivity Receiver.
- 2 Resistivity Transmitter.
- 2 Pony Sub.
- 4 Resistivity Subs.

The tool string is set up according to Resistivity BHA Diagram. Bow spring style interconnects must run with this tool because they are the electrical contact with the BHA. Proper measurement must also be ensured so that the interconnects touch the BHA in the correct spot. It is also very important that the blades on all the centralizer have adequate tension so they make good electrical contact to the BHA. It is very important that the second bottom centralizer makes contact once landed between the four insulator rings as drawn in the Resistivity BHA Diagram. It is also very important that the second from the top centralizer makes contact once landed between the four insulator rings of the top two subs as drawn in the Resistivity BHA Diagram. The very bottom interconnect should also never land above the bottom insulator ring on RES SUB 1. The third interconnect from the bottom should never go below the very top insulator ring on RES SUB 2. The interconnect between the Gamma probe and Receiver 2 should always land bellow the insulators on RES SUB3. The interconnect between Receiver2 and Transmitter2 should always land between the insulators of RES SUB3 and RES SUB4. And the very top interconnect should never land on or below the insulators of RES SUB4 If any of these parameters are altered the resistivity tool will fail to operate normally. To achieve these measurements selecting pony subs and a UBHO sub with the correct length will ensure these parameters are met.

Resistivity Length Diagram



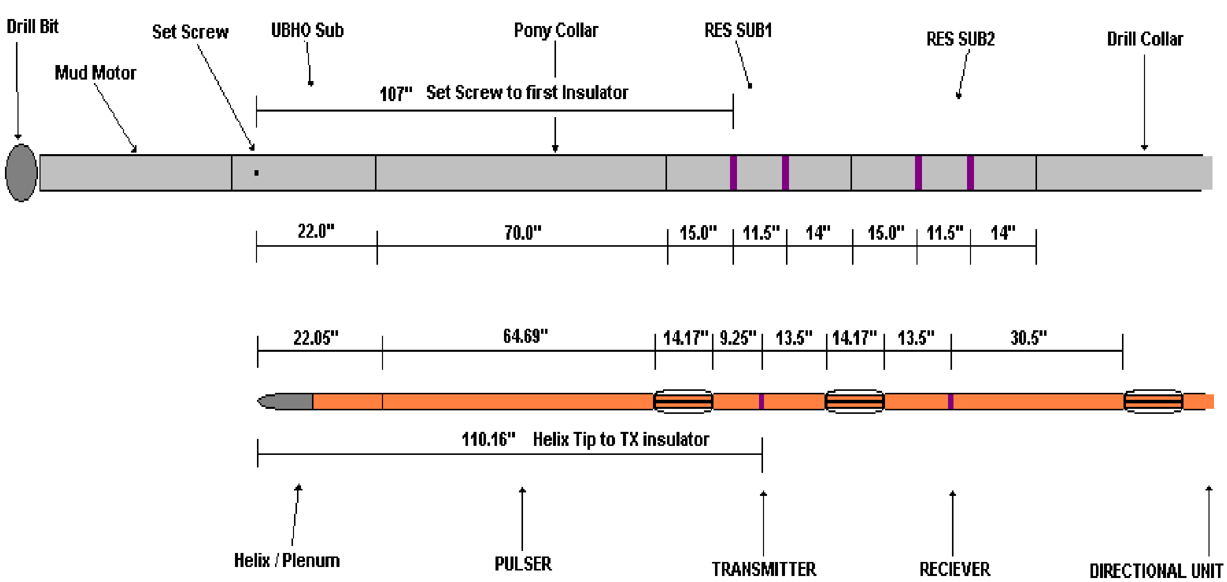
Measurement Setup for Pony Collar 1

For the correct measurements please refer to “Resistivity Length Diagram”. This diagram illustrates a typical set up of the BHA and the tool. For the most part the tool lengths will be fixed and will be used as a reference. The BHA lengths will not be fixed due to thread re-cuts so pre-job length measurements are necessary. The Most important length of the BHA is from the UBHO set screw to the bottom insulator of resistivity sub 1. This length should be a maximum of 110.16 inches and a minimum length of 98.66 inches. Any lengths outside of this will miss align the bow spring contact points on the BHA. Good practice is to leave the two resistivity subs torqued together to prevent thread damage and re-cuts of the threads. This will keep the length between the insulators constant. If the length between the bottom insulator of the bottom resistivity sub and the top insulator of the top resistivity changes this will affect the resistivity readings and cause interconnect contact spacing problems.

EXAMPLE:

This is an example of how to determine if a BHA is the correct length.
UBHO sub (setscrew to box) = 22.0”
Pony Collar = 70.00”
RES SUB 1 = 15.00“ (from pin thread face to bottom insulator)
Total Length = 107.00”
This value falls in between the 110.16 inches and the 98.66”. This would be a good BHA to run.

Resistivity Length Diagram



Testing the Tool before Putting in the Ground

There are four variables that are transmitted to the directional module. They are resistivity, resistance, voltage and current.

Resistivity: It is a unit in ohms per meter. The resistance is multiplied with a geometric factor of approximately 13.4 to give you resistivity.

Resistance: It is a unit in ohms. It is calculated from the current and voltage.

Voltage: It is a unit in volts. It is the voltage of the received signal.

Current: It is a unit in amps. It is a measure of the current being emitted into the formation.

These four values are tagged to generic variables in the directional module.

GV2 = Resistivity1 (ohms/meter)

GV3 = Resistance1 (ohms)

GV4 = Resistivity2 (ohms/meter)

GV5 = Resistance2 (ohms)

If an exact representation of what the resistivity tool is sending a minimum of 13 bits must be used. An example of this for resistivity would be: GV2:13:Parity. Depending on the operation resistivity or resistance can be sent up. Voltage and current are merely variables for trouble shooting and are not needed to make up a resistivity curve.

Tap Testing tool (With fluid simulator test box)

Testing with a fluid simulator box enables you to test the resistivity tool in a dynamic state. The tool string should consist of the complete resistivity tool and a directional module. The pulser and batteries can be left off of the string at this time. Complete programming the tool and connect the fluid simulator to the top of the directional module. The q-bus line must be turned off or you will get zeros for all the resistivity values. Attach the resistivity test box as illustrated in “Test Setup Diagram”. Select a resistor value on the test box and turn the flow to the “on” position on the fluid simulator test box. Now observe the data coming up on the telemetry interface. If you sent up GV2 you must divide the value by 13.4 to get the resistor value. If you sent up GV3 then the value should match within plus or minus 1.5 ohms. You can now turn the dial on the resistivity test box to different values and observe them on the telemetry screen. The test box has five different settings on it. They are 1.2 ohms, 3.3 ohms, 5.1 ohms, 10.0 ohms, and 22.0 ohms. These different values can be selected by turning the dial on the top of the test box. The actual value will be sent up as GV3 and should read within 1.5 ohms. It is very important to have the different colored clamps of the test box attached in the correct spot on the tool. The black hadled clamp must be connected on the top of the reciever insulator. The Blue handled clamp must be connected anywhere between the reciever and transmitter insulator. The red insulator must be connected on the down hole side of the transmitter insulator. This setup is illustrated in the “Test Setup Diagram”.

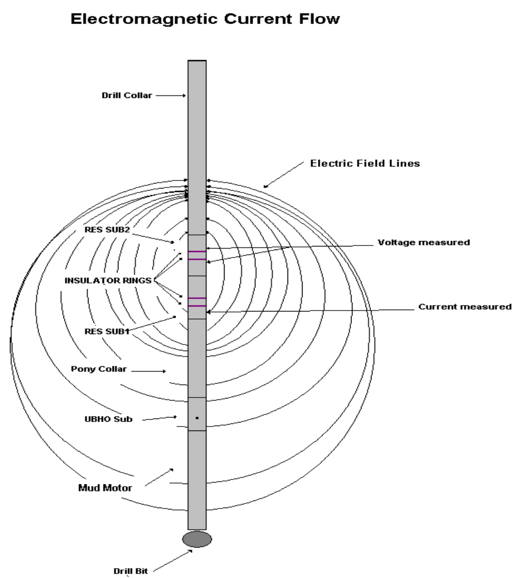
Test Setup Diagram

Tap Testing tool (Without fluid simulator test box)

Once the tool is completely assembled and programmed a tap test can be performed. When tap testing the tool you must <u>not</u> have the programming cable plugged into the tool or use inverse flow (invf) to turn on the flow switch. Attach the test box and as illustrated in “Test Setup Diagram” and set the switch to a corresponding resistor value. Tap the flow switch to activate the flow switch and continue tapping the tool long enough for it to go through the full sequence to the point the tool would have pulsed up the resistivity value. After this point the resistivity value will be stored in the directional modules memory. At this point you can stop tapping the tool and plug the programming cable into the tool and query the generic value you programmed into the tool. If you sent up GV2 you must divide the value by 13.4 to get the resistor value. If you sent up GV3 then the value should match within plus or minus 1.5 ohms. You can then repeat this process with different resistor values to verify multiple readings

Theory of Operation

The resistivity tool emits an electromagnetic signal from two poles and a voltage is measured at the receiving end. Current is measured at the transmitting end to derive resistance. Refer to the illustration labelled “Electromagnetic Current Flow”. An internal calculation for resistivity is calculated by multiplying the resistance reading with 13.40580417. The operation of the tool is as follows. Once the flow is turned on a 30 second timer begins counting down. If the flow turns off before the timer is done counting down it rests until flow is turned on again. Once flow has been turned on for a continuous 30 seconds and the timer is finished an electromagnetic signal is emitted every twelve seconds. At each of these burst 1024 samples of the received voltage are read and 1024 samples of the transmitted current are read. These values are then converted to numbers the directional module can understand and are broadcasted onto the communication line. These values are then stored in the directional units memory and ready to be pulsed to surface.



CHAPTER 7 ANNULAR PRESSURE WHILE DRILLING / VIBRATION MONITOR

ANNULAR PRESSURE

Annular pressure requires the Pressure Stinger and pressure Muleshoe sleeve. The Muleshoe sleeve is seated into the UBHO Sub and is oriented to the high side of the mud motor. Modified set screws with a ported hole in the middle are used to tighten up the Muleshoe sleeve to the UBHO Sub. An alternate method is to use a UBHO Sub that is ported.

When setting the Muleshoe sleeve to the high side, use solid set screws to lock the sleeve in place first. Pick up tool string and seat the tool string in the collar. Pull the BHA up to the UBHO Sub and replace the solid set screws with the ported set screws one at a time. This will prevent any flow from coming back to surface if the ported set screws are used.

The Transducer is located inside the barrel above the helix end. The Pressure Stinger is screwed on to the helix end with blue Loctite. Make sure all o-rings are installed on the Pressure Stinger - outside 210 o-ring x 4, and 115 o-ring on threads. Make sure wear shoulder is not worn down. If it is, it will not line up the ported hole on the Pressure Stinger to the ported holes on the Muleshoe sleeve. Slide the pressure test sleeve over the Muleshoe and use the hydraulic pump to apply pressure.

Configuration of the annular pressure can be setup in the “Survey Sequence” or “Toolface Sequence.” The variable used for annular pressure is “GV1,” the minimum bits that should be used is 13. For example, “GV1:13 Parity.” *Inc*, *Azm*, *Grav*, and *MagF* should be added to the Toolface Logging Sequence. The Toolface should be added to the survey sequence.

Tap test the tool and watch GV1 come up with the pressure reading.

The re-sync option Mode 4 (3 Amps) should be run for underbalanced situations. For situations when the tool will not turn off because the well is flowing, the tool will automatically shut off after 16 minutes and look for sync again.

Annular Pressure (optional)

- E.g.. GV1:13P
- Mode 4 Re-Sync option
- Add Inc/AZM screws prior to landing tool
- Replace with ported set screws once tool is seated

Vibration Monitoring (optional)

The drilling environment can introduce severe vibration to the drill string. Drill string vibration which can cause excessive bit wear, reduce ROP and premature MWD failures.

Description

Compass VIB monitoring tool can be adapted to the EM tool string. The VIB provides real time monitoring and early warnings of excessive vibration. The VIB has 2 axis monitoring the reads 0 to 35G.   Updates are transmitted to surface via mud pulse through generic variables; the variables can be logged with your existing gamma software. The drillers can take the data and adapt to the drilling environment before any costly damage can occur. The VIB indicates to the driller when bit bounce and pipe whirl is occurring and can prevent drill string fatigue.

Features

- Temperature option up to 350°F °(175°C)

- Simple to operate under a wide range of flow rates from 75 to 1100 gal/min

- 12.0” long by 1.875” OD module that plugs into the top of the tool string

  - 0-35g
  - GV6-Z axis (bit bounce)
  - GV7-x, y axis (pipe whirl, lateral vibration)
  - 13 bit mi

CHAPTER 8 PEM TOOL

PEM Tool

This tool is equipped with an EM transmitter coupled with a DC brush less pulser. The tool is equipped to run in one telemetry only but the ability to switch back and forth. The EM telemetry is run in modes 1, 2 and 3 and mud pulse telemetry in mode 4. The EM telemetry is equipped to survey in flow off state and when in mud pulse mode operate like normal and transmit only when flow is turned on.

Flow off Surveys

While in modes 1-3 (EM mode) surveys are acquired and transmitted on the flow off state. A typical survey will go as follows:

Top Drive

1) Stand is drilled down and pipe is put in slips and pumps are turned off.
2) Tool will stop pulsing and the transmit delay time later the tool will begin transmitting the survey. It will transmit for 2 minutes (pump up time on software) if the flow is not turned on.
3) If the flow is turned on within the two minutes it will continue to pulse and drilling can resume.
4) If the tool turns off after the two minutes it enters a downlink mode. It will act like a normal pulse tool (only transmit on flow on) until the flow has been on for more than 1 minute 10 seconds. At this time it resumes normal survey while pumps off.
5) Re-surveying while flow is off is done by turning the flow back on for 15 seconds then off. The tool will then turn back off and back on after the transmit delay time and transmit up the new survey. At this time flow can be turned back on and drilling can resume.

Kelly Bar Style Rig

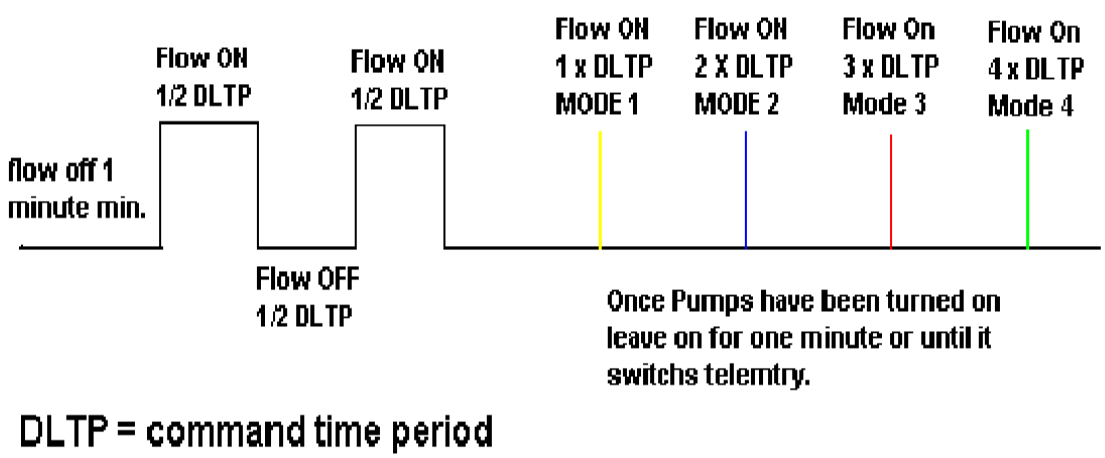
1) Make connection and wash to bottom and continue with flow on for 1 minute.
2) Turn flow off and wait the transmit delay time for survey to transmit.
3) If the survey is good flow can be turned on and drilling can continue.
4) If survey is bad flow must be turned on for 15 seconds and then off to make it survey and transmit again.

* In mud pulse mode (mode 4) tool acts like normal (Transmits while pumps are on).

Down Linking from EM to Mud Pulse

Down linking cannot happen while tool is transmitting.

1) You must pull high Kelly or at a safe place in the hole where pumps can be turned off for up to 8 minutes.
2) The tool must complete the two minutes on time (flow off) after the pumps have been turned off. One more minute must happen before tool can be initiated into the downlink sequence. You will do this first part with the EM surface equipment first.
3) Refer to the diagrams as and example.



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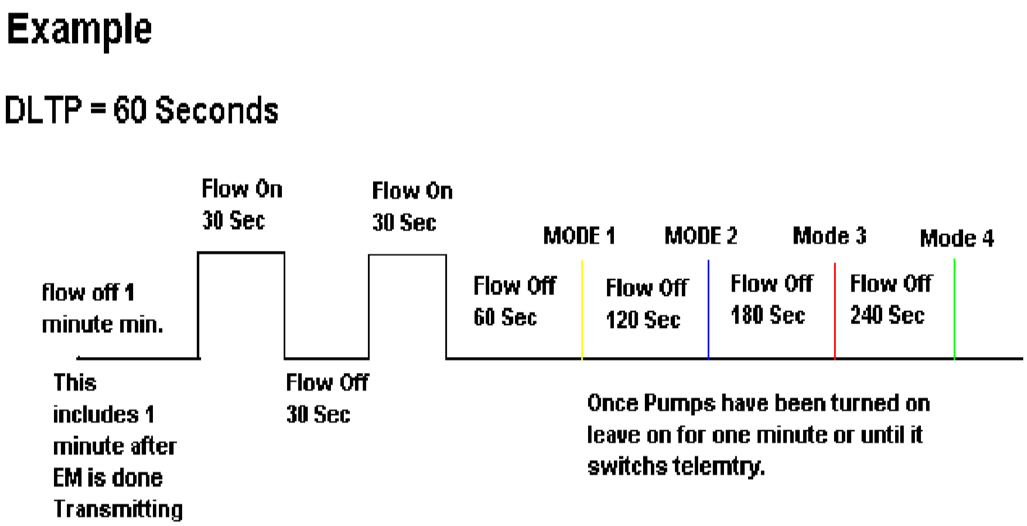
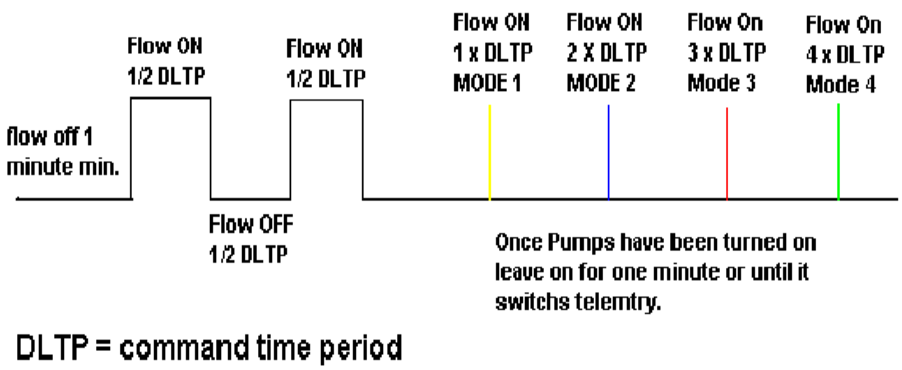
This is an example with the command time period set to 60 seconds



From this example after the pumps have been turned on then off then on then off you would leave the pumps off for 240 seconds then turn the pumps on. You will know that the tool is down linked because it will take twice your transmit delay time to see pulses on your scope. If you set your mud pulse to a different pulse width you will see the difference on the scope. Keep the pumps on until the EM pulses disappear which should take about 1 minute. At this time the EM receiver transducer cable can be unplugged and the pressure transducer from the standpipe can be plugged into the mud pulse receiver. At this time you must change the surface receiver from the EM mode (mode 1-3) to mode 4 (modn). You will also have to change the pressure transducer full scale (“ptfs”) to the correct number for your pressure transducer. At this time you should see mud pulses on your computer screen. You can then resume normal mud pulse drilling operations.

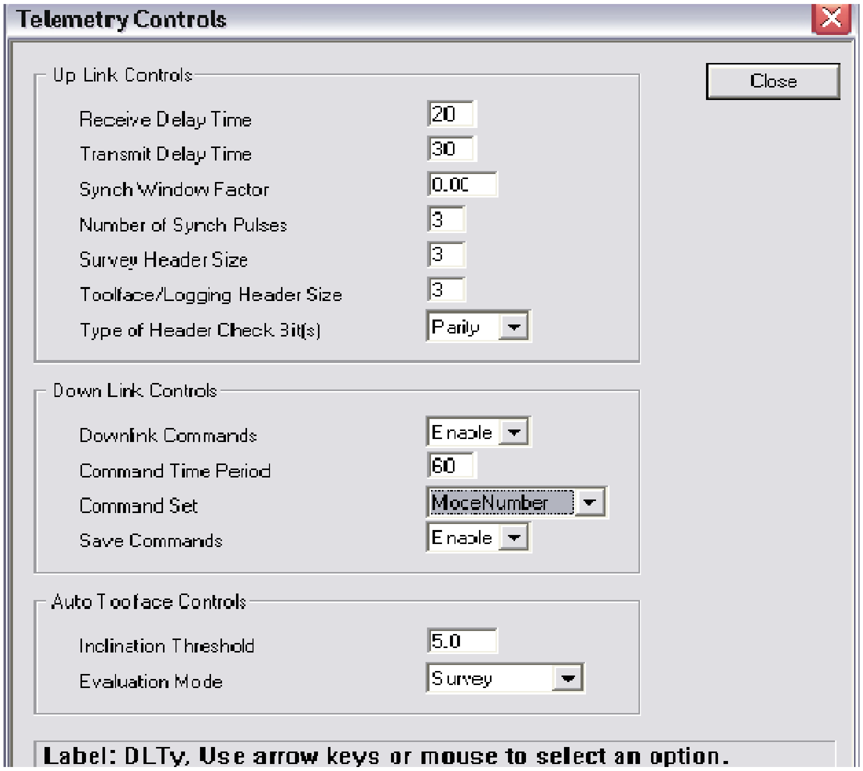
Down Linking from Mud Pulse to EM

Changing from mud pulse to EM is done by first turning the pumps off for 1 minute. Then following the procedure detailed below.

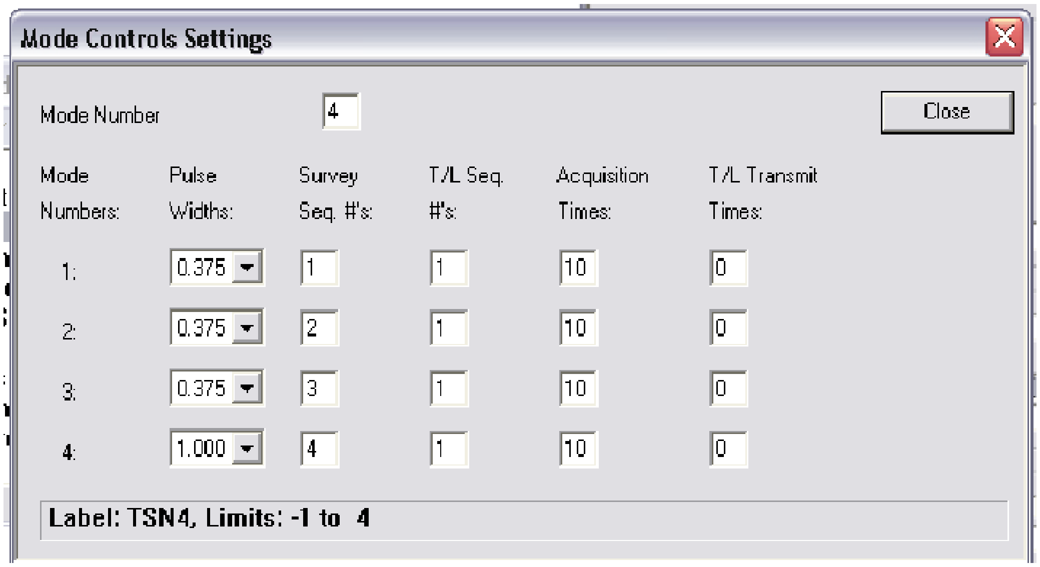


You will need to plug in your EM surface equipment to see pulses. Once the tool has down linked the tool will resume normal EM operation.

Suggested programming setup.

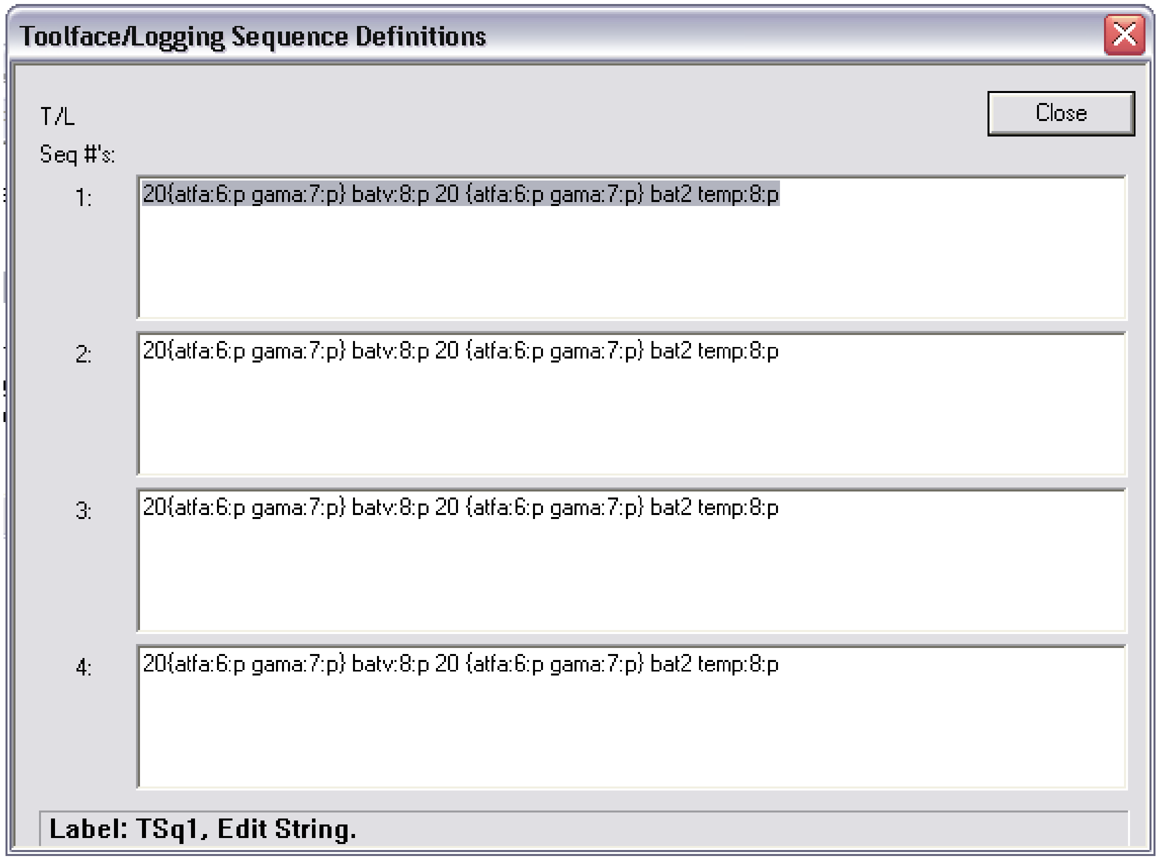


Transmit delay time should be set long enough for mud Pulse.



Modes 1 –3 should have the pulse width set to the same. Mode 4 should be set to the mud pulses pulse width. Survey Seq#'s should correspond to the mode numbers so it can be verified which mode the tool is in. The same T/L Seq # should be used for all modes.

All survey sequences should be the same incase the tool down links accidentally. This will prevent having to change the mode numbers in the receiver every time.



All toolface logging sequences should be the same.
Battery hours will consist of an EM portion and a Mud pulse portion.

If you are just running EM refer to the below charts.

100 AH Batteries (50 AH per pack)

		Amps			
		8	5	3	Pulses/minute
	0.25	38	60	97	50
	0.375	62	97	153	30
Data Rate	0.5	91	139	215	20
	0.6	112	169	256	16

Assuming TLSQ 1 (Pulse width = 0.375)

80 AH packs (40 AH per pack)

		8	5	3	Pulses/minute
	0.25	30	48	77	50
Data Rate	0.375	50	77	122	30
	0.5	73	111	172	20
	0.6	89	135	205	16

Assuming TLSQ 1 (Pulse width = 0.375)

High Voltage Tool (28 V packs at 25 AH per pack for a total of 50 AH)

		4	2.5	1	Pulses/minute
	0.25	37	57	124	50
Data Rate	0.375	59	89	180	30
	0.5	84	124	230	20
	0.6	102	147	263	16

Assuming TLSQ 1 (Pulse width = 0.375)

If you are running just mud pulse the tool will last approximately 750 hours between two 50 AH batteries (total 100AH).
If you are running a combination of the two you will use this formula.

1.) EM Transmitting Hours * $\frac{\text{Battery Capcity (100 AH)}}{\text{Total Hours from EM Chart}}$ = AH used

2.) 100AH - AH used = AH Left

3.) $\frac{\text{AH Left}}{\text{0.1333 Amps}}$ = MUD Pulse Hours Left

Below is an example of a typical calculation.

Tool Settings
8 Amp
0.6 second pulse width
EM transmitting for85 Hrs.
Using two 22V 50 AH batteries for a total of 100 AH

1.) 80 Transmit Hours * $\frac{\text{Battery Capcity (100 AH)}}{\text{112 Hrs}}$ = 71.4 AH used

2.) 100AH - 71.4 AH used = 28.6 AH Left

3.) $\frac{\text{28.6 AH Left}}{\text{0.1333 Amps}}$ = 214.5 MUD Pulse Hours Left

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