

Directive™ - a Tensor Elite MWD

Directive Directional Module

The Directive technology suite has redefined expectations for accuracy and reliability of Directional Modules. The market leading electronics, designed and manufactured by Black Diamond, dramatically improves Tensor Elite MWD performance.

Users benefit from improved reliability and preventive diagnostics significantly reducing total cost of ownership. Tensor Elite is the proven and most cost effective probe MWD platform for High-Temperature, High-Pressure [HTHP] applications - while reducing NPT and increasing mean time between failure [MTBF].

The Directive Directional Module [DM] is the core of the Tensor Elite MWD system and has three main sub-assemblies:

- Micro-Processor Unit [MPU]
- Triple Power Supply [TPS]
- Orientation Module [OM]

Proven Reliability

System development included HALT testing over a temperature range of -60 - 220 °C/ -76 - 428 °F under vibration levels up to 80 g RMS.

Rigorously verified with more than 10,000 field test hours of benchmarking at temperatures up to and beyond 175°C, more than 1,000 hours drilling and more than 50,000 feet drilled in various formations in North America with both EM and mud pulse telemetry.

Rugged Design

Complete redesign of PCBs has delivered a reduction in components and an improved layout. New encapsulation technology packages the electronics with market leading thermal and vibration protection. The multi-layered, pre-formed Ulti-Pak™ delivers unmatched protection thus improving reliability and realizing real reductions in total cost of ownership.



High Temperature as Standard

Directive electronics are rated to 175 °C/ 347 °F as standard thus delivering premium performance at a non-premium price.



Directive Micro Processor [MPU]

The Directive MPU is the heart of Directive Directional Module and is responsible for controlling the acquisition, storage and transmission of data from the MWD and LWD systems.

Shock Evaluation

On-board accelerometer electronics monitor lateral, transverse, and total shocks. Transmission of real time shock levels allow modification of drilling parameters to reduce shock and vibration therefore increasing ROP. Memory can be downloaded post-run and used together with lifetime recorders to define preventative maintenance schedules.

Memory

With 32 MB of on-board memory the Directive MPU is capable of recording multiple channels of survey, logging and diagnostic data at a resolution to meet any operational requirements.

Rotation Sensing

The MPU uses either accelerometers or magnetometers to measure drill string rotation. The tool can be programmed to transmit different data parameters based on the measured rotation to efficiently use all available transmission bandwidth.

Re Sync Capability

Allows the tool to automatically recover telemetry signals when the tool signal is lost, without having to stop the drilling process to regain signal.

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Downlink Capability

The user can change the operating behavior of the tools while downhole using pressure cycles. This allows for increased drilling efficiency and fewer trips out-of-hole to reconfigure the MWD system.

Industry Wide Capability

The Directive MPU is compatible with Scinturion™ Gamma and Centerfire™ resistivity tools and has been tested with a variety of industry standard surface receiver systems. Proven compatibility with Tensor v1.6x compliant surface receiver systems.

Simple Firmware Management

Black Diamond delivers firmware upgrades that are installed by the customer to ensure the MPU delivers the exact performance and data that is required by an evolving and dynamic industry.



Triple Power Supply [TPS]

The Directive Triple Power Supply is a modular switching power supply assembly designed for use in downhole tools. The Triple Power Supply converts input battery voltage to +5 and ±13 V output supply. Both durable and reliable, the tool delivers market leading performance for downhole power needs.

Improved Reliability

Completely redesigned electronics provide proven durability with reliable performance across the entire temperature range.

Accurate Performance

The Directive TPS gives market leading stability and accurate output in all operating environments.

Predictive Testing

The Triple Power Supply is designed to be easily tested during routine maintenance. Performance is tracked allowing any problems to be identified before they cause failures thus delivering improved utilization.

Electrical Specifications

| | |
|-----------------|---|
| Input Voltages | 19 - 36 Vdc |
| Output Voltages | + 5 Vdc +/- 100 mV @ 100 mA +13 Vdc +/- 0.5 V @ 150 mA |

Orientation Module [OM]

The Directive Orientation Module was designed to maintain industry standard measurement accuracy while reducing total cost of ownership.

Redesigned for Reliability

A reduction in the number of electronic boards and utilizing surface mount technology drives the Directive mission statement of lowering total cost of ownership.

4 x Sensor Calibration Stability

Recognizing that the requirement for re-calibration is a major cause of DM downtime the Sensor was designed with a major focus on calibration stability. Improved mechanical architecture together with electronic stability the OM has been proven to deliver up to 4 x sensor calibration stability, the equivalent of >2000 hrs operating at 175 °C / 473 °F.

Performance Confidence

Industry demands for repeatable accuracy drove the development of a sensor with market leading specifications. The Directive OM delivers a 2 x improvement in the requirement of 0.25° Azimuth accuracy in all orientations, locations and temperatures.

Directive Specifications

Dynamic Specifications

| | |
|-------------|----------------------------------|
| Vibration | 20 g RMS |
| Shock Limit | 1.00 g/ 0.5 ms 1/2 sine all axes |

Temperature Specifications

| | |
|-----------------------|------------------------------------|
| Operating | -25 °C to 175 °C/ -13 °F to 347 °F |
| Max. Thermal Gradient | 3 °C per minute/ 5.4 °F per minute |