

Introducing a Paradigm Shift in the Accuracy and Reliability of Directional Measurements



In today's challenging energy economics, it is imperative to safely reduce the cost of well construction—while improving reservoir exposure and reducing formation damage. To help achieve this objective, enabling drilling technologies strive to differentiate by improving system reliability and performance. Reliable, precise, and efficient downhole measurement while drilling (MWD) systems are key prerequisites for accurate well placement with an optimal rate of penetration (ROP). Equipment reliability plays a key role in reducing nonproductive time (NPT), costs and associated risks.

Downhole directional-sensor-related failures are the second largest source of failure, and constitute about one-fifth of all the MWD failures that require operators to pull out of hole (POOH) to change out equipment. GE's customers have successfully relied on our proven reliability and measurement accuracy to help operators reduce drilling costs. Equipment reliability also manifests itself in terms of less frequent repairs and calibrations, and a higher utilization rate over a longer period of time, which reduces total cost of ownership for the service providers.

Tensor MWD System

The GE Oil & Gas range of MWD equipment is recognized for providing simple, dependable and functional solutions for all types of directional surveying and steering operations. Our probe-based Tensor MWD platform is designed to be retrievable and re-seatable to reduce the lost-in-hole risk. Tensor's modular architecture allows the flexibility to use the same set of tools to drill the vertical, intermediate, and the lateral sections—reducing operating and maintenance costs. The system is scalable to add LWD services such as Natural Gamma Ray, and Multiple Propagation Resistivity in a completely seamless manner. The ruggedized Tensor platform is suitable for operating in HPHT environments (175°C, and 20,000 psi), and the harsh drilling conditions experienced across many unconventional installations in the United States.

GE's Tensor offering provides critical directional measurements such as tool face, hole inclination and azimuth to drill directional or horizontal wells. These measurements can be thought of as a 'downhole GPS.' The accuracy and reliability of these directional measurements over an extended period of time under harsh drilling conditions is an absolute prerequisite, since survey errors can be very costly. Directional survey accuracy and reliability requirements are far more pronounced when multiple wells are drilled from the same platform with very tight well spacing. Collision avoidance in these circumstances relies on the accuracy of directional measurements.



As the cornerstone of GE's Downhole Technology Drilling Measurements portfolio, the Tensor system demands continuous attention to maintain its technological edge in today's competitive oil and gas market. GE has made significant investments in research and development to provide meaningful upgrades to our Tensor suite of tools, which can benefit service providers, drillers, and operators alike. Our new and improved Tensor Directional Module (DM) offers industry leading measurement accuracy and reliability for continuous operation in a high temperature environment.

Our newly added real-time shock and vibration measurements enable drillers to reduce vibrations and improve the rate of penetration. Dealing with downhole vibrations in real time can also reduce equipment damage and potential sources of nonproductive time. Its simplified, ruggedized design—with fewer components and improved layout—has undergone extensive in-house and field test campaigns to validate strict performance criteria and endurance. Calibration stability is now up to four times higher, allowing less frequent trips to the shop and associated repair costs. The result is an MWD system with less likelihood of downhole failure, higher utilization rates, and a longer service life. This Tensor refresh has been branded as Directive* to symbolize system fidelity that carries out a directive to land the well precisely in a desirable direction, time after time—without failing.

The following sections provide an overview of the Directive system's key building blocks, which are all conveniently packaged together as a robust Directional Module (DM).

Directive Directional Module

The Directive Directional Module (DM) is the core of the Tensor MWD system. There are three main sub-assemblies of the Directive DM:

- Orientation Module (OM).
- Micro Processor Unit (MPU).
- Triple Power Supply (TPS).

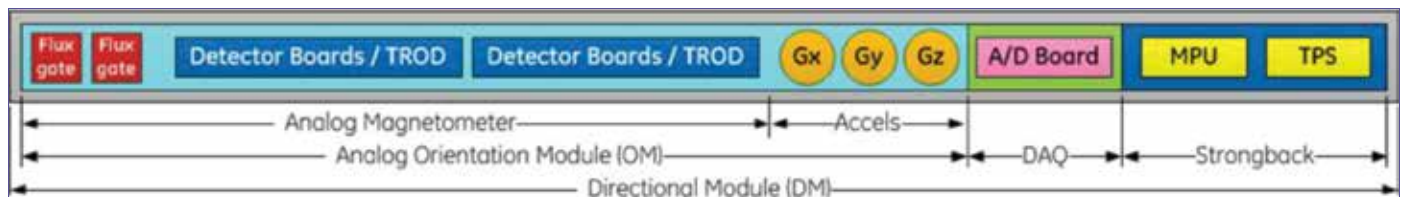
Directive Orientation Module (OM)

The Directive OM instrument provides accurate and stable measurements of the earth's gravitational and magnetic fields, using measurements from the accelerometer and magnetometer packages. This data is processed and converted to digital output using a total of six PCBAs (X,Y,Z, TROD and two DAQ boards) . The data is used to calculate critical Directional Drilling measurements such as wellbore Inclination, Azimuth and Toolface.

Directive Microprocessor Unit (MPU)

The Directive MPU is the heart of GE's Tensor Directional Module and it is the unit responsible for controlling the entire functionality of the MWD and LWD systems.

The Directive MPU is the system controller for Tensor MWD and LWD systems as it controls the acquisition, storage and transmission of MWD and LWD data. The MPU works with the Safe Area Interface and qMWD software package to provide reliable downhole information, allowing the operator to act swiftly and appropriately when needed. The MPU's efficiency and reliability have been rigorously tested with over 10,000 hours of bench testing at temperatures up to and beyond 175°C, and more than 50,000 feet drilled in various formations in North America.



Directive Triple Power Supply (TPS)

The Directive TPS is a modular switching power supply assembly designed for use in downhole drilling applications. It provides regulated system power to the Directional Module and the rest of the MLWD system by converting the battery voltage into +5 and ± 13 V supplies. This TPS tool provides an efficient instrument for downhole power needs, ensuring that instances of downtime are kept to an absolute minimum.

Directive System Initiative

The Directive initiative was launched to elevate performance and reliability to a whole new level, and also to address two primary customer needs: shock and vibration measurement, and improved diagnostics capabilities. There is no industry standard for measurement of downhole shock and vibration; each service company has developed independent measurements and threshold levels. The goal of the Directive initiative is to provide a highly simplified shock and vibration monitoring mechanism that allows drillers to react in real time by adjusting drilling parameters as required.

GE's Directive MWD system is suitable for all types of drilling fluids, while the highly stable sensor package is compatible for use both with traditional mud pulse telemetry or the electromagnetic (EM) system. The Directive TPS offers increased reliability and efficiency, and the new MPU firmware version (v3.02) enables customers to do more without any expansion of hardware. With firmware v3.02, the MEMS accelerometers incorporated in the new MPU design have been activated to perform real-time shock and vibration measurements. Additionally, it provides enhanced diagnostics by storing the details of shock levels coupled with temperature for the life of the tool. Lifetime monitoring of tool health allows service companies to improve utilization through predictive maintenance.

Key Modifications

All of the components have undergone a refresh to maintain their market-leading edge, and as a result of new layout and design, the printed circuit boards (PCBs) have been reduced from four to two. The TPS provides the same voltages as its predecessor. However, the designs of the new sensor pack (in addition to the TPS) provide more than double the rate in reliability. The MPU has been modified to provide real-time shock and vibration measurement, improving ROP and reducing NPT—and a 32 MB memory has been integrated.

Operational Benefits

GE's Directive system can extend product life and further strengthen our customers' edge in the marketplace. Customers can benefit from improved reliability, reduced NPT, and enhanced (preventive) diagnostics. This refresh can help provide tighter industry standard compliance, and higher mean time between failure (MTBF). Overall, it can serve to address significant oil and gas industry requirements in the areas of high temperature, high shock and vibration drilling measurement—while reducing downtime incidents and total cost of ownership.

Availability

The Directive MPU and the Directive TPS are available for commercial use with the FW3.02, whereas the complete Directive directional module is available for pre-order with anticipated delivery by May 15th, 2014.

System Qualification

The promise of the Directive system is backed by an extensive test campaign. An integral component of the test campaign was the rigorous Highly Accelerated Life Testing (HALT) program. The objective of the HALT program was to improve the new design's vibration and temperature performance through stressing the core of the MPU system; i.e., the processor, oscillator or crystal, and the external memory.



The Directive Microprocessor Unit (MPU) is designed to work with the Safe Area Interface and qMWD software package to provide reliable downhole information, allowing the operator to act swiftly and appropriately at all times.

All functions were tested before and after the testing. Additionally, cold stress step or CSS test (down to -50°C), hot stress step or HSS (up to 190°C), and vibration step stress or VSS tests (up to 30 grms) were performed to validate system survival under extreme temperature conditions. Destructive testing was also performed with accelerated temperature variations to establish full confidence in system performance and reliability at the operating range of 175°C .

Directive system and modules have undergone extensive field test campaign in the US land, and the system performed to desirable specifications even under harsh drilling conditions of unconventional wells.



The Directive MWD system is both retrievable and reseatable, reducing rig downtime and the lost-in-hole financial risk.

www.geoilandgas.com/drillingmeasurements

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