Model 1150 Advanced

High-Accuracy Directional Sensor

Applied Physics Systems

Datasheet

Features

- High accuracy ±0.1º for toolface (roll) and inclination, ±0.3º for azimuth
- Digital serial input/output
- Small size 1.360" OD by 29.2" long
- Temperature compensated to 150°C
- Vibration detection for real-time monitoring and on-the-fly adjustments
- "Inc-while-drilling" provides inclination data while drill string is rotating
- Rotation monitoring for future enhancement such as Stick/Slip detection
- Optional Integrated Axial Shock Mounts

Applications

- Advanced Drop-in Replacement for GE Tensor Digital Orientation Module
- Orientation of borehole logging instruments
- Directional drilling

Description

The Model 1150 Advanced Directional Sensor is designed to enable high accuracy measurement of the toolface (roll), inclination and azimuth orientation angles in borehole logging and drilling applications. The unit is configured to be a direct replacement for Tensor MWD directional sensors. The length of the sensor is 29.2”, which is the same length as Tensor units.

The 1150 data interface is implemented with a Maxim Max186 analog to digital (A to D) converter; the user accesses this converter by means of the exposed SPI port. Calibration constants are stored in a Microchip 24AA16 flash memory chip accessed by means of an exposed IIC interface. Both the A to D and flash memory design are Tensor compatible. The Tensor 10 pin Q-Bus is also implemented as a means to carry signals through the sensor.

The Model 1150 Advanced sensor contains both a 3-axis fluxgate magnetometer and a 3-axis accelerometer. The combination of these two sensor systems enables the toolface, inclination and azimuth angles of the 1150 reference frame to be determined. The toolface and inclination angles are calculated from the accelerometer sensor outputs. The magnetometer sensor outputs are used to calculate the system azimuth angle.

The 1150 sensor employs very high performance magnetometer and accelerometer sensors. To maintain high accuracy over the temperature range of the system, the sensors are temperature compensated. This enables an accuracy of ±0.1° for toolface and inclination and an accuracy of ±0.3° for azimuth to be achieved over the full temperature range of the system.

In addition to the Tensor A to D and flash memory interfaces, the Model 1150 Advanced has a digital serial interface. This interface is capable of transmitting either the magnetometer and accelerometer outputs or the system orientation angles. The data transmitted over the digital interface is temperature calibrated and can be transmitted in either ASCII or binary format. The ASCII protocol is based upon sending ASCII characters to the 1150 to obtain data. The data returned by the 1150 is transmitted as an ASCII data stream complete with carriage returns and line feeds so that it can be easily displayed on a video terminal (provided a TTL to RS232 conversion is made by the user). The binary protocol is used for high speed computer to computer interchange. In this case, one byte is sent to request data. The 1150 can be configured to transmit digital data upon command or can be configured to autosend data upon power up. The serial in and serial out lines of the digital interface operate at TTL/CMOS levels and are normally set to operate at 9600 baud with one stop bit and no parity. Other baud rates can be user programmed. The electrical interface to the 1150 sensor is shown on the next page.

Vibration Detection, Rotation Monitoring, and “Inc-While-Drilling” Features

The Vibration Detection feature of the Model 1150 Advanced allows the sensor to transmit the Vibration Severity variable as a 3-bit, 1 to 5 scale (1 = very low, 5 = extremely high) which allows the operator to mitigate downhole vibration in real time (1-2 normal, 3-4 = possible tool damage, 5 = imminent tool damage). The Vibration Severity algorithm reduces the timing impact of this additional data to the logging sequence. Peak G levels can be transmitted real time, or logged to memory for retrieval after the run.

In addition to these features, there is an "Inc-While-Drilling" sensor with an accuracy of ±3° (rated at maximum RPM). This will give the Directional Driller the measurement needed to monitor changes in Inclination, without having to stop drilling for a survey.

The 1150 sensor also includes a Rotation Monitoring feature that, in its current state, will display the current downhole RPM. Future advancements, which include Stick/Slip monitoring, will further enhance the features of this sensor.

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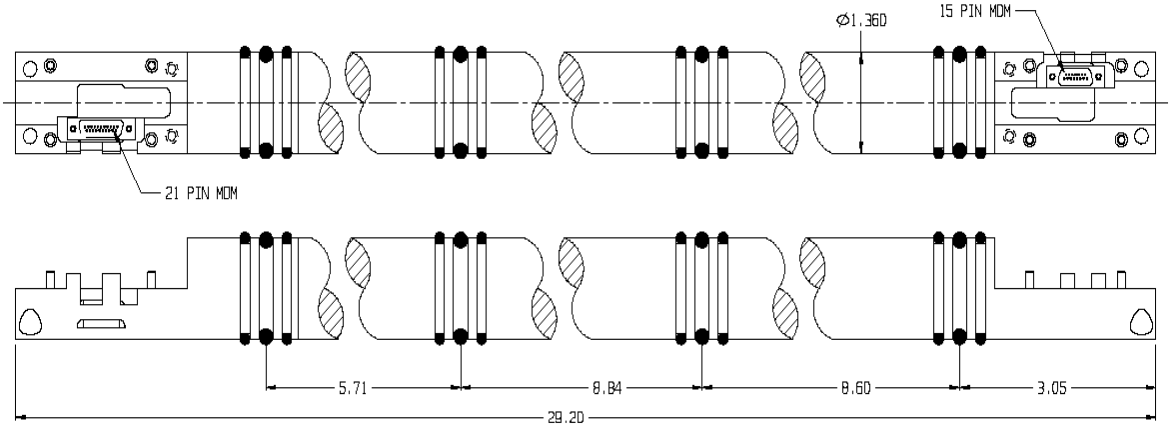
Table 1. Model 1150 Advanced Specifications

Angular Accuracy	
Azimuth (latitude < ±55°) Toolface (roll) Inclination Inclination while drilling (at maximum rated RPM) Inclination while drilling (at 50 RPM with normal drilling vibration)	±0.3° ±0.1° ±0.1° ±3° ±0.5°
Temperature Range	
Operating Storage	-20 to +150°C -30 to +175°C
Power	
Input Voltage Range Current Draw	+12V to +30V 70 ma @ 15V
Physical	
Weight Size	1.5 lbs. 1.360" OD x 29.2" long cylinder
Environmental Performance	
Shock Vibration	1000G 1ms half sine wave 5G RMS random, 50-200Hz
Rotation	
Maximum Accuracy	200 RPM 50 RPM: ±2 RPM & IncR ±0.5° 51-200 RPM: ±5 RPM & IncR ±3.0°
Digital Interface	
Logic Level Baud Rate Protocol	TTL / CMOS User programmable to 9600 Baud User selectable, ASCII or Binary
Connectors	
Top Bottom	MDM21PH003F (ITT Cannon) MDM15SH003B (ITT Cannon)

Figure 1. Model 1150 Advanced Pin Connection Diagram



CONNECTOR IS: MDM-21PH003F			
PIN #	FUNCTION	PIN #	FUNCTION
1	GND	16	BATTBUS
2	+14V to +16V	17	ADC-DATA IN
3	QBUSS	18	NO CONNECT
4	NO CONNECT	19	MODE 1
5	FLOW	20	MODE 2
6	ADC-CLOCK	21	BATT 2
7	ADC-DATA OUT		
8	ADC-SELECT		
9	SCL (I2C)		
10	SDA (I2C)		
11	BATT 1		
12	NO CONNECT		
13	PULSER		
14	-14V to -16V		
15	GAMMA		

THROUGH CONNECTIONS

CONNECTOR IS: MDM-15SH003B	
PIN #	FUNCTION
1	GND
2	BATT 2
3	TXRX
4	NO CONNECT
5	FLOW
6	BATTBUS
7	SERIAL IN to APS CPU
8	SERIAL OUT from APS CPU
9	MODE 1
10	MODE 2
11	BATT 1
12	NO CONNECT
13	PULSER
14	NO CONNECT
15	GAMMA

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1. Additional Information

The Model 1150 Advanced DI Sensor is a drop in sensor that can be added to the current Tensor MWD tool, enabling the transmission of real time Inc While Rotating, RPM, and vibration data. The Model 1150 Advanced DI Sensor incorporates its own microprocessors, and since it is a smart sensor, it communicates directly with the processor in the Directional Module. The Model 1150 Advanced will need the GVD8 variable enabled in the GE system memory. This will allow the system to record the data in the DM Memory for a higher resolution table of all gamma and vibration data.

Model 1150 QBus Parameters (Node 30 on Qtalk)		
G#	List of all parameters	One command to list all current parameters
Ga	Axial Threshold (APS Lab Use Only)	
Gf	Firmware version	Displays the version of firmware
Gp	Vibration Acquisition Period	20 Second
Gq	Onboard Vibration 1=on, 0=off	Gq=0 when Model 1151 Gamma is used
Gt	Transverse Threshold (APS Lab Use Only)	
Gx	Total updates time (1 second increments)	17 Second auto transmit
Gz	QBUS TX Mode 1=on 0=off	Switches Qbus on or off

Read Example- G#?
Write Example- Gq=0

About the Measurements

Lookup Table — The Model 1150 QBus Gamma utilizes a lookup table to record and calculate all of the shock and vibration data. The tool records shock and vibration at a rate of 200 samples/second. The default recording period is 20 seconds (4000 samples). The sensor also transmits a real time Inc While Rotating measurement for monitoring inclination without having to stop for a survey.

Inc While Rotating (IncR) — With the Model 1150 Advanced, the operator can transmit a Real Time IncR measurement enabling the operator to monitor the trend of the well, while drilling ahead. While surveys are still required, the ability to see the results of a slide, without waiting until the next survey, is a tremendous advantage and time saver.

Vibration Severity — The Vibration Severity variable is a compact and efficient 3 bit variable that indicates the level of vibration the tool is encountering down hole. This allows the operator to transmit the Real Time variable without having a huge impact on the toolface & gamma timing. The scale is 1 to 5 (1 being no vibration, 5 being extreme vibration). Normal drilling will be in the range of 2 or less with an occasional 3.

Max Vibration — The firmware monitors the lookup table and transmits the highest measurement recorded during the acquisition period. The processor then transmits a number from 0 to 50 G's.

Model 1150 Advanced QBus Tx (Gq=1)		Model 1150 Advanced QBus Tx (Gq=0)	
GV0	NA	GV0	NA
GV1	Inclination While Rotating	GV1	Inclination While Rotating
GV2	Axial Vibration Severity	GV2	OFF
GV3	Axial Max for Acquisition Period	GV3	OFF
GV4	MWD Tool RPM	GV4	MWD Tool RPM
GV5	Transverse Vibration Severity	GV5	OFF
GV6	Transverse Max for Acquisition Period	GV6	OFF
GV7	NA	GV7	NA

Bits to Transmit		Format		Real Time Resolution
GV1	0-127 Degrees	GV1:u7	IncR	1°
GV1	0-127 Degrees	GV1:u8.-1	IncR	.5°
GV1	0-127 Degrees	GV1:u9.-2	IncR	.25°
GV1	0-127 Degrees	GV1:u10.-3	IncR	0.125°
GV2	1-5	GV2:u3	Axial Vibe Severity	
GV3	0-50G's	GV3:u6	Axial Max Vibe	.78 Count
GV3	0-50G's	GV3:u4.2	Axial Max Vibe	3.13 Count
GV4	0-63 RPM	GV4:u6	RPM	1 RPM
GV4	0-127 RPM	GV4:u7	RPM	2 RPM
GV4	0-255 RPM	GV4:u8	RPM	3 RPM
GV5	1-5	GV5:u3	Lateral Vibe Severity	
GV6	0-50G's	GV6:u6	Lateral Max Vibe	.78 Count
GV6	0-50G's	GV6:u4.2	Lateral Max Vibe	3.13 Count

Toolface Logging Sequence Example

3{aTFA:6:P;Gama:9} GV2:u3 aTFA:6:P GV5:u3 Gama:9 GV1:u8.-1 Bat2 aTFA:6:P BatV:8:P 3{aTFA:6:P;Gama:9} Temp:8:P GV2:u3 aTFA:6:P GV5:u3 aTFA:6:P Gama:9

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