APS TECHNOLOGY

Global perspective. Independent thinking.

Rotary Pulser

Fixed-mount or Retrievable Positive Mud Pulse Transmitter

SureShot-MP

APS Technology's patented Rotary Pulser* is the toughest, most advanced mud pulse transmitter in the industry. Our Rotary Pulser chews through LCM content which would choke any other pulser, over a wide range of mud weights and conditions.

APS's commitment to continuous improvement has increased reliability and decreased power consumption in our pulser. Recent improvements include an ultra-reliable, high-efficiency DC brushless motor and controller which can run thousands of hours without a failure. The motor/controller combo is 30% more efficient when pulsing and consumes 1/3 the quiescent power of the previous generation. Other improvements include more durable shafts and seals, and better serviceability.

The APS Rotary Pulser is designed to operate with batteries or with the APS Turbine Alternator.† It offers a reliable, economical alternative to pulsers from other OEMs. Crossovers to other popular MWD systems are available, or can be custom-designed. All materials are highly wear-resistant to provide exceptional reliability and service life in demanding drilling environments.

Features	Advantages	Benefits
New DC brushless motor	> Increased reliability > Improved power consumption	> Improved MTBF > Works with 8 DD cell (28v) and 10 DD cell (36v) systems
Oscillating rotary motion	> Self-clearing > Low shaft speed	> Reliable operation with high LCM concentrations > Improved seal reliability / life
Open flow path	> No screens to plug	> Enhanced reliability in wells with poor solids control
Direct-drive magnetic coupling	> Rugged drive train > No rotating seals in mud	> Enhanced service reliability > Reduced service cost
Tungsten carbide flow surfaces	> Superior fluid erosion properties	> Extended component life > Reduced service cost
Adjustable pulse width and magnitude	> Adaptable to all flow rates, depths and mud weights	> Extends the range of reliable operation
Wide range of pulser sizes for 3.125 in. (79 mm) to 9.5 in. (241 mm) or larger BHAs	> Easily convertible between sizes, and between fixed-mount or retrievable configurations	> Reliable operation in any hole size > Reduced inventory
Retrievable or fixed-mount options	> Basic design and construction are consistent without regard to configurations	> Adaptable to fit customer needs > Reliable service in all configurations

** U.S. Patents #6,714,138 and #7,327,634* *† U.S. Patent #7,201,239*

APS TECHNOLOGY

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Rotary Pulser

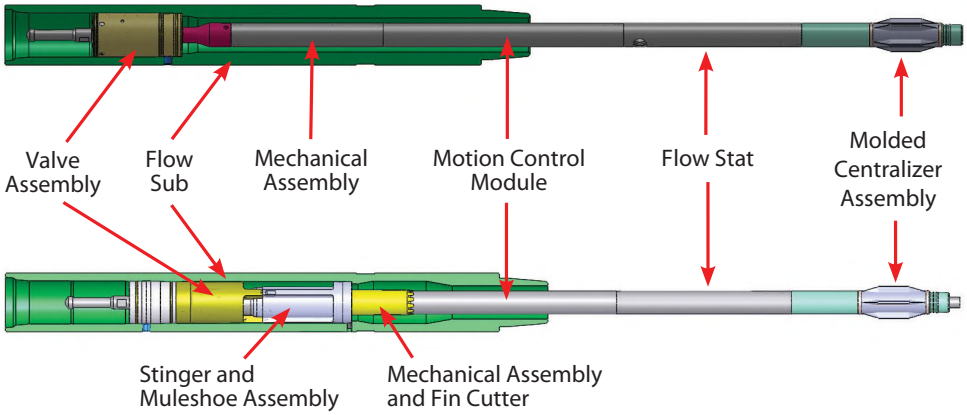
Fixed-mount or Retrievable Positive Mud Pulse Transmitter

Product Specifications

Signal Transmission	Positive mud pulse	
Pulse Height	Adjustable	
Retrievable/Reseatable	Available	
Fixed Mount	Available	
Activation	Electromechanical	
Operating Voltage	28 - 40 VDC	
Pulser Sub O.D.	9.5§, 8, 6.25 to 6.75, 4.75, 3.5 & 3.125 in.**	241§, 203, 159 to 171,121, 89 & 79 mm**
Flow Ranges (8.4 ppg mud)	9.5 in. or larger – 650 to 1200 gpm 8 in. – 300 to 1100 gpm 6.25 to 6.75 in. – 150 to 750 gpm 4.75 in. – 150 to 350 gpm 3.125 & 3.5 in. – 70 to 250 gpm	241 mm or larger – 41 to 76 L/sec 203 mm – 19 to 69 L/sec 159 to 171 mm – 9 to 47 L/sec 121 mm – 9 to 22 L/sec 79 & 89 mm – 4 to 16 L/sec
Sand Content	< 1% by volume recommended, 3% by volume maximum	
LCM Tolerance	50 lb. per bbl medium nut plug	143 kg/m³ medium nut plug
Operating Temperature	-13˚ to 302˚F; 347˚F option	-25˚ to 150˚C; 175˚C option
Maximum Pressure	20,000 psi; 25,000 psi option	137.9 MPa; 172.4 MPa option
Differential Pressure	No requirement	
Dogleg Capability	API connection limited	

** Specifications subject to change without notice*
§ Larger O.D. subs can be accommodated using the pulser for 9.5 in. (241 mm) O.D.
*** Pulsers for 3.125 in. (79 mm) & 3.5 in. (89 mm) BHAs are available in fixed-mount only*

Fixed-mount Pulser



Retrievable Pulser

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Rev. 151229-vD

APS TECHNOLOGY

Global perspective. Independent thinking.

APSPlot™ Version 1

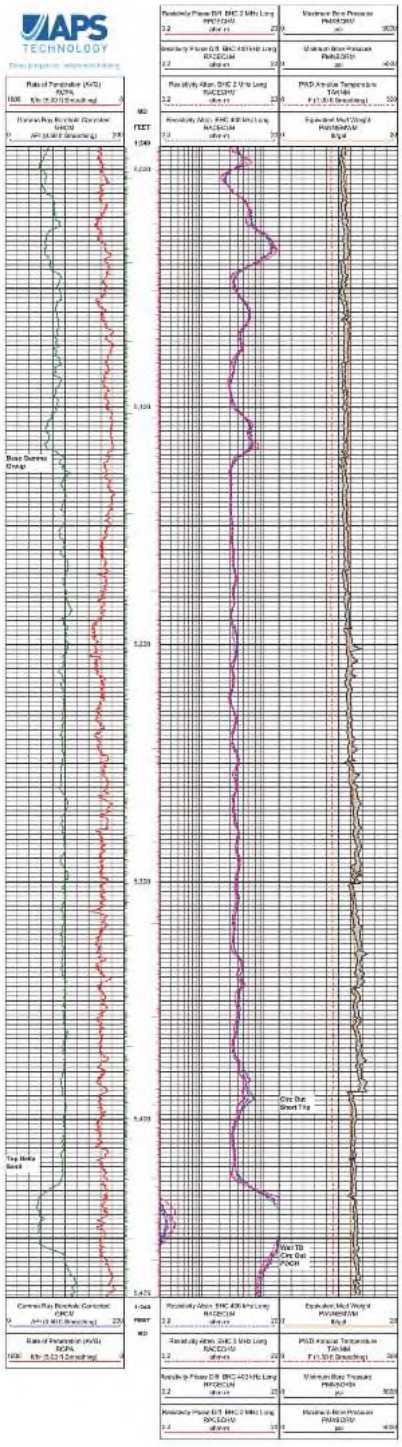
APS Technology's APSPlot software is a complete plotting package with easy-to-use graphical user interface. This package allows the user to quickly configure and plot API RP 31A compliant logs based on Measured Depth (MD), True Vertical Depth (TVD) and time scales. Configured header and log formats and styles can be stored as templates, separate from the log data, so that identical log presentations can be easily applied to all data sets for specific customer or situations. Logs and templates can be created using SI (metric) or English units.

APSPlot offers unparalleled ease-of-use, including:

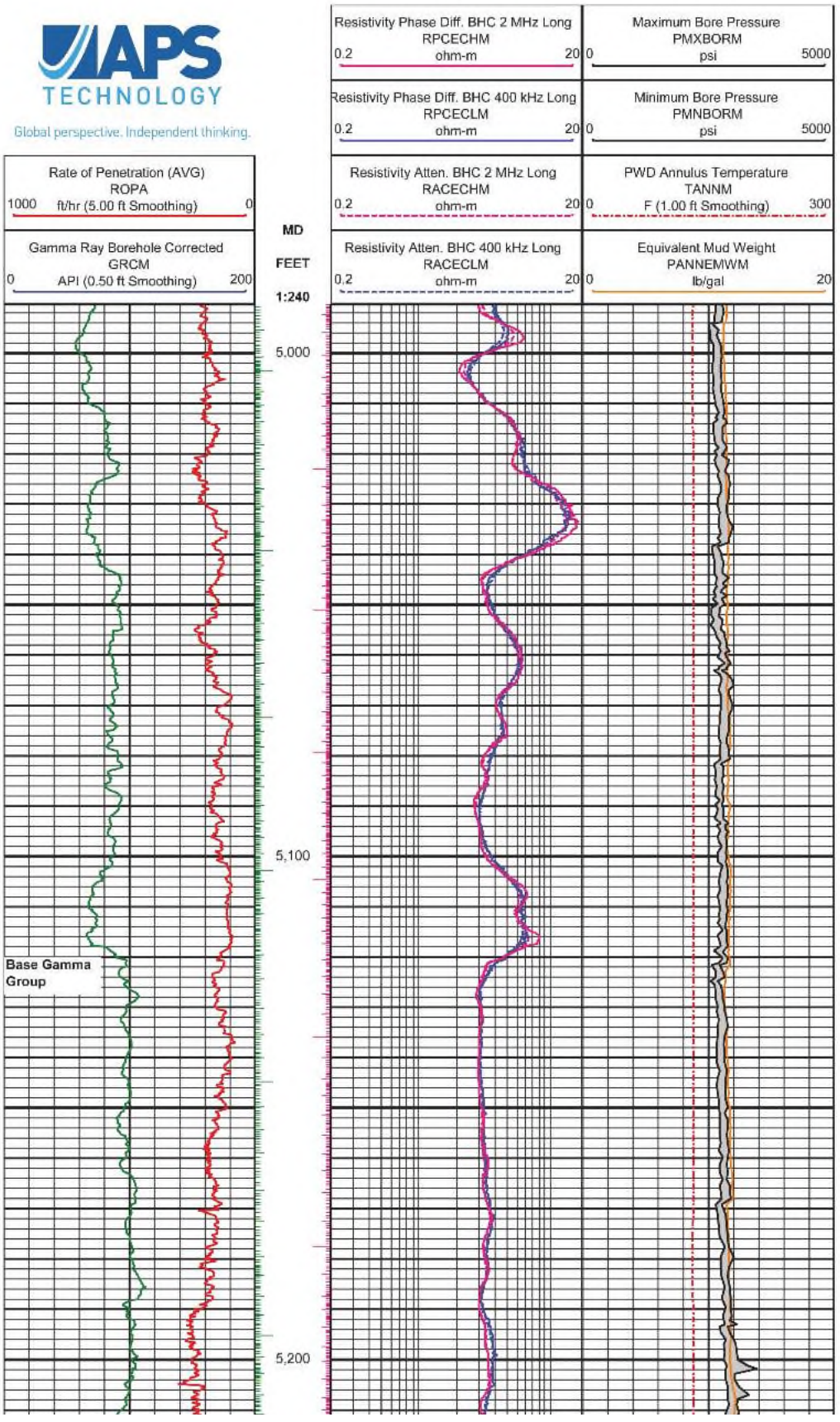
- > Rapid plot creation: A 3-track plot can be created in 10 mouse clicks
- > 1-click track mnemonic change
- > Straightforward, intuitive changes to track or plot scaling
- > Multiple simultaneous open logs
- > Simple, robust PDF output
- > Straightforward insertion of casing, coring, connection and sliding symbols and annotations

APSPlot works as a seamlessly-integrated component of APS's SureShot Control Center version 5 (SSCC™ v5), our time-proven SureShot suite of MWD / LWD operating software:

- > Plots are always derived from the most current SSCC data
- > SSCC's time, depth, bit run and download event filtering tools may be applied to plots and traces
- > Plot headers and footers may be automatically populated by SSCC
- > SSCC enables the user to construct a well plot from multiple sidetracks



APSPlot™ Version 1



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Rev. 160127-vB

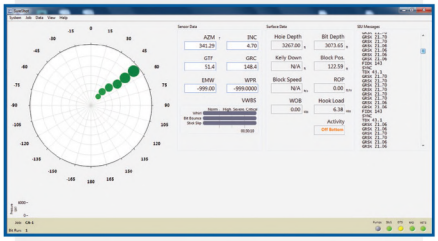
SureShot™ EM Telemetry System

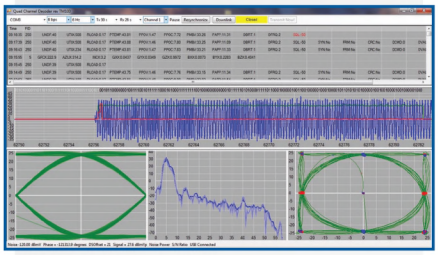
Global perspective. Independent thinking.

SureShot-EM

Features

- > Data rates up to 12 bps
- > High-power 50 W transmitter
- > Downhole selectable data sequences – choose the optimum combination of directional, LWD and pressure measurements for the drilling operation
- > EM Downlinking – Quickly adjust power, bit rate, carrier frequency and telemetry sequences for the conditions
- > Plug-and-Play compatibility with APS SureShot downhole and surface equipment
- > Quad channel digital surface receiver to rapidly select the best signal from among 4 antenna pairs as the well progresses
- > Turbine alternator option for extended bit runs and high current draw applications
- > Unique rugged, reliable dual gap sub
- > WPR resistivity compatible



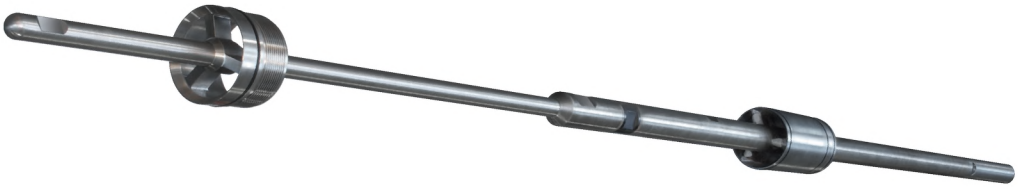


EM Telemetry

The APS EM system communicates by transmitting electromagnetic waves through the formation instead of pressure pulses through a fluid column. Benefits include time saved by transmitting surveys during a connection, high data rates and the ability to operate in conditions where mud pulse telemetry cannot.

Applications

- > High ROP drilling with frequent surveys
- > High data density LWD and drilling optimization applications
- > Underbalanced drilling
- > Foam and air drilling
- > Extreme lost circulation conditions



SureShot EM

SureShot EM is a state-of-the art system. The downhole tool features two-way EM communication. The sequence and frequency of transmitted measurements is EM downlink selectable. Whether it's a higher density log to pick a casing point, more pressure measurements for drilling optimization or emphasis on directional measurements while sliding, SureShot EM enables the operator to quickly choose the optimum data sequence for the drilling operation.

Power, data rate and carrier wave are user adjustable while drilling – helpful for transmitting through changing formations and when automatic adjustments are ineffective due to overburden or changing surface conditions. The innovative quad surface receiver is actually four receivers in one. The receiver can decode using one antenna while simultaneously monitoring up to four antennas. As the wellbore changes direction the operator can select antennas at the optimum time for best reception. Utilizing the strongest signal conserves batteries and allows for higher data rates. The gap sub is a dual gap design for added reliability. Features include ceramic sleeves to prevent loss of power due to arcing; no coating to wear and arc; dual insulator rings for more reliability; and higher power to the formation due to gap distance.

Fixed-mount and retrievable configurations are available. The fixed-mount tool features a sliding electrode contact ring – no need for spacers to accommodate various length subs. The fixed-mount tool is field configurable to work with different size drilling tubulars.

The EM tool operates with batteries or turbine alternator. The turbine alternator enables longer downhole time, high transmitting power for longer periods and power for high draw applications with multiple sensors. The turbine alternator configuration includes backup batteries for operation during periods of no flow.

Depth tracking options include the SureShot Depth Tracker, the SureShot mud pulse SIU and WITS.

Compatibility

SureShot EM works with all APS downhole sensors. The EM transmitter uses the same flow subs and is a drop-in alternative for the mud pulse transmitter, having many parts in common with the SureShot mud pulse system. Operators benefit from reduced inventory cost and increased flexibility when providing a mix of EM and mud pulse MWD services.

SureShot™ EM Telemetry System

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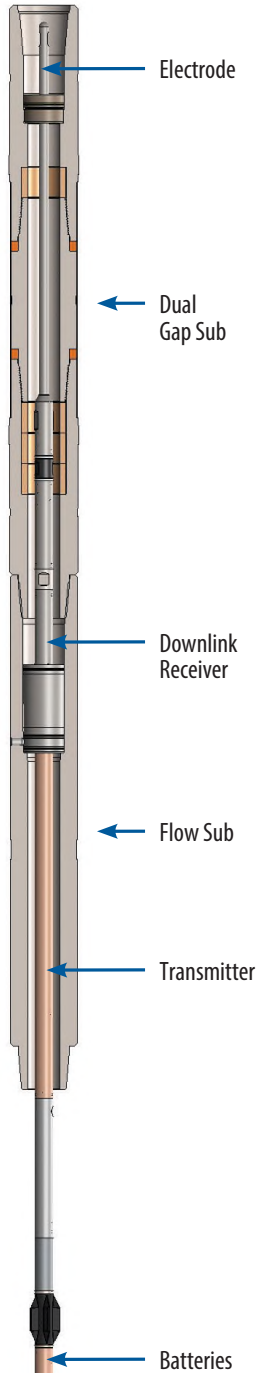

Product Specifications

Downhole Transceiver		
Data Rate	1 to 12 bps uncompressed; selectable	
Power Output	2 to 50 W, selectable	
Power Source	2 - 4x 10 DD lithium battery or APS Turbine Alternator + 1x 10 DD lithium battery	
Downlink Methods	EM and flow	
Downlink-adjustable Parameters	Data Rate Power Output Operating Frequency Data/Survey Sequences Survey-on-command	
Operating Frequency	2 to 12 Hz; selectable	
Collar OD	8.0 in. 6.75 / 6.50 in. 4.75 in.	204 mm 172 / 165 mm 121 mm
Flow Rate Limits	8.0 in. – 300 to 1100 gpm 6.75 / 6.50 in. – 150 to 750 gpm 4.75 in. – 125 to 350 gpm	203 mm – 19 to 69 L/sec 171 / 165 mm – 9 to 47 L/sec 121 mm – 7.9 to 22 L/sec
Sand Content	< 1% by volume recommended	
Operating Temperature	-13˚ to 302˚F	-25˚ to 150˚C
Maximum Pressure	20,000 psi	138 MPa
Surface System		
Operating Temperature	32˚ to 158˚F	0˚ to 70˚C
Storage Temperature	14˚ to 185˚F	-10˚ to 85˚C
Surface Sensors	Depth encoder, hookload, standpipe pressure	
SureShot MWD with EM		
Downhole Configurations		
Available Platforms	Fixed-mount or retrievable	
Fixed-mount System	Battery Battery and PWD Turbine, battery and PWD	
Retrievable System	Battery Battery and PWD	
Available Sensors	Directional, gamma, vibration, WPR, annular and bore pressure	
Length	Equal to mud pulse transmitter; 30 - 31 ft for DGMWD collar	
Surface System		
Surface System	Surface receiver, downlink transmitter, laptop, rig floor display	
Depth Options	WITS, SureShot Depth Tracker, SIU 1 or SIU 2	

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APS TECHNOLOGY

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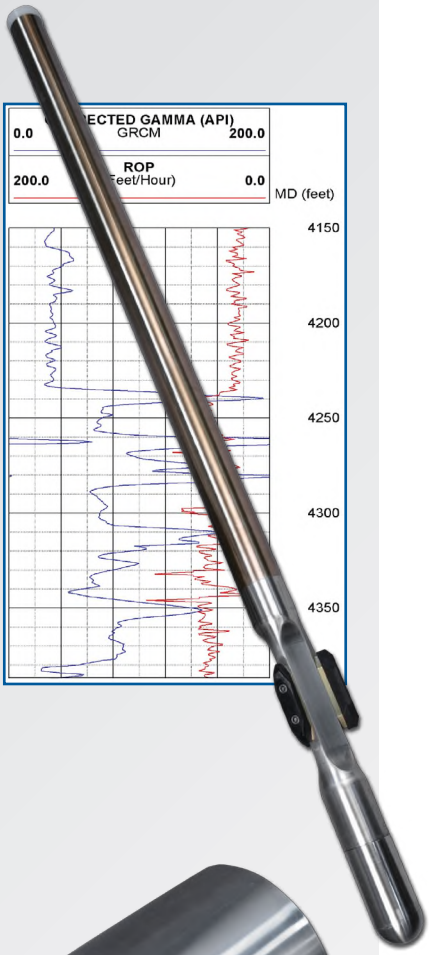
SureShot™ MWD Gamma Sensor with Environmental Monitoring

SureShot-Gamma



APS's next-generation SureShot natural gamma sensor employs a rugged scintillation counter and photomultiplier mounted in a specially designed package which provides protection against the high levels of shock and vibration encountered in the drilling environment. In addition, this extensively qualified new design offers environmental monitoring capability and lower power consumption, while maintaining back-compatibility with APS's earlier sensor designs.

APS's gamma sensor is an add-on to our SureShot Measurement-While-Drilling (MWD) system. The APS gamma sensor is calibrated to API-standard units, and a wellsite check source is available to verify tool performance in the field or maintenance repair shop. The easy-to-use SureShot surface system scales natural gamma ray data to API units; corrects for borehole size, mud weight and drill collar effects; assigns each point a depth from the depth tracking system; and plots both real-time displays and configurable hard copy logs. Data can be exported in standard industry formats (WITS and LAS).

The SureShot MWD downhole system can be programmed to send a combination of gamma ray and tool face data transmissions to allow logging while steering and sliding. A rotation sensor in the directional package enables the tool to optionally transmit only gamma ray data while rotating. The SureShot MWD can store up to 32 MB of gamma data for retrieval during trips.

Product Specifications

Physical Parameters		
Length	46 in.	117 cm
Outside Diameter	1.875 in.	48 mm
Measurement		
Sensor	NaI scintillation detector with PMT	
Measurement Range Accuracy (Apparent API Units)	API-calibrated 0 - 800 API ±3 API @ 100 API (based on typical API scale factor of 1.35 API counts/sec)	
Vertical Resolution	6 in.	152 mm
Max. Data Sampling	Every 5 sec	
Update Resolution (real time)	2.5 to 3.5 points/ft at 50 ft/hr; 0.8 to 1.2 points/ft at 150 ft/hr	
Environmental		
Operating Temperature	0˚ to 347˚F	0˚ to 175˚C
Maximum Pressure	20,000 psi; 25,000 psi option	137.9 MPa; 172.4 MPa option

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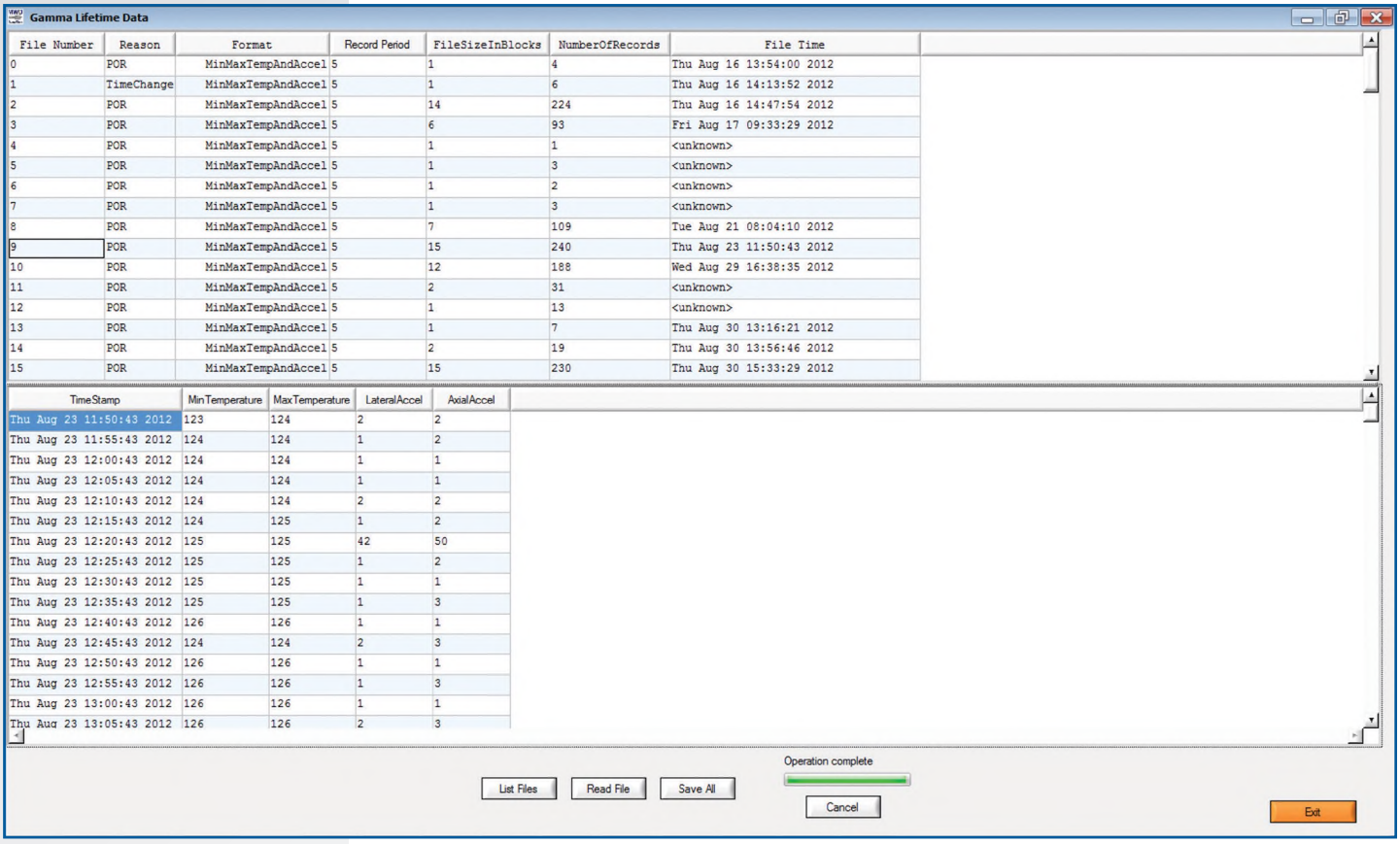
SureShot™ MWD Gamma Sensor with Environmental Monitoring

Gamma Controller Environmental Data Files and Event Log



File Number	Reason	Format	Record Period	FileSizeInBlocks	NumberOfRecords	File Time
0	POR	MinMaxTempAndAccel	5	1	4	Thu Aug 16 13:54:00 2012
1	TimeChange	MinMaxTempAndAccel	5	1	6	Thu Aug 16 14:13:52 2012
2	POR	MinMaxTempAndAccel	5	14	224	Thu Aug 16 14:47:54 2012
3	POR	MinMaxTempAndAccel	5	6	93	Fri Aug 17 09:33:29 2012
4	POR	MinMaxTempAndAccel	5	1	1	<unknown>
5	POR	MinMaxTempAndAccel	5	1	3	<unknown>
6	POR	MinMaxTempAndAccel	5	1	2	<unknown>
7	POR	MinMaxTempAndAccel	5	1	3	<unknown>
8	POR	MinMaxTempAndAccel	5	7	109	Tue Aug 21 08:04:10 2012
9	POR	MinMaxTempAndAccel	5	15	240	Thu Aug 23 11:50:43 2012
10	POR	MinMaxTempAndAccel	5	12	188	Wed Aug 29 16:38:35 2012
11	POR	MinMaxTempAndAccel	5	2	31	<unknown>
12	POR	MinMaxTempAndAccel	5	1	13	<unknown>
13	POR	MinMaxTempAndAccel	5	1	7	Thu Aug 30 13:16:21 2012
14	POR	MinMaxTempAndAccel	5	2	19	Thu Aug 30 13:56:46 2012
15	POR	MinMaxTempAndAccel	5	15	230	Thu Aug 30 15:33:29 2012

TimeStamp	MinTemperature	MaxTemperature	LateralAccel	AxialAccel
Thu Aug 23 11:50:43 2012	123	124	2	2
Thu Aug 23 11:55:43 2012	124	124	1	2
Thu Aug 23 12:00:43 2012	124	124	1	1
Thu Aug 23 12:05:43 2012	124	124	1	1
Thu Aug 23 12:10:43 2012	124	124	2	2
Thu Aug 23 12:15:43 2012	124	125	1	2
Thu Aug 23 12:20:43 2012	125	125	42	50
Thu Aug 23 12:25:43 2012	125	125	1	2
Thu Aug 23 12:30:43 2012	125	125	1	1
Thu Aug 23 12:35:43 2012	125	125	1	3
Thu Aug 23 12:40:43 2012	126	126	1	1
Thu Aug 23 12:45:43 2012	124	124	2	3
Thu Aug 23 12:50:43 2012	126	126	1	1
Thu Aug 23 12:55:43 2012	126	126	1	3
Thu Aug 23 13:00:43 2012	126	126	1	1
Thu Aug 23 13:05:43 2012	126	126	2	3

Environmental Monitoring

The gamma sensor's built-in accelerometers measure axial and lateral vibration. Peak axial shock, lateral shock, and temperature data are stored in on-board memory every 5 minutes, up to 5,000 hours. Information on the service history of the tool is also stored in on-board memory.

This lifetime log provides valuable information to evaluate the health of the tool, and to develop preventative maintenance cycles base on the actual operating environment over time rather than total downhole hours alone. Vibration measurements can also be used to justify claims for repairs that are a result of out-of-spec drilling conditions.

Gamma module environmental data can be downloaded using APS's MWD Master Interface PC application. Future APS software releases will run the downloaded data through an "Accumulated Damage Model" to enable Condition-Based Maintenance scheduling based on the gamma module's operating history.

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APS TECHNOLOGY

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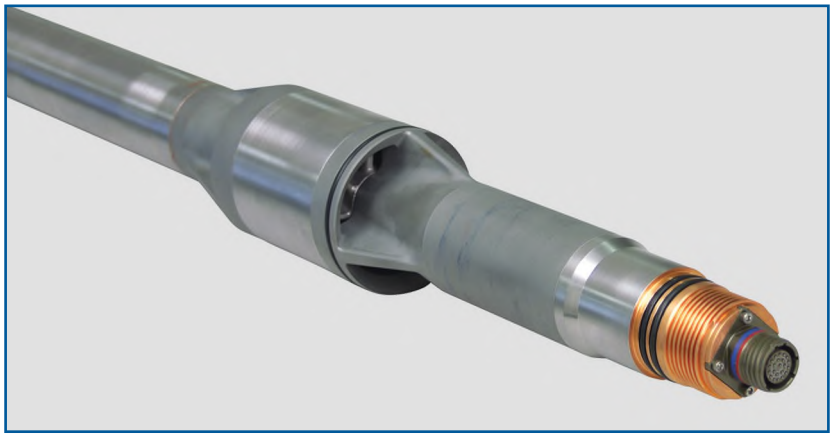
MWD Turbine Alternator

The APS Turbine Alternator[†] is a high-temperature, axial flow design for use in measurement-while-drilling (MWD) and logging-while-drilling (LWD) systems. This device provides reliable, ongoing power at temperatures of up to 175˚C, taking the place of expensive, short-lived disposable batteries. The turbine is configurable to match the required flow rates for typical BHA/hole size combinations.



Product Specifications

Operating Temperature	347˚F (175˚C)
Pressure	20,000 psi (138 MPa)
Output Power	150 W
Voltage, Regulated (Configurable)	28 - 60 VDC
Flow Rate	3.125 in. (79 mm) – 150 to 270 gpm (6.5 to 17 L/sec) 3.75 in. (95 mm) – 250 to 775 gpm (15.8 to 48.8 L/sec) 4.82 in. (122 mm) – 400 to 1300 gpm (25.2 to 82 L/sec)
Housing Diameter	1.875 in. (48 mm) / 2.06 in. (52 mm) / 1.875 in. (48 mm)
Overall Length	60 in. (1,524 mm)
Weight	Approx. 45 lbs. (20.4 kg)
Turbine Housing Diameter	3.125 in. (79 mm) for 4.75 in. (121 mm) drill collar 3.75 in. (95 mm) for 6.5 in. (165 mm) & 6.75 in. (171 mm) drill collar 4.82 in. (122 mm) for 8 in. (203 mm) & larger drill collar
Connections	The uphole and downhole connections use the robust APS 1.625-10 Stub Acme shouldered connections. Male threads are copper plated for galling resistance. Other connections or crossovers can be supplied for different architectures.
Connectors & Feed-Through Conductors	Deutsch 22 conductor connectors with 4 x 26 AWG unshielded and 5 x 32 AWG coaxial shielded feed-through conductors, plus 2 power and 2 ground lines and a frequency line.

[†] *U.S. Patent #7,201,239*

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Rev. 160713-vC.01

APS TECHNOLOGY

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SureShot™ MWD Pressure While Drilling Sensor (PWD)

SureShot-PWD

APS's Pressure While Drilling (PWD) sensor measures annular and drill pipe pressures in all collar sizes. Captured data may be transmitted in real time via APS's SureShot™ MWD/LWD system, or stored in downhole memory for later download and analysis. Real-time data or pressure alarms may be transmitted via SureShot.

Applications include:

Managing Downhole Pressures

Measurement and real-time monitoring of hydrostatic and dynamic circulating fluid pressures for balanced, managed pressure drilling (MPD), and underbalanced drilling (UBD).

Maintaining Formation and Borehole Integrity

Real-time annular and bore pressure measurements help assess the optimum pressures required within narrow fracture and pore pressure windows.

Managing Hydraulics Programs

Real-time determination of equivalent circulating density (ECD) for hole cleaning, swab and surge pressures for borehole stability, and BHA pressure loss.

Supporting Early Detection Programs

Timely annular, bore, and differential pressure readings facilitate early detection of fluid influx and lost circulation.

Product Preliminary Specifications

Measurement		
	Range	**Accuracy**
Annular Pressure	0 - 20 kpsi (137.9 MPa)	±0.1% of FSR
Drill Pipe Pressure	0 - 20 kpsi (137.9 MPa)	±0.1% of FSR
Resolution	1.0 psi (6,895 Pa)	
Local Temperature Compensation	Yes	
Data Sampling Rate	5 seconds total (annular + drill pipe)	
Data Storage	Raw and compensated data are time-stamped and stored in SureShot memory.	
Environmental		
Operating Temperature	-13˚ to 347˚F (-25˚ to 175˚C)	
Maximum Pressure	20 kpsi (137.9 MPa)	

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APS TECHNOLOGY

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SureShot-MWD

SureShot™ Surface Systems & Components

APS's SureShot family includes our modular approach to building MWD decoding and logging systems according to your business's changing needs.

The base model of our expandable SureShot surface system is the Sensor Interface Unit 2 (SIU 2) which includes everything needed to measure, filter, decode, display, store, retrieve, transmit and remotely access data for basic survey jobs. A separate PC and rig floor display can be added when needed for full directional MWD capability, and a depth-tracking system (DTS) SIU 2 retrofit and Printrex plotter can be added for LWD service when required. SureShot's intuitive, menu-based operating system allows you to lock-out some parameter changes while allowing the field engineer to still make necessary adjustments on the job. SureShot systems are available in both "ruggedized" and "lite" versions.

Application	MWD Tool	Gamma Sensor	SIU 2	SIU 2 with DTS Option	PC* with SureShot Software	Printrex Plotter	Rig Floor Display	Surface Sensors**		
								Pressure	Hook Load	Depth
Survey-on-connection	✓		✓					✓		
MWD	✓		✓		✓		✓	✓		
Gamma / LWD	✓	✓		✓	✓	✓	✓	✓	✓	✓

** Server ("Ruggedized") or laptop ("Lite")*

*** Intrinspak® barriers provide an intrinsically safe connection to all surface sensors which connect to the SIU 2 in a nonhazardous environment.*

✓ = required

Standard APS Surface System

APS TECHNOLOGY

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SureShot™ Surface Systems & Components

Product Specifications

Surface System		
SIU 2 & Plotter General Specifications		
Electrical Requirements	100 - 240 VAC, 50 - 60 Hz, 13 W	
Operating Temperatures	32˚ to 158˚F	0˚ to 70˚C
Storage Temperatures	14˚ to 185˚F	-10˚ to 85˚C
"Ruggedized" System		
Directional	Case – 19 in. EIA Standard 17 in. (h) x 27 in. (w) x 34.25 in. (d) Weight – 119 lb	Case – 483 mm EIA Standard 482 mm (h) x 686 mm (w) x 870 mm (d) Weight – 54.0 kg
Directional & Depth Tracking	Case – 19 in. EIA Standard 17 in. (h) x 27 in. (w) x 34.25 in. (d) Weight – 119 lb	Case – 483 mm EIA Standard 482 mm (h) x 686 mm (w) x 870 mm (d) Weight – 54.0 kg
"Lite" System		
Directional	3.5 in. (h) x 19 in. (w) x 16 in. (d) Weight – 12 lb plus laptop	89 mm (h) x 483 mm (w) x 406 mm (d) Weight – 5.4 kg plus laptop
Directional & Depth Tracking	3.5 in. (h) x 19 in. (w) x 16 in. (d) Weight – 12 lb plus laptop	89 mm (h) x 483 mm (w) x 406 mm (d) Weight – 5.4 kg plus laptop
Printrex Plotter		
	7.25 in. (h) x 22 in. (w) x 20 in. (d) Weight – 37 lb	184 mm (h) x 559 mm (w) x 508 mm (d) Weight – 16.8 kg
Rig Floor Displays		
Standard	Certified Zone 1 Division 2; 9 in.; wireless -4˚ to 140˚F (-20˚ to 60˚C) operating; -40˚ to 167˚F (-40˚ to 75˚C) storage	
Low-temperature	Certified Zone 1 Division 2; 15 in.; wired/wireless -40˚ to 122˚F (-40˚ to 50˚C) operating; -40˚ to 167˚F (-40˚ to 75˚C) storage	
Surface Sensors		
Pressure Transducer	4 - 20 mA current loop; certified intrinsically safe Class 1 Division 1, Class 1 Zone 0 -40˚ to 250˚F (-40˚ to 121˚C) operating; -67˚ to 302˚F (-55˚ to 150˚C) storage	
Hook Load Sensor	4 - 20 mA current loop; certified intrinsically safe Class 1 Division 1, Class 1 Zone 0 -40˚ to 180˚F (-40˚ to 80˚C) operating; -40˚ to 257˚F (-40˚ to 125˚C) storage	
Depth Encoder	Standard NAMUR Type; certified intrinsically safe Class 1 Zone 0 -40˚ to 180˚F (-40˚ to 80˚C) operating; -40˚ to 257˚F (-40˚ to 125˚C) storage	

Low-temperature Rig Floor Display

SureShot Ruggedized System with Integrated Server and Terminal

Printrex Plotter

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