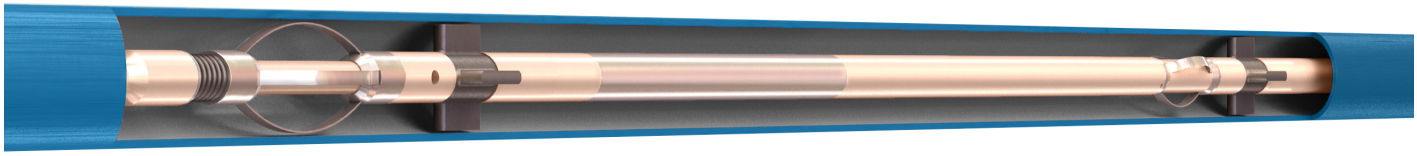
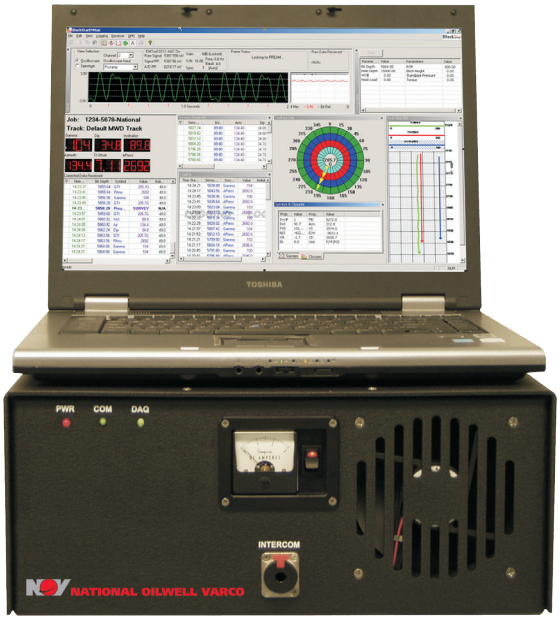
BlackStar II EM MWD Tool



The **BlackStar™ II** electromagnetic (EM) MWD tool is the latest advancement in NOV's BlackStar EM MWD system. Our BlackStar II EM MWD tool transmits data measurements from the bottom of the hole back to the surface, allowing the driller to control and monitor the location and orientation of the drill bit. Surveys can be transmitted during connections, minimizing the nonproductive time associated with conventional mud-pulse tools.



BlackStar EM MWD computer and surface amplifier

Features and Benefits

- High power output (up to 40 watts)
- Multiple open-circuit voltages, available in step increments
- EM downlinking, in addition to traditional RPM mode
- Standard 30-ft monel to replace requirement for non-standard length instrument collars used in previous design
- Addition of rotary connectors between modules for ease of assembly
- Multiple user-programmable frames; survey, steering, and rotation
- Power management options (can shut down transmitter while rotating)
- Axial, radial, and total vibration channels
- All modules operate from single 28 V battery stack
- No requirement to break down modules for tool programming (can be programmed with batteries installed)
- Integration of gamma (360° and DRG) module, with optional annular and Internal pressure
- Logging of survey data to onboard tool memory
- Dual battery support

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General Tool Specifications

Length	Single battery (directional only): 28.90 ft (8.81 m) Single battery (360° gamma/DRG): 30.75 ft (9.37 m) Dual battery option: add 7.45 ft (2.27 m) to toolstring length PWD option: add 23 in. (0.6 m) to toolstring length Mud-pulse option: add 54 in. (1.4 m) to toolstring length
Size	OD 1.875-in. (4.762-cm)
Pressure rating	20,000 psi (137,895 kPa)
Powered by lithium battery	80 to 150 operating hours depending upon borehole conditions and transmitter power selection. Dual battery option is available.
Operating temperature	-40 to 302°F (-40 to 150°C)
Downhole data storage	DRG • Log duration: 217 to 3,472 hr • Logging interval: 15 seconds to 4 minutes Time, gamma, high-side gamma, low-side gamma, left-side gamma, right-side gamma, temperature, axial vibration (max), radial vibration (max) 360° gamma • Log duration: 150 to 2,400 hr • Logging interval: 15 seconds to 4 minutes Time, gamma, axial vibration (average), radial vibration (average), axial vibration (max), radial vibration (max) Smart directional sensor • Log duration: Up to 1,000 hr (configuration dependent) **Survey:** Gx, Gy, Gz, Hx, Hy, Hz, DS temperature, axial vibration, radial vibration **Steering:** Gx, Gy, Gz, Hx, Hy, Hz, SDS temperature, axial vibration, radial vibration **Rotation:** SDS temperature, axial vibration, radial vibration **Alert:** • High temperature • High vibration • Ready for EM downlink • EM downlink success • Tool entering sleep mode • Low battery voltage
Downlinking	RPM and EM to change tool's mode of operation

Parameter Specifications

Parameter	Range	Resolution	Accuracy
Inclination	0 to 180°	0.05°	+/- 0.1°
Azimuth	0 to 360°	0.18°	+/- 1.0°
Toolface	0 to 360°	0.18°	+/- 1.5°
Dip angle	+/- 90°	0.1°	+/- 0.2°
Mag field	0 to 70,000 nT (gamma)	100 nT	+/- 200 nT
High-side gamma	2,000 cps Window size 0 to 120°	1 cps	+/- 1 max RPM 120
Low-side gamma	2,000 cps Window size 0 to 120°	1 cps	+/- 1 max RPM 120
Left-side gamma	2,000 cps Window size 0 to 120°	1 cps	+/- 1 max RPM 120
Right-side gamma	2,000 cps Window size 0 to 120°	1 cps	+/- 1 max RPM 120
Gamma	2,000 cps	1 cps	+/- 1 max
Annular pressure	0 to 20,000 psi	8 psi	1%
Pipe pressure	0 to 20,000 psi	8 psi	1%
Temperature	-40 to 302°F (-40 to 150°C)	1°F (0.07°C)	+/- 1.0°
Tool rotary speed	0 to 120 RPM	4 RPM	+/- 2 RPM
Radial vibration	0 to 18 g rms	0.01 g rms	+/- 0.5 g rms
Axial vibration	0 to 18 g rms	0.01 g rms	+/- 0.5 g rms
Gap current	60 to 2000 mA	60 mA	+/- 30 mA

Data Transmission, 3 to 18 sec data update

Type	Low-frequency EM waves
Operating frequency	Field configurable 2 to 12 Hz
Data rates	1, 1.5, 2, 2.4, 4, 4.8, 6.0 bits per second
Transmitted parameters	Field configurable
Data update rates	18 sec at 1 baud 3 sec at 6 baud

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Formation Parameters

Formation resistivity	3 to 1,000 ohm meters, depending upon formation strata and borehole conditions

EM signal modeling service is available through NOV for prejob planning

Tubular Sizes and Pressure Drop

Size	Pressure drop at maximum flow rate with 8 ppg mud
3.75-in. OD, 2.3125-in. ID	180 psi at 160 gpm
4.75-in. OD, 2.6875-in. ID	76 psi at 370 gpm
6.5-in. OD, 3.75-in. ID	39 psi at 700 gpm
8.0-in. OD, 4.0-in. ID	21 psi at 1,200 gpm
9.50-in. OD, 4.0-in. ID	21 psi at 1,200 gpm

Tubular Sizes and Max Dogleg

Tubular size	Hole size	Max dogleg – Degree/100 ft	
		Sliding	Rotating
3.75 in.	4.750 to 5.875 in.	33	14
4.75 in.	5.875 to 7.875 in.	28	12
6.5 in.	7.5 to 9.875 in.	20	10
8.0 in.	9.875 to 12.5 in.	12	7
9.5 in.	12.5 to 14.5 in.	12	7

Mud and Fluid Parameters

Conventional drilling	Mud flow	Maximum dependent on NMDC ID fluid velocity flowing past tool not to exceed 40 ft/sec
	Mud sand content	Maximum 0.5% for continuous operation at maximum flow rate. Higher content tolerable at low rates
Underbalanced air/mist drilling	Minimum fluid injection rate: 30 gpm	