

Magnetometers



In the early 1940s, the first fluxgate marine magnetometers were used to detect submarines and other 'large' submerged or buried objects. For these applications, the maximum obtainable accuracy of $\pm 1\text{nT}$ was sufficient. Since their development, magnetometers have evolved from the proton types, proton-free precession technology to Overhauser-Abragam and optically pumped caesium magnetometers, and, currently, more accurate systems are available with an absolute scalar reading of the total magnetic field to an accuracy of $\pm 0.1\text{nT}$.

Today, the most commonly used magnetometer is the nuclear precession or proton magnetometer. Since the early 1950s, magnetometers were based on the 'Overhauser effect', named after the American physicist Albert Overhauser who discovered the transfer of energy from electrons to protons in hydrogen atoms. At about the same time, A. Abragam discovered the same effect, although he used a different method. This invention relates to nuclear magnetometers for measuring weak magnetic fields, based on dynamic polarisation of nuclei and a free radical substance for use therein.





Overhauser-Abragam magnetometers are vastly more energy efficient than their predecessors, proton precession magnetometers, which relied on excitement of protons by a direct current source. Overhauser magnetometers also have faster sampling frequencies (>10 magnetic measurements per second) and higher sensitivities than the older proton precession magnetometers.

Caesium magnetometers use the alkali metal caesium and are optically pumped. A cell containing the gaseous form of the metal caesium is polarised (or pumped) by exposure to light of a very specific wavelength. The light depopulates one electron energy level in the gas by pumping the electrons to a higher energy level. These electrons spontaneously decay to both energy levels, and, eventually, a lower energy level is fully populated. Next, the cell is 'depolarised' by shifting the electrons in the lower energy level back to their original position using lower wavelength radiofrequency (RF) power. The energy required to repopulate this energy level varies with the ambient magnetic field, according a principle called the 'Zeeman effect'. Therefore, the frequency of the depolarising RF power corresponds to the magnetic field value. Caesium magnetometers offer high sensitivity (0.001nT) at very high sample frequencies (>30Hz).

For high-precision surveys, two or three magnetometers are towed in a fixed geometric shape. The sensor outputs are compared and a value for the magnetic gradient can be calculated. This enables the user to locate the target in 2D. By using a third sensor, vertical distance can also be calculated.



When properly used, especially in combination with side-scan sonars, sub-bottom profilers and bathymetric systems, the magnetometer can be a useful tool for all kinds of detection surveys.

Marine Magnetometers 2009	
General	
Company	Geometrics
Product	G-882 Marine Magnetometer
Year of development	2004
Sensor specifications	
Type of sensor (caesium, Overhauser, potassium, proton)	Caesium vapor
Is the sensor a gradiometer? (Y/N)	Single sensor, can be configured as gradiometer or multi-sensor array
Absolute accuracy (nT)	2 (note that this has little relevance to actual marine surveys)
Resolution (nT)	0.001
Operating range (nT)	18,000–90,000
Gradient tolerance (nT/m)	5,000
Sensitivity (nT)	0.004/rtHz RMS
Sample rate (Hz)	40
External trigger possibility (Y/N)	Y
Operating temperature (°C)	–35 to +50
Power requirements	10W @ 24VDC
Limits of geographic operating zones	All directions worldwide, except due N-S at equator
Direction of sensitivity	Heading error less than 0.15nT over 360° spin
Towfish specifications	
Fish dimensions	Body diameter 2.75in (7cm), 4.5ft (1.37m) long with fin assembly (11in cross width)
Weight in air, water (kg)	18kg – including sensor and electronics and 1 main weight
Depth range	4,000psi
Towfish mounting (towed, fixed mount, other)	Nose or CG tow
Power requirements	24–32VDC, 500mA (1A on start up, 2 min)
Towcable specifications	
Type	Kevlar, 6 conductor, steel coax with telemetry
Maximum length	300m standard, 800m with voltage sense supply, 6km with telemetry
Breaking strength	3,600lb
Diameter (mm)	12.2
Weight in air, water	52kg/300m, 20kg/300m
Is cable termination field replaceable? (Y/N)	Y
Data storage and output	
Is visual read-out available? (Y/N)	Y, with data-logging software
Analog output	N
Digital output (Y/N)	Y
Supported digital data formats	Multiple
Software	
Data-aquisition/processing package	MagLog Lite, MagMap2000 (Free), MagPick (Free)
Integration options	
ROV (Y/N)	Y
Side-scan sonar (Y/N)	Y
Sub-bottom profiler (Y/N)	Y
Single-beam echosounder (Y/N)	Y
Depth sensor (Y/N)	Y
Heading sensor (Y/N)	Y
Typical applications	Search for pipelines, power/telecommunication cables, unexploded ordnance (UXO), wrecks, treasure, oil/gas and mineral exploration surveys, infrastructure, hazards, degaussing station surveys, geophysical research

			
IXSEA	IXSEA	IXSEA	JW Fishers Mfg
Magis 300	Magis 2000	Gradiomagis	Proton 4 magnetometer
2007	2008	2007	2005
Magnetic nuclear resonance	Magnetic nuclear resonance	Magnetic nuclear resonance	Proton
N	N	Y	N
0.5	0.5	0.5	2
0.01	0.01	0.01	1
25,000–75,000	25,000–75,000	25,000–75,000	
Unlimited	Unlimited	Unlimited	
0,004	0,004	0,01	1
10	10	10	0.5
N	N	N	N
–20 to +40	–20 to +40	–20 to +40	0 to +70
24VDC	24VDC	24VDC	24VDC
None	None	None	
Omnidirectional	Omnidirectional	Omnidirectional	360°
L: 1,840mm; tube D: 155mm; overall D: 457mm	L: 2,022mm; tube D: 174mm; overall D: 503mm	L: 2,058mm; D: 1,456mm; Hmax: 1,132mm	120cm × 10cm diameter
36.8, 2	68.8, 8	64, 8	25, 12
300m	2,000m	300m	150m
Towed	Towed	Towed	Towed
20W rms, 45W peak	60W rms, 105W peak	30W rms, 112W rms	24VDC
Kevlar/polyurethane	Kevlar/polyurethane	Kevlar/polyurethane	Polypropylene
2,000m		2,000m	300m
>2,000daN	>2,000daN	>2,000daN	250kg
12.6 ± 1.20	12.6 ± 1.20	12.6 ± 1.20	15
191kg/km, 66kg/km	191kg/km, 66kg/km	191kg/km, 66kg/km	0.3kg/m, 0kg/m
N	N	N	N
Y	Y	Y	Y
N	N	N	N
Ethernet	Ethernet	Ethernet	Y
xtf, ASCII	xtf, ASCII	xtf, ASCII	RS232
Magis software, Delph Mag Locator	Magis software, Delph Mag Locator	Magis software, Delph Mag Locator	Fishers Tracker II software
N	N	N	N
Y	Y	Y	N
Y	Y	Y	N
Option	Option	Included	N
Included	Included	Included	Y
Option	Option	Included	N
Geological, route, debris and site surveys	Geological, route, debris and site surveys	Small objects search; debris and route surveys	Locating sunken vessels, vehicles, pipelines, anchors, shipwrecks, dredge heads, etc.



Marine Magnetometers 2009			
General			
Company	Marine Magnetics	Marine Magnetics	Marine Magnetics
Product	Explorer	SeaQuest	SeaSPY
Year of development	2003	2002	1998
Sensor specifications			
Type of sensor (caesium, Overhauser, potassium, proton)	Overhauser	Overhauser	Overhauser
Is the sensor a gradiometer? (Y/N)	Can be configured as one	Y	Can be configured as one
Absolute accuracy (nT)	0.1	0.1	0.1
Resolution (nT)	0.001	0.001	0.001
Operating range (nT)	18,000–120,000	18,000–120,000	18,000–120,000
Gradient tolerance (nT/m)	10,000	10,000	10,000
Sensitivity (nT)	0.02	0.01	0.01
Sample rate (Hz)	0.1–4	0.2–4	0.1–4
External trigger possibility (Y/N)	Y	Y	Y
Operating temperature (°C)	–40 to +60	–40 to +60	–40
Power requirements	2W	2W per sensor, up to four sensors	3W
Limits of geographic operating zones	None	None	None, worldwide
Direction of sensitivity	Not affected. No dead zones	Not affected. No dead zones	Not affected. No dead zones
Towfish specifications			
Fish dimensions	86cm x 6cm diameter	1.5m span, 0.5m height, 1.5m length	124cm x 12cm diameter
Weight in air, water (kg)	3	56, 22, buoyant with float attachment	16
Depth range	1,000m	1,000m	Different models: 300m, 1,000m, 3,000m, 6,000m
Towfish mounting (towed, fixed mount, other)	Towed	Towed	Towed
Power requirements	2W total system	Up to 10W with four sensors and altimeter	3W total system
Towcable specifications			
Type	Kevlar	Vectran	Vectran
Maximum length	250m	1,000m	1,000m; up to 10,000m with other cables
Breaking strength	2,500kg	2,500kg	2,500kg
Diameter (mm)	10	10	10
Weight in air, water	34g/m	44g/m	44g/m
Is cable termination field replaceable? (Y/N)	Y	Y	Y
Data storage and output			
Is visual read-out available? (Y/N)	Y	Y	Y
Analog output	N	N	N
Digital output (Y/N)	Y	Y	Y
Supported digital data formats	ASCII (raw) output, Geosoft XYZ	ASCII (raw) output, Geosoft XYZ	ASCII (raw) output, Geosoft XYZ
Software			
Data-aquisition/processing package	SeaLINK	SeaLINK	SeaLINK
Integration options			
ROV (Y/N)	Y	Y	Y
Side-scan sonar (Y/N)	Y	Y	Y
Sub-bottom profiler (Y/N)	Y	Y	Y
Single-beam echosounder (Y/N)	N	Y	Y
Depth sensor (Y/N)	Y	Y	Y
Heading sensor (Y/N)	N	Y	N
Typical applications	Oil/mineral exploration, geophysical research, archaeology, wreck detection, object detection, UXO clearance. Explorer is designed for small boats and inshore surveys where the small size is a great advantage	SeaQuest is designed for detection of small magnetic targets, excelling at UXO search. It is effective at defining small anomalies with high resolution, and suppressing sources of cultural noise, such as geology	Oil/mineral exploration, geophysical research, archaeology, wreck detection, object detection, UXO clearance. A versatile system that can be deployed in small inshore vessels or large bluewater survey ships

	
Marine Magnetics	Planet Electronics Ltd
Sentinel	MX500 Digital Magnetometer
2000	2005
Overhauser	Proton
N	Uses two tow-fish for gradiometer
0.1	1
0.001	1
18,000–120,000	25,000–65,000
10,000	
0.01	1
1/min to 2Hz	0.5
Y	N
-40 to +60	N/A
1W	24VDC
None	None, worldwide
Not affected. No dead zones	Omidirectional
124cm x 12cm diameter	86cm x 31cm
16, 4	12
1,000m	70m
Fixed on tripod, base station	Towed
1W	24VDC
No tow cable	Polyurathane sheath with integral Kevlar braid
	150m
	800kg
	7.75
	84kg/km, 36kg/km
	Y
Y	Real-time graphical display of all data on PC
N	N
Y	NMEA 183 format (RS232)
ASCII (raw) output	.DAT for 3D plotter software
SeaLINK	MXSurveyII
N	N
N	N
N	N
N	N
N	Supplied as standard
N	N
Sentinel is a base station magnetometer, designed to sit in one location and collect data that are used to correct mobile magnetometer data for diurnal variation. Using an integrated tripod, it can be deployed on land or under water at a depth of up to 1,000m	Low-cost magnetometer survey system for locating wrecks, anchors, pipelines, etc. Dual tow-fish system for reduced survey time and improved detection of small objects

Versatile and Flexible Software for all Your Survey Needs

Photo courtesy of OOF-Subsea



NaviPac

INTEGRATED NAVIGATION

- System integration
- Comprehensive survey planning
- Extensive geodetic support
- Versatile device I/O driver support
- Data collection & output
- Unlimited Helmsman displays
- USBL/LBL/INS support
- AIS integration



NaviScan

SONAR DATA ACQUISITION

- Interactive patch test calibration
- Sensor data displays
- Real-time 2D/3D DTM
- Side scan sonar imagery
- 3D sonar mosaic support
- ROV/AUV support
- Pipeline inspection & eventing

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MARINE SURVEY SOLUTIONS

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