

Acoustic Modems

We are used to using cable connections for underwater data transfer between two locations. This is the most commonly used method for long-distance transmission. However, wireless underwater data telemetry technology is currently proving capable of providing an alternative method. Acoustic modems are designed to offer a seamless interface for subsurface data transmission and are already in use in many applications.

So the technology works. But practicality is the issue in many cases where, for instance, horizontal and vertical performance is involved. A system might perform to full satisfaction in one case but a change in conditions or application may reduce performance. Optimum performance of wireless acoustic modem systems depends upon several conditions: speed of sound, water depth, existence of thermocline zones, ambient noise and seasonal change. It appears that long-term average rates of successful transmission may fall dramatically at a range of several km in the typically adverse shallow-water acoustic channel. This might be adequate for networked acoustic modems to be cost-effective in providing quantities of data typically required for data assimilative modelling of coastal oceanographic processes. However, systems equipped with message storage and handshaking-protocol technology can improve the liability and performance of the wireless data connection. Most systems are capable of being mounted on moving platforms such as AUVs, drifters, submarines, ships and buoys. These applications require multiphase Doppler correction algorithm in order to render them capable of compensating for relative movements between source and receiver. For longer-distance connections, network solutions with repeater stations are another possibility.

Hydro International is much indebted to all the manufacturers who contributed to this product survey, thus exposing their products to scrutiny. Some manufacturers, announced the launch of new data-communication products later this year. These are not included in this Product Survey. We would also like to acknowledge the assistance of Paul van Walree of TNO, who helped prepare the survey. ■

Company Name	Aquatec
Name of Product	AQUAmodem
Year of initial development	1998
General Specifications	
L/W/H (cm)	From 24.2cm long x 16.5cm diameter (external power)
Housing material	Anodised Aluminium 6082 standard, other materials to suit application
Weight in air (kg)	From 5kg (external power)
Weight in water (kg)	Appr. 1.5kg (external power)
Operating power voltage	10V to 20V standard or to application
Transmit mode power consumption (W)	20W typical
Receive mode power consumption (W)	600mW
Sleep mode power consumption (W)	5mW (low power acoustic wakeup mode)
Max deployment depth (m)	1000m standard, or according to housing
Operating temperature range (°C)	-5°C - 40°C
Max battery lifetime	According to pack, wakeup and transmit cycle
Acoustics	
Source level (dB re 1µPa@1m)	185 dB re 1µPa@1m typical
Transducer beam width (deg)	Hemispherical as illustrated, others according to application
Max working range in sea water (m)	Up to 10km, according to acoustic path
Operating frequency range (Hz)	8-12kHz as illustrated, 20-27kHz and 55-65kHz alternatives
Signal Processing	
Data link modulation type (e.g. PSK, FSK, OFDM, DSSS)	DSSS or MFSK
Raw data rate (bit/s)	1000
User data rate (bit/s) (user data divided by the total transmit time, taking into account channel estimation, training, coding, etc.)	300
Bit error rate	Typically 1e-6
Minimum required SNR (dB)	6dB
Doppler tolerance (relative velocity in m/s)	10m/s
Maximum channel delay spread (ms)	Depends on operating mode
Other specifications	
Type of dataformat	NMEA-0183 style ASCII, ASCII, Binary, or customer agreed
Interfacing (eg RS232)	RS232 or USB
Half duplex or full duplex?	Half duplex
Is the performance specified for a vertical link, horizontal link, or ...?	Vertical, Horizontal, Shallow water reverberant
Multiplexing capability available?	Customised functions / processing available at customers request
Can the subsea modem be powered from other source?	Y
What data storage capabilities?	1GB SD Card
What processing features are available?	Customised functions / processing available at customers request
Are repeater functions available?	Y
Does the system provide range information?	Y
Ranging accuracy (m)	< 1m
Does the subsea modem have release functionality?	No, but can be used to trigger an external release
Does the system support network capability?	Y
Can the system be used for covert communications?	N
What is the typical application for your system (max 30 words)	This system may be used in vertical applications, but has been optimised for acoustically difficult environments, including shallow water reverberant conditions and long range Arctic under-ice communication.

N/A Not Applicable
 □ No information received



develogic GmbH	EvoLogics GmbH	EvoLogics GmbH
Digital Hydroacoustic Modem with Multi-Node Capability HAM.NODE	Hydroacoustic Modem S2C M 7/17 H	Hydroacoustic Modem S2C M 18/34
2000	2005	2005
Electronics: 110mm diameter, 145mm height	54 x 13cm	25 x 12cm without batteries, 40 x 12cm with internal accumulators
Seawater resistant aluminium, hard anodized and PTFE coated (standard). Titanium, super duplex steel and synthetics housings available upon request.	Titanium, stainless steel or aluminium on request	Aluminium alloy, stainless steel or titanium on request
12kg w/o batteries (standard aluminium housing)	□	□
4kg w/o batteries	□	□
5...36VDC (below 11V receiver only)	24VDC (12VDC option)	24VDC (12VDC option)
Up to 500W peak, 30-80W typical	Adjustable 10...100W	Adjustable 10...100W
< 3W	200-800mW	200-800mW
< 1mW	8mW	8mW
1200m standard aluminium housing, 6000m with deep rated composite aluminium housing, 9000m with deep rated titanium or super duplex steel housing.	250m (6,000m optional)	200m (2000m opt.)
-5° - 40°C	-10°C - 40°C	-10°C - 40°C
Typically >1-2 years, depending on mission scenario and battery configuration	On request	9Ah, others on request
Depending on transducer choice	Up to 191dB, adjustable	Up to 194 dB, adjustable
Omnidirectional beam, toroidal beam or directional beam, depending on transducer choice.	Hemispherical	Horizontally omnidirectional
>25,000m with ITC 2002a transducer	8,000m	3,500m
Depending on transducer, from 3-6kHz up to 40-75kHz.	48,000Hz - 78,000Hz	18,000Hz - 34,000Hz
OFDM-MDPSK, DF-Equalizing; (OFDM: Orthogonal Frequency Division Multiplexing, MDPSK: M-ary Differential Phase Shift Keying)	S2C	S2C
Depending on transducer choice, channel characteristics and parameterization up to 32 kbit/s with high frequency wideband transducer.	Up to 6,500 bit/s	14,000 bit/s
150 bit/s up to >>10 kbit/s, depending on channel characteristics and carrier bandwidth	Ca. 3,500 bit/s, range dependent, self-adaptive	Ca. 8,000 bit/s, range dependent, self-adaptive
Depending on channel characteristics, operation mode (uni- or bidirectional) and error correction mode.	Less than 10e-7	Less than 10e-7
4dB	-3dB	-5dB
Two-phase Doppler compensation for relative movements up to ± 12m/s, incl. long and short period movements with acceleration up to 1g	More than 2m/s	More than 3m/s
Inapplicable due to equalizing and cyclic pre-/postfixing	No restrictions	No restrictions
Transparent or telegram based	Any	Any
RS232/RS422 (selectable), optionally up to 4 additional interfaces	RS232 and Ethernet, others on request	RS232 and Ethernet
Time division duplexing	Half duplex	Half duplex
Doppler tolerance is specified for both, shallow water and near vertical channels, specified maximum data rates are applicable for near vertical channels (see above), decreasing with distance and shallow water/horizontal channels.	Horizontal and vertical link	Horizontal and vertical link
Y	N/A	N/A
Optional power sources: Primary batteries (internal or external); Rechargeable batteries (internal or external); External power supply	Y	Y
SD card (up to 4GB) also usable for user data	1Mbyte	1Mbyte
Data compression/other processing available upon request	FEC, data packet management, up to 8 internal data channels, distance and velocity measurement, USBL opt, Signal integrity and multipath structure diagnosis.	FEC, data packet management, distance and velocity measurement, USBL opt, Signal integrity and multipath structure diagnosis.
Y	Y	Y
Runtime based ranging available, precision ranging optionally available	Y	Y
Depending on environment	1m	1m
Y, mechanical release interface available as option	N	N
Y, up to 15 nodes in bidirectional mode	Y	Y
Y	Y	Y
Digital wireless data transmission between seafloor sensor systems and surface buoys; ; Communication and data transmission to and from research vessels and autonomous underwater vehicles; Wireless underwater networks.	Deep sea, AUV, offshore industry, tsunami-warning systems, hydrography etc.	AUV, offshore industry, hydrography etc.



Company Name	EvoLogics GmbH	L-3 Communications ELAC Nautik GmbH	Sonardyne
Name of Product	Hydroacoustic Modem S2C M 48/78	Digital Underwater Modem UM 30	uCOMM Omni MF
Year of initial development	2005	2005	2006
General Specifications			
L/W/H (cm)	25 x 13 cm without batteries, 40 x 13 cm with internal accumulators	Diameter 151mm; length 541mm (without transducer)	500mm x 95mm OD (incl. batt.)
Housing material	Aluminium alloy, stainless steel or titanium on request	Stainless steel (other materials e.g. titan on request)	Aluminium Alloy or Titanium
Weight in air (kg)	□	Approx. 16kg	5kg (Al version)
Weight in water (kg)	□	Approx. 6.3kg	2.1kg (Al version)
Operating power voltage	24VDC (12VDC option)	24VDC	18 - 50VDC input range
Transmit mode power consumption (W)	Adjustable 10...100W	100W	<50 Watts
Receive mode power consumption (W)	200-800mW	3W	1W
Sleep mode power consumption (W)	8mW	10mWatts	0.030W
Max deployment depth (m)	250m (2000m opt.)	Depending on selected transducer; UM 30: 6000m with titan housing	3000m or 7000m
Operating temperature range (°C)	-10 / 40	0...+55°C	-5 +40 °C
Max battery lifetime	9Ah, others on request	No internal battery, ext. power required	Battery dependent (30 days min)
Acoustics			
Source level (dB re 1µPa@1m)	Up to 194 dB, adjustable	Depending on selected transducer, here TSE7 185 dB µPa	188dB
Transducer beam width (deg)	Horizontally omnidirectional	Omni	240°
Max working range in sea water (m)	2,000m	DEPENDING ON TRANSDUCER	3
Operating frequency range (Hz)	48,000Hz - 78,000Hz	LF: 12 ± 2kHz; HF: 30 ± 5kHz	19-36kHz
Signal Processing			
Data link modulation type (e.g. PSK, FSK, OFDM, DSSS)	S2C	MFSK	QPSK
Raw data rate (bit/s)	Up to 28,000 bit/s	LF: 1536 bit/s; HF: 3840 bit/s	1,500 - 15,000bit/s
User data rate (bit/s) (user data divided by the total transmit time, taking into account channel estimation, training, coding, etc.)	Ca. 15,000 bit/s, range dependent, self-adaptive	LF: 1536 bit/s; HF: 3840 bit/s	>600 to >10,000bit/s
Bit error rate	Less than 10e-8	10 e-4	<10e-9
Minimum required SNR (dB)	-7dB	10dB	10dB
Doppler tolerance (relative velocity in m/s)	More than 3m/s	15m/s	5m/s
Maximum channel delay spread (ms)	No restrictions	N/A	N/A
Other specifications			
Type of dataformat	Any	ELAC proprietary	ASCII or Binary
Interfacing (eg RS232)	RS232 and Ethernet	RS232	RS232 / 485
Half duplex or full duplex?	Half duplex	Half duplex	Full-duplex
Is the performance specified for a vertical link, horizontal link, or ...?	Horizontal and vertical link	Horizontal link	Environment dependent
Multiplexing capability available?	N/A	N	On request
Can the subsea modem be powered from other source?	Y	Y	Y
What data storage capabilities?	1Mbyte	No internal data-storage capabilities	256kbytes
What processing features are available?	FEC, data packet management, up to 8 internal data channels, distance and velocity measurement, USBL opt, Signal integrity and multipath structure diagnosis.	Several data coding schemes	N/A
Are repeater functions available?	Y	N	On request
Does the system provide range information?	Y	N	Y
Ranging accuracy (m)	1m	N/A	0.01m
Does the subsea modem have release functionality?	N	N	On request
Does the system support network capability?	Y	N	Y can address multiple instruments
Can the system be used for covert communications?	Y	N	On request
What is the typical application for your system (max 30 words)			
	High-speed data and video image transmission, AUV, offshore industry, hydrography etc.	Data exchange between two host computers using 2 x UM30 or 1 x UM30 + ELAC underwater comms system UT3000	Real-time recovery of data from internal or external sensors; (pressure, temperature, current, sound velocity, heading, attitude etc); Sonardyne can provide integrated systems with positioning & telemetry functionality.



Sonardyne	Sonardyne	Wireless Fibre Systems Ltd	Wireless Fibre Systems Ltd
uCOMM Dir MF	uCOMM Dir LMF	S1510 Radio Modem	S5510 Broadband Data Link
2006	2006	2006	2006
510mm x 95mm OD (incl. batt.)	585mmx183mm OD (incl. batt.)	Modem 31.5cm x 31.5cm x 20cm Antenna 50cm x 50cm x 3cm	Modem 31.5cmx31.5cmx20cm Antenna 20cmx20cmx2cm
Aluminium Alloy or Titanium	Aluminium Alloy or Titanium	Metal or plastic	Metal or plastic
6.5kg (Al version)	11kg (Al version)	9kg	3kg
3.1kg (Al version)	6kg (Al version)	1kg	0.5kg
18 - 50VDC input range	18 - 50VDC input range	24Vdc	12Vdc
<50 W	<50 W	2.4W	4.2W
1W	1W	1W	1W
0.030W	0.030W	6mW	6mW
3000m or 7000m	3000m or 7000m	4,000m	4,000m
-5°C - +40°C	-5°C - +40°C	- 10°C - + 35°C	- 10°C - + 35°C
Battery dependent (30 days min)	Battery dependent (30 days min)	2 years in listening mode	2 years in listening mode
193dB	196dB	N/A - This system is electromagnetic	N/A - Electromagnetic Technology
+/-50°	+/-25°	N/A	N/A
5	7000	N/A	N/A
19-36kHz	14-22kHz	N/A	N/A
QPSK	QPSK	Any	All
1,500 - 15,000bit/s	1,500 - 15,000bit/s	25 to 16,000 Bits/s	□
>600 to >10,000bit/s	>600 to >10,000bit/s	□	□
<10e-9	<10e-9	Very low	1 to 100Mbits/s
10dB	10dB	N/A	N/A
5m/s	5m/s	Very high	Very high
N/A	N/A	□	□
ASCII or Binary	ASCII or Binary	Analogue or digital	Analogue or Digital
RS232 / 485	RS232 / 485	RS232	RS232
Full-duplex	Full-duplex	Both	Y
Environment dependent	Environment dependent	Both	□
On request	On request	256 channels	Both
Y	Y	Y	Y
256kbytes	256kbytes	Can be incorporated	Y
N/A	N/A	Can be tailored	Can be added
On request	On request	Y	Can be tailored
Y	Y	N/A	Y
0.01m	0.01m	N/A	N
On request	On request	N/A	N/A
Y can address multiple instruments	Y can address multiple instruments	Y	N
On request	On request	Y	Both
□	□	Transfer of data through water, through water/air boundary. Can be used for diver comms, instrumentation comms & control and real time control of AUVs or actuators. Use in Environmental Monitoring, Oceanography, Oil & Gas exploration and Harbour Security.	Broadband data harvesting by UUVs from underwater data loggers, Data transfer from AUVs to mother ship, AUV docking.

