Navigation sous-marine
Partie IV : Exemples de capteurs

FISE Semestre 5 HYO / UE 5.1

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Date : Septembre 2020 v0.1.2

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E. Exemples de capteurs

E.1. Avertissement

Le document présente quelques exemples de capteurs utilisables en positionnement et en navigation sous-marine à travers des plaquettes constructeurs.

Cela permet d'avoir une idée des différents types de capteurs et de la façon dont leurs performances sont spécifiées.

EN AUCUN CAS, cela ne doit être considéré comme une recommandation sur le choix d'un capteur ou une quelconque préférence de l'auteur.

E.2. Exemple de sources de référence temporelle

Ce sont des horloges qui se synchronise sur le temps GNSS et simulent en absence de satellites la référence de temps (sous forme de signal PPS et trame ZDA) via un oscillateur OCXO.

GPS1300-10-1000

- **Sub-miniature smd GPS disciplined 10.000MHz frequency standard; Sine wave and 1PPS LVCMOS outputs**
- **MTIE Stratum 1 compliance; theoretically approaching the 1 x 10^{-12} long term accuracy of the GPS caesium standard**
- **Excellent holdover from integrated precision ovened oscillator with very low phase noise**
- **Military, industrial and commercial applications in synchronization and timing**

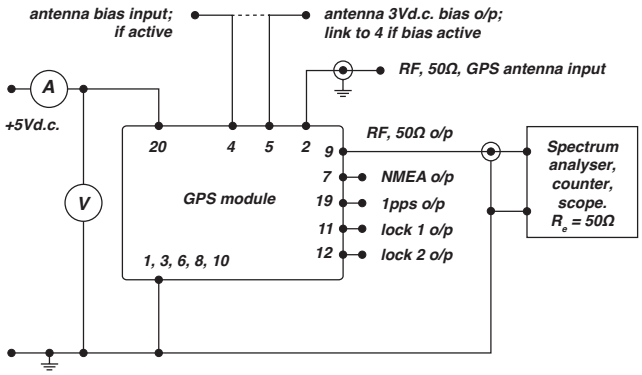
The GPS1300 sets a new benchmark for miniature smd frequency standards. The combination of regulation through the aquisition of GPS data, the storage of control levels, miniature size and integrated OCXO provides a component level module for incorporation into OEM equipment.

Disciplined from satellite data the module exibits near Caesium standard accuracy and excellent holdover accuracy, during periods of GPS unavailability, from its integral low phase noise OCXO.

Available as a 10.000MHz precision reference standard the module may also be supplied to custom frequencies and specifications together with a range of internal oscillator performance variations and supply options.

Applications will include instrument calibration, system synchronisation, portable reference units, telecommuncation base stations and extreme timing accuracy.

Test circuit:



Lock detect status levels; LVCMOS:

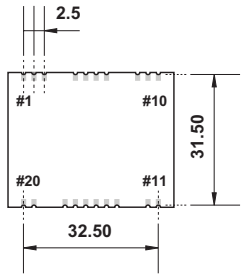
Levels will alternate at 8Hz for the first 4 seconds after turn on or when GPS receiver is not operational

lock 1	***lock2***	
Low	*Low*	*No signal being received*
High	*Low*	*GPS detect*
Low	*High*	*GPS lock*
High	*High*	*Reference Lock*

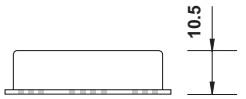
1 pps output level LVCMOS

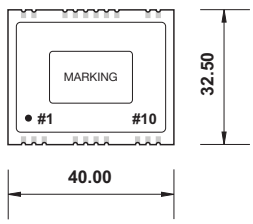
Development conducted with active GPS antenna, gain (+25 ±2)dBm including cable

Dimensions(mm):



pads viewed from bottom
pad size (2.0 x 1.5)mm
pads are electroless gold

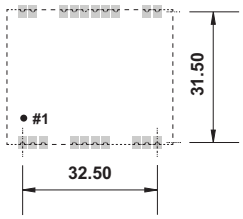




connections

# 1	ground
# 2	antenna
# 3	ground
# 4	antenna bias (if active)
# 5	antenna bias supply output; 3Vd.c., if active link to # 4
# 6	ground
# 7	NMEA (3V CMOS RS232)
# 8	ground
# 9	r.f. output 10MHz 50Ω
# 10	ground
# 11	lock 1
# 12	lock 2
# 13	N/C factory use only
# 14	N/C factory use only
# 15	N/C factory use only
# 16	N/C factory use only
# 17	N/C factory use only
# 18	N/C factory use only
# 19	1 pps (LVCMOS)
# 20	V_{cc}

suggested land pattern
land pad size (3.0 x 2.0)mm



hand soldering recommended

July 3rd 2014

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OCXO performance - GPS disciplined

During periods of lock the GPS1300 module provides r.f. output accuracy approaching the satellite on-board Caesium standards. Initial lock can be achieved within 15 minutes maximum dependent upon satellite availability. The lock condition is indicated by the status of the lock 1 and lock 2 outputs.

Performance during periods of GPS lock:

r.f. output	*10.000MHz, sine wave*
long term stability	*theoretically approaching the 1×10^{-12} long term accuracy of the GPS caesium standard (Δt = 24 hours)*
short term stability	*1×10^{-11} (Δt = 1 sec)*
phase noise*:	
single sideband	*130dBc/Hz, f_o +10Hz*
1Hz bandwidth	*150dBc/Hz, f_o +100Hz*
	160dBc/Hz, f_o +1kHz
	170dBc/Hz, f_o+10kHz

****phase noise is identical to that of the internal precision OCXO except during periods of frequency correction which cause a phase shift and therefore degradation of phase noise performance.***

1PPS accuracy	*±50ns*

OCXO performance - holdover

After initial warm up and GPS lock, and if lock is subsequently lost, the GPS1300 module provides r.f. output accuracy from the previously disciplined internal precision OCXO. The retention and application of the discipline data allows the OCXO set accuracy to be maintained and r.f. output is then a function of the OCXO performance. A fast return to disciplined performance is assured when satellite data is again available.

Performance during holdover:

r.f. output	*10.000MHz, sine wave*
holdover stability	*±0.02ppm max.(-40+70)°C, after 30 days continuous operation*
short term ageing	*±2 x 10^{-10} max. per day after 30 days continuous operation*
long term ageing	*±0.05ppm max. per year after 30 days continuous operation*
against V_{cc} change	*±0.002ppm max. for V_{cc} ±5%*
phase noise:	
single sideband	*130dBc/Hz, f_o +10Hz*
1Hz bandwidth	*150dBc/Hz, f_o +100Hz*
	160dBc/Hz, f_o +1kHz
	170dBc/Hz, f_o+10kHz

Generic specification:

power supplies:	
supply voltage	*+5Vd.c., custom options available*
start up current	*450mA max. -40°C*
quiescent current	*250mA max. +25°C*
output level	*Sine wave; +10dBm ±3dBm, 50Ω, CMOS o/p as custom option*
harmonics	*<-25dBc*
spurious	*<-90dBc*
PPS output	*1 PPS LVCMOS*
lock 1 levels	*LVCMOS*
lock 2 levels	*LVCMOS*
NMEA	*LVCMOS RS232 data stream*
OCXO warm up time	*5 minutes max. to within ±0.1ppm of nominal*
insulation resistance	*500MegΩ min., 100Vd.c.*
operating temperature	*(-40 +70)°C, custom options available*
storage temperature	*(-40 +125)°C*
marking	*part number, frequency, date code, serial number*

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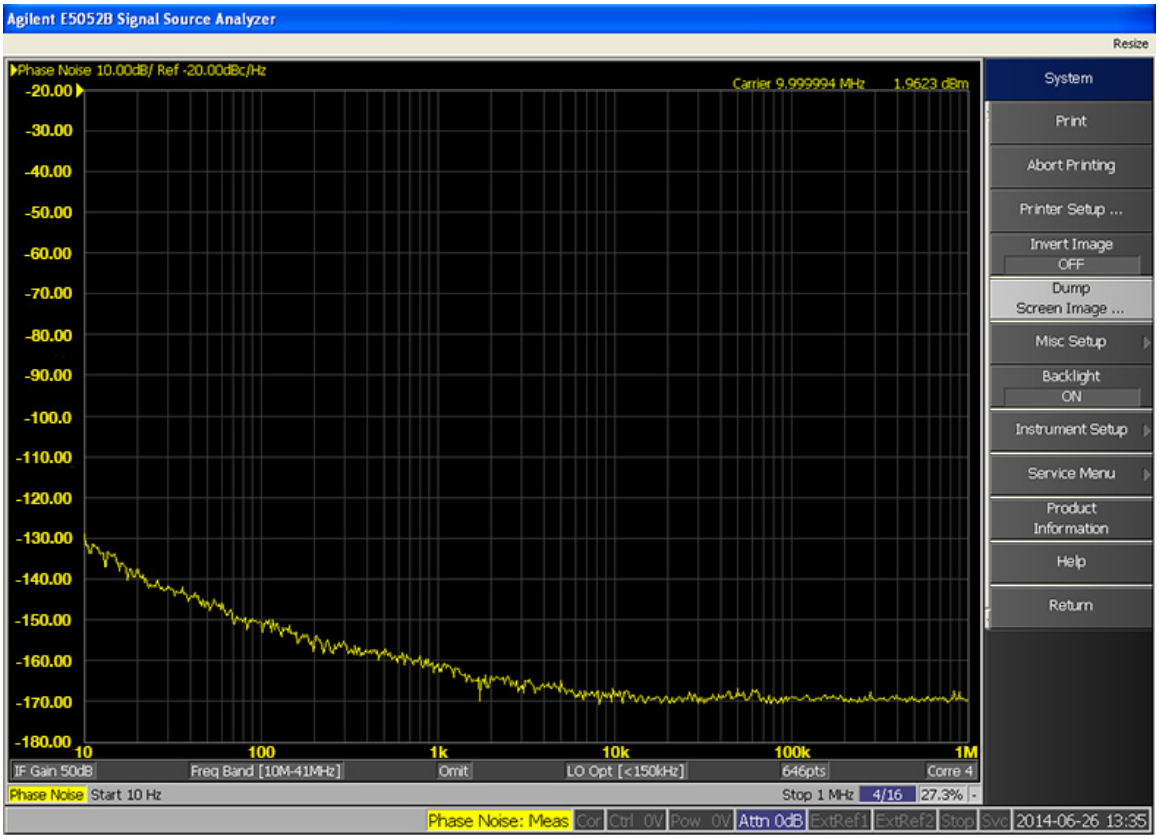
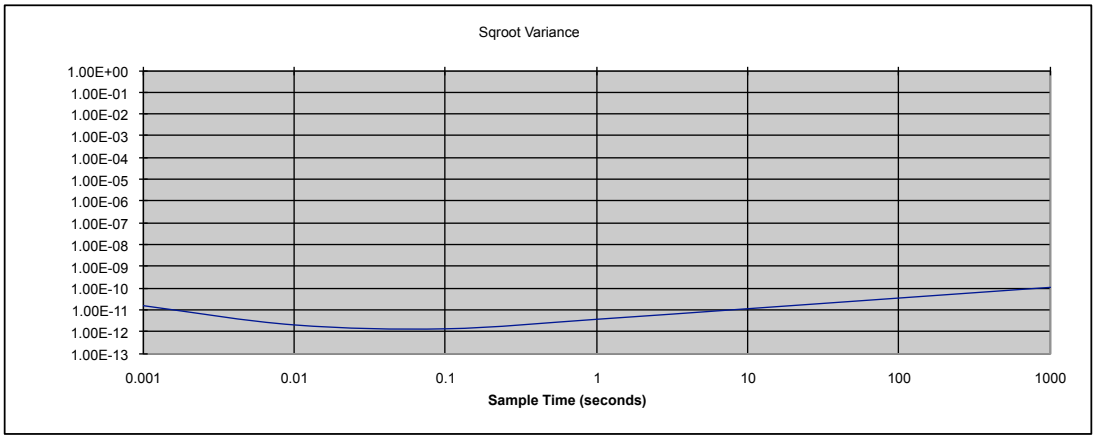
Typical 10.000MHz internal OCXO phase noise performance



Allan Variance calculation from typical internal OCXO phase noise



Ref: David W. Allen, "Time and Frequency (Time-Domain) Characterization, Estimation, and Prediction of Precision Clocks and Oscillators"

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E.3. Exemple de centrales inertielles

E.3.1. Centrale inertielle de technologie MEMS de classe “navigation” SBG Ekinox 2

Exemple d’une centrale inertielle moderne de technologie MEMS, qui similaire à celle que possède l’ENSTA Bretagne (la seule différence est que celle de l’école est étanche jusqu’à 300 m.

Ekinox 2 Series

Brings robust and cost-effective MEMS to the Tactical Grade

Ekinox Series is a product range of high accuracy inertial systems. It has been designed to bring robust, maintenance free, and cost-effective MEMS to the tactical grade. Thanks to a drastic selection of high end MEMS sensors, an advanced calibration procedure, and powerful algorithm design, the Ekinox 2 Series achieves 0.02° attitude accuracy.

- High Performance Inertial Systems
- ITAR Free
- Cost-effective & Robust MEMS technology
- Maintenance Free

KEY FEATURES

- Up to 4 connected equipment
- Survey Grade GNSS receiver (Ekinox2-D)
- 8 GB Data Logger
- IP68 Enclosure
- Web Interface & Ethernet
- 200 Hz Output Rate

Accuracy

3D ORIENTATION

Roll, Pitch	0.03° 0.02° 0.015°	GNSS aiding RTK aiding Post-Processing
Heading	0.08° 0.05° 0.03°	Dual Antenna GNSS (baseline < 2 m) Dual Antenna GNSS (baseline < 4 m) Post-Processing

POSITION

Single Point L1/L2	1.2 m	
SBAS	0.6 m	
DGPS	0.4 m	
RTK	0.02 m	
RTK 30s Outage	3 m	Marine conditions
RTK 60s Outage	0.2% TD 3 m	Marine conditions, DVL* aided Automotive mode - With odometer
PPK**	0.02 m	3 m

HEAVE

Real-time	5 cm or 5%	Whichever is greater, velocity aided
Wave period	0 to 20 s	Auto-adjusting
Delayed	2.5 cm or 2.5%	Whichever is greater, velocity aided
Wave period	0 to 40 s	

** Depends on DVL performance. - TD: Travelled Distance.- Typical RMS values*
***Post-processing Kinematic*

Specifications

Preliminary

SENSORS PERFORMANCE

	Accelerometers		Gyroscopes
	A2	**A3**	
Measurement range	8 g	14 g	300 °/s
Random walk	7 µg/√Hz	30 µg/√Hz	0.14°/√Hz
Bias in-run instability	2 µg	5 µg	< 0.5 °/hour

INTERFACE

Aiding Sensors	2x GNSS, RTCM, DVL, Odometer, Gyro-compass
Protocols	Output: NMEA, ASCII, Binary, TSS, Simrad Input: NMEA, Trimble, Novatel, Septentrio, Hemisphere, Veripos, Fugro, PD0, PD6
Output Rate	1 to 200 Hz
Logging Capacity	8 GB or 48h @ 200 Hz
Serial RS-232/422	Model D - 2 outputs / 4 inputs Model A/E - 3 outputs / 5 inputs
CAN	1 CAN 2.0 A/B bus up to 1 Mbit/s
Pulses	Inputs: PPS, Event marker up to 1 kHz Outputs: SyncOut, Trigger 5 inputs / 2 outputs
Ethernet	Full Duplex (10/100 Base T)

ENVIRONMENTAL SPECIFICATIONS

Operating Vibrations	20 Hz to 2 kHz as per MIL-STD-810G Accelerometer 8 g: 3 g RMS Accelerometer 14 g: 8 g RMS
IP Rating	IP68
Operating Temperature	-40 to 75°C / -40 to 167°F
MTBF	50,000 hours

PHYSICAL CHARACTERISTICS

	Ekinox2-A/E	Ekinox2-D
GPS	-	L1/L2 Single or Dual Antenna GNSS receiver
Weight	400 grams 0.88 pounds	600 grams 1.32 pounds
Dimensions (L x W x H)	10 x 8.6 x 5.8 cm 3.9 x 3.4 x 2.2 ”	10 x 8.6 x 7.5 cm 3.9 x 3.4 x 2.9 “
Power Consumption	< 3 W	< 6 W
Supply Voltage	9 to 36 VDC	9 to 36 VDC

PRODUCT CODE INS

▪ *standard product options*

EKINOX2-#-G4A#-####

MODEL
A: AHRS
E: INS
D: INS with internal GNSS

GYROSCOPES
4: 300 °/s ▪

ACCELEROMETERS
2: 8 g
3: 14 g

Other ranges available upon request

GNSS OPTIONS

Typical RMS values. All specifications subject to change without notice.

E.3.2. Centrale inertielle de technologie FOG de classe “navigation” iXblue PHINS

Phins

FOG-based high-performance inertial navigation system

Phins is an inertial navigation system providing position, true heading, attitude, speed, depth and heave. Its high-accuracy inertial measurement unit is based on iXblue's fiber-optic gyroscope technology coupled with an embedded digital signal processor that runs an advanced Kalman filter.

FEATURES

- All-in-one high-accuracy 3D positioning with heading, roll and pitch
- FOG, unique strap-down technology
- Multiple aiding available:
  (DVL, EM log, GPS, USBL, LBL and depth sensor)
- Compact, light and reliable
- Ethernet, web server (GUI)

APPLICATIONS

Highly demanding civil or defense surface vessels or autonomous underwater vehicles

BENEFITS

- High grade INS performance
- High reliability and maintenance free
- Ease of use and quick installation
- Perfectly silent
- Small power consumption
- Low latency
- Small power consumption

2017-03-DS-Phins

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iXblue

TECHNICAL SPECIFICATIONS

Performance

Position accuracy	
With GPS	Three times better than GPS
With USBL / LBL (subsea applications)	Three times better than USBL / LBL
With DVL	0.1% of traveled distance (CEP 50)
No aiding for 2 min / 5 min	3 m / 20 m (CEP 50)
Pure inertial mode	0.6 nm / hour (CEP 50)
Heading accuracy	
With GPS / USBL / LBL	0.01 deg secant latitude RMS [1]
With DVL	0.02 deg secant latitude RMS [1]
Roll and pitch dynamic accuracy (no aiding)	0.01 deg RMS
Heave accuracy (Smart Heave) [2]	2.5 cm or 2.5% RMS

Operating range/environement

Operating / storage temperature	-20˚C to 55 ˚C / -40˚C to 80 ˚C
Rotation rate dynamic range	Up to 750 deg/s
Acceleration dynamic range	± 15 g
Heading / roll / pitch	0 to +360 deg / ±180 deg / ±90 deg
MTBF (observed)	100 000 hours

Physical characteristics

Dimensions (L x W x H)	180 x 180 x 162 mm
Weight in air	4.5 kg
Waterproof	IP66

Interfaces

Serial	RS422 or RS232
Ethernet	100 MBit - UDP / TCP server / TCP client / web server (GUI)
Pulse	PPS, Trigger
Inputs / outputs	Configurable 7i / 5o - Pulse [3] 4i / 2o - Configuration port
Baud rates	Up to 460 kbaud
Data output rate	0.1 Hz to 200 Hz
Power supply / consumption	24 VDC (20 - 32 V) / < 20 W

(1) Secant latitude = 1/cosine latitude
(2) Whichever is greater for periods up to 30 seconds. Smart heave is delayed by 100 s fixed value
Real-time heave accuracy is 5 cm or 5% whichever is greater for period up to 25s.
(3) Use GPS PPS pulse for accurate time synchronization of Phins

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E.4. Exemple d'accéléromètres pendulaires (PA)

E.4.1. Description de l'accéléromètre pendulaire AI-Q-2030 de la société Innalab

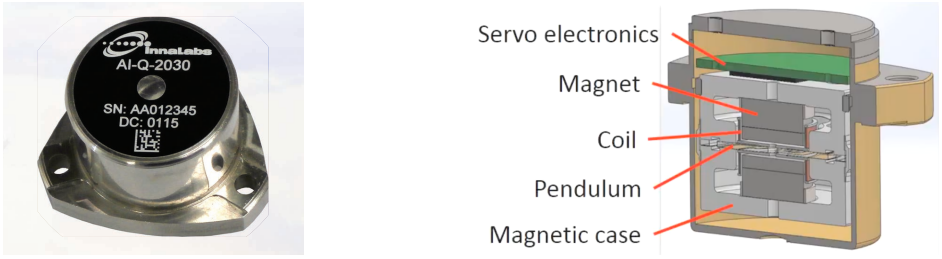


FIG. E.1. : Photographie et vue éclaté de l'accéléromètre AI-Q-2030 ([Bei+15]

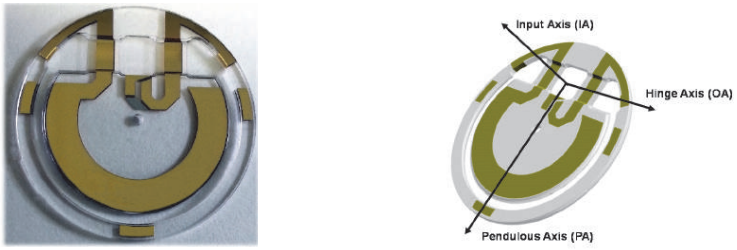


FIG. E.2. : Photographie et schéma de principe de la masse pendulaire de l'accéléromètre AI-Q-2010 (modèle voisin du AI-Q-2030) ([Bei+15]

La figure E.2 présente le principe général et une photographie de la partie sensible d'un accéléromètre pendulaire.

La masse et le système de support sont en quartz. L'axe est constitué de deux parties flexibles en haut de la photographie. La taille de l'élément est de l'ordre de 1 cm.

Le détail de la conception est décrit dans l'article [Bei+15].

La déviation d'Allan du capteur AI-Q-2010 est présenté figure E.3 et page suivante est incluse la description des performances du capteur AI-Q-2030 (dérivé du capteur AI-Q-2010.

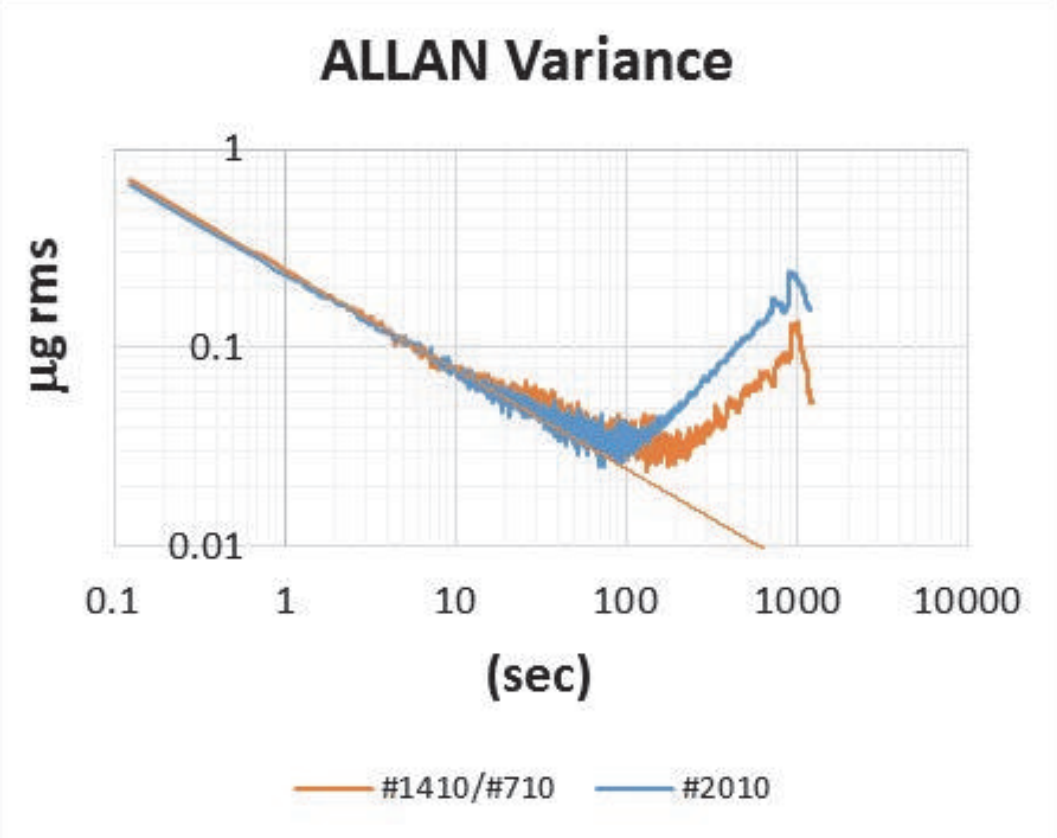


FIG. E.3. :
Déviation d'Allan de l'accéléromètre pendulaire AI-Q-2010 d'Innalab ([Bei+15])

DATASHEET

AI-Q-2030

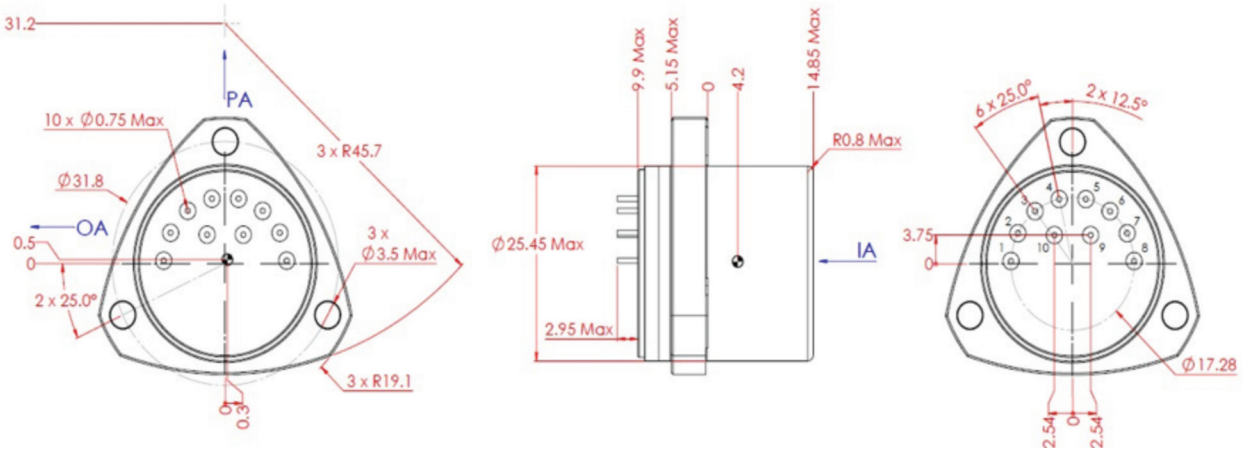
ANALOGUE OUTPUT ACCELEROMETER

Ideal for Marine Inertial Navigational Systems
The AI-Q-2030 is built with Quartz Flexure technology to deliver accurate navigational grade performance. With an enhanced bias stability, improved scale factor and greater axis misalignment, the AI-Q-2030 is a perfect fit for Marine Inertial Navigation Systems and many other demanding Marine Applications.

AI-Q-2030

Key Performance Features
- High input range
- Analogue current output
- Compact, rugged design
- High stability under temperature changes
- High reliability
- Internal temperature sensor for thermal compensation
- Dual built-self test

Accelerometer Dimensions (mm)



AI-Q-2030

ANALOGUE OUTPUT ACCELEROMETER

SPECIFICATION

Parameter	Unit	Value
Input Range	g	±60
Bias	mg	<4
One-year Composite Repeatability	µg	<160
Temperature Sensitivity	µg/°C	<30
Scale Factor	mA/g	1.2 to 1.46
One-year Composite Repeatability	ppm	<310
Temperature Sensitivity	ppm/°C	<180
Axis Misalignment	µrad	<2000
One-year Composite Repeatability	µrad	<100
Vibration Rectification	$\mu g/g^2$	<20 (50-500 Hz) <60 (500-2000 Hz)
Intrinsic Noise	μg_{RMS}	<7 (0-10 Hz) <70 (10-500 Hz) <1500 (500-10000 Hz)
Operating Temperature	°C	-55 to +95
Shock	g	250
Vibration Peak Sine	g, Hz	15g @ 20 to 2000 Hz
Resolution/Threshold	µg	<1
Bandwidth	Hz	>300
Temperature Model		Yes
Quiescent Current per Supply	mA	<16
Quiescent Power @ ±15VDC	mW	<480
Electrical interface		Temp Sensor Voltage Self Test Current Self Test Power/Signal Ground -10 V_{DC} Output +10 V_{DC} Output
Input Voltage	V_{DC}	±13 to ±28
Weight	g	71 ±4
Diameter below mounting surface	mm	Ø 25.45 Max
Height – bottom to mounting surface	mm	14.85 Max
Case Material		300 Series Stainless Steel

Revision History

1.0 - Document Format Change (21 August 2017)

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E.5. Exemple d'accéléromètres à poutre vibrante (RBA)

Documentation d'un accéléromètre à poutre vibrante.

L'accéléromètre présenté page suivante est le RBA500 de la société Honeywell.

Cet accéléromètre est d'une gamme inférieure aux accéléromètres pendulaires, plutôt pour la catégorie "tactique" des systèmes inertiels.

Accelerex® RBA500 Accelerometer

Digitally-compatible frequency output sensor

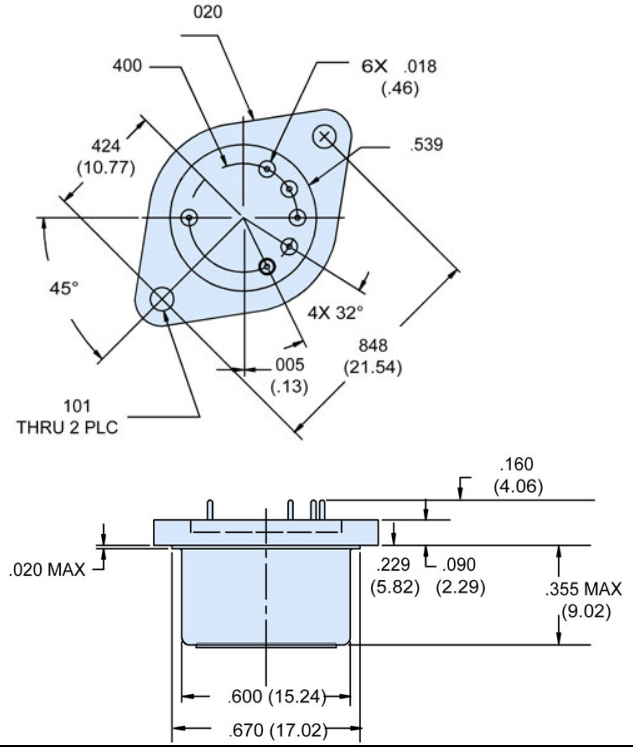
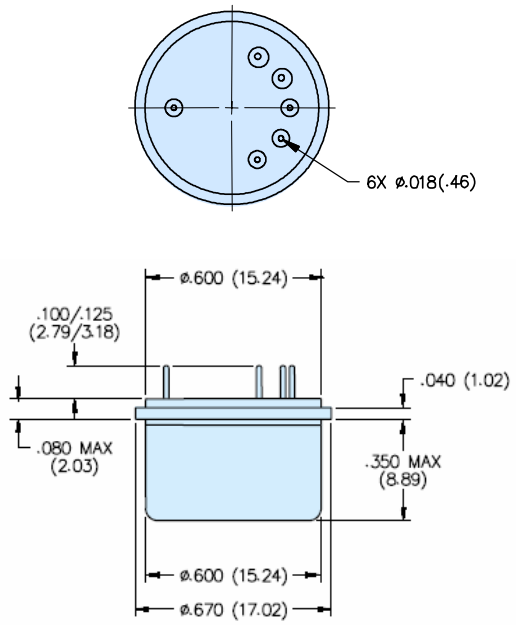
For a frequency output sensor, Honeywell produces the Accelerex RBA500 accelerometer. It is primarily used to supplement GPS navigation systems. It is a good choice where frequency output, high-g, small size, low power, and light weight are necessary.

The acceleration is measured as a function of the frequency difference between two vibrating quartz beams. The output of the Accelerex accelerometer is also thermally compensated through the use of an internal temperature sensor and Honeywell-supplied coefficients; when integrated over time, delta Velocity is directly provided to the user's system.

Features

- Frequency output for direct interface to digital electronics
- Low price
- High-g capability
- Very compact design
- Integral 2 fastener mounting flange
- Low power consumption
- Hermetically sealed case
- Internal temperature sensor for thermal compensation
- Robust design and quality assurance provides superior reliability.

Configuration Drawings

RBA500 with Flange	RBA500 without Flange
	

Performance Characteristics

Additional product specifications, outline drawings and block diagrams, and test data are available on request.

Performance	
Input range	±70 g
Bias	
- One year repeatability	<4 mg
Scale Factor	80 Hz/g
- One year repeatability	<450 ppm
Axis misalignment	<12 mrad
- One year repeatability	<400 µrad
Resolution/Threshold	<1 µg
Bandwidth	>400 Hz
Environmental	
Operating temperature range	-55 to +105°C
Shock	250 g
Vibration	20g, peak, DC-2000 Hz
Electrical	
Input voltage	+14 to +16 VDC
Current	<5 mA
Power	<75 mW @ +15 VDC
Physical	
Weight	12 grams
Size	0.80 in. dia. x 0.42 in. high
Case material	Stainless Steel

ISO-9001 Certification Since 1995

Find out more:
www.inertialsensor.com

Defense & Space Redmond

Honeywell International, Inc.
MAIL ADDRESS: P.O. Box 97001
15001 N.E. 36th Street
Redmond, Washington 98073-9701
PHONE: 888 206 1667
FAX: 425 883 2104
www.honeywell.com

EXP030, August 2005

Honeywell

E.6. Exemple d'accéléromètres MEMS

Extrait de la documentation technique d'un accéléromètre MEMS

gemini™

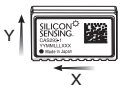
Dual-Axis Accelerometer

CAS290 Technical Datasheet

SILICON SENSING®

www.siliconsensing.com

Actual size



Features

- Small (10.4 x 6.7 x 2.7mm)
- Excellent bias repeatability over temperature
- Dual-axis MEMS accelerometer in a hermetically sealed ceramic LCC surface mount package for temperature and humidity resistance
- Five dynamic range options; ±0.85g, ±2.5g, ±10g, ±30g, ±96g
- Analogue and digital (SPI®) outputs for linear acceleration and temperature
- Wide bandwidth (typically 170Hz digital, 250Hz analogue)
- Temperature range -40 to +125°C
- Low power consumption (3mA Typ) from a 3.3V supply
- Integral temperature sensor
- RoHS compliant

Applications

- Aerospace and industrial
- Aircraft AHRS and controls
- Platform stabilisation
- Drilling guidance
- Surveying and mapping
- Land and marine navigation
- Transportation
- Inertial measurement units
- Levelling and tilt sensing

1 General Description

Gemini™ is a new family of integrated MEMS accelerometers from Silicon Sensing, providing high performance dual-axis linear acceleration measurement in a small surface mounted package. It comprises a dual-axis MEMS sensing device with a dedicated control ASIC in a single ceramic LCC package. Sensor data is output via analogue and digital (SPI®) interfaces. The CAS290 series of parts are the orthogonal version of the CAS200 (flat) package.

The CAS290 series of parts provides two in-plane axes of linear acceleration sensing and is available in five different dynamic ranges:

- ±0.85g - CAS291
- ±2.5g - CAS292
- ±10g - CAS293
- ±30g - CAS294
- ±96g - CAS295

CAS290 is supplied as a PCBA surface mountable standard LCC ceramic packaged device, which is hermetically sealed providing full environmental protection.

Precise linear acceleration sensing is achieved by a Silicon MEMS detector forming an orthogonal pair of sprung masses. Each mass provides the moving plate of a variable capacitance formed by an array of interlaced 'fingers'. This structure also provides critical damping to prevent resonant gain. Linear acceleration results in a change of capacitance which is measured by demodulation of the square wave excitation.

3 Specification

Unless otherwise specified the following specification values assume Vdd = 3.15 to 3.45V over the temperature range -40 to +125°C.

3.1 Digital Output Specification

Parameter	CAS291	CAS292	CAS293	CAS294	CAS295	Notes
Dynamic range	±0.85g	±2.5g	±10g	±30g	±96g	–
Scale factor	33,500lsb/g	11,000lsb/g	2,800lsb/g	1,050lsb/g	300lsb/g	Nominal (non-ratiometric)
Scale factor error at +25°C	±1%	±1%	±1%	±1%	±1%	–
Scale factor variation over temperature	±1.2%	±1.2%	±1.2%	±1.2%	±1.2%	-40°C to +125°C normalised to 25°C
Scale factor stability (one year)	±1,000ppm	±1,000ppm	±1,000ppm	±1,000ppm	±1,000ppm	Max change over one year
Scale factor non-linearity	0.5% FSR	0.5% FSR	2% FSR	2% FSR	2% FSR	Max error from best fit straight line over the full range
Bias setting error at +25°C	±335lsb	±110lsb	±28lsb	±30lsb	±30lsb	Uncompensated (see note 1)
Bias run to run variation at +25°C	±0.35mg	±0.75mg	±0.75mg	±3.0mg	±8.0mg	–
Bias stability (one year)	±7.5mg	±7.5mg	±7.5mg	±25mg	±75mg	Max change over one year
Bias variation over temperature	±50mg	±50mg	±50mg	±150mg	±500mg	-40°C to +125°C normalised to 25°C
Resolution/threshold @1Hz	0.03mg	0.10mg	0.10mg	0.30mg	1.0mg	With over-sampling techniques
Noise spectral density	≤50µg/√Hz	≤150µg/√Hz	≤150µg/√Hz	≤350µg/√Hz	≤1,200µg/√Hz	Typical
Bandwidth	>170Hz	>170Hz	>170Hz	>170Hz	>170Hz	–
Vibration rectification	0.15mg/g^2 @ 0.5g$_{rms}$	0.15mg/g^2 @ 2.0g$_{rms}$	0.15mg/g^2 @ 8.0g$_{rms}$	0.1mg/g^2 @ 12g$_{rms}$	0.1mg/g^2 @ 12g$_{rms}$	Bias change under applied random vibration 20Hz to 2kHz

Note 1:

The bias setting error is a fixed offset, set with 3.3V applied to the device. This bias may change for other applied voltages and can be removed by external compensation.

E.7. Exemple de gyromètre (Dynamically Tuned Gyroscope (DTG)

Documentation d'un Dynamically Tuned Gyroscope. Il est dans la gamme tactique.

THE VALUE OF PERFORMANCE.

NORTHROP GRUMMAN

G-2000 Gyroscope Inertial Product Family

The Northrop Grumman G-2000 two-axis gyroscope is the smallest tactical-grade dynamically-tuned gyroscope available. The G-2000 gyro offers proven high performance, small size, excellent reliability and low cost.

The commercial-off-the-shelf G-2000 gyroscope and integrated product family are only subject to Export Administration Regulation (EAR) for export control.

Description

The G-2000 provides high accuracy for platform/gimbal stabilization and targeting applications. More than 60,000 gyros have been delivered since 1992 for use in a wide variety of military and commercial applications around the world.

The G-2000 requires control electronics and power conditioning to provide rate outputs (e.g., delta thetas). This is accomplished using a Northrop Grumman miniature Digital Gyro Control Unit (DGCU) servo card specifically designed to maximize G-2000 performance, or these can be incorporated into the host application.

Using a single input voltage source (11 to 34 Volt DC), the DGCU includes all power regulation circuitry and software needed to operate the G-2000 gyro. The DGCU offers digital RS-422 synchronous 21.6 kHz outputs.

Applications

- Downhole drilling and North-Finding
- Line-of-Sight stabilization
- Tactical missile and torpedo guidance/navigation
- Ground vehicle navigation
- Electro-optical/infrared cameras (EO/IR)
- Targeting and pointing
- Gun/turret stabilization

Advantages

The two-axis G-2000 gyroscope offers superior performance, high Mean Time Between Failure (MTBF), light weight, small volume and low operating power. The G-2000 is well-suited for high vibration and high shock environments where fiber-optic or micro-electro-mechanical gyros are unable to perform. Key advantages of the G-2000 include:

- Small size (.37 cubic inches) and light weight (<25 grams)
- Angle Random Walk of <0.005°/√hr
- Random drift of 0.02° to 0.6°/hr, 1σ
- High shock capability of 750 g's (2 µsec, 1/2 sine)
- High MTBF of 100,000 hours
- Low power consumption
- Fully qualified to MIL-spec performance
- DGCU servo card option for turnkey, enhanced performance.

	G-2000 Gyro	G-2000 with DGCU
Parameters	**Performance**	
Random Drift (in-run stability)	0.02° to 0.6°/hr, 1σ	
Angle Random Walk	<0.005°/√hr	
Threshold (Resolution)	0.0003°/sec	
Dynamic Range	±200°/sec (continuous)	
Torquer Scale Factor (TSF)	1445 ±5% °/hr/mA	
TSF Non-linearity	<200 PPM	
Gyro Axis Misalignment	0-1° (adjustable)	
G-Sensitive Drift	<±25°/hr/g (adjustable)	
G^2-Sensitive Drift	0.3°/hr/g^2	
Motor Spin Frequency	800 Hz (16,000 RPM) (adjustable)	
Pickoff (PO) Scale Factor	7.0 ±5% Vrms/°	
PO Excitation	43.2 kHz, 6.5 Vrms	
Bandwidth (-90°)	270 Hz (adjustable)	120 Hz (adjustable)
Parameters	**Characteristics**	
Dimensions	Gyro only: Length: 0.74 in (1.88 cm) Width: 0.75 in (1.91 cm) Height: 0.97 in. (2.46 cm)	DGCU only: Length: 2.1 in. (5.3 cm) Width: 1.4 in. (3.56 cm) Height: 0.4 in. (1 cm)
Weight	<25 grams (gyro only)	<15 grams (DGCU only)
Input Voltage	Start: 32 Vrms (0.5 amp) Run: 12 Vrms (0.15 amp)	11 to 34 VDC (20W for 3 sec, <4W continuous)
Start Time	<1.4 sec	3 sec
Digital Outputs Format	N/A	RS-422 synchronous
Loop Rate	N/A	21.6 kHz
Bit Rate	N/A	2.75 mbps
Latency	N/A	<200 µsec
Transmit	N/A	96 bit-frame
Parameters	**Environmental**	
Operating Temperature	-54°C to 100°C	-40°C to 85°C
Storage Temperature (non-operational)	-54°C to 100°C	

G-2000 Family of Products

G-2000 Gyro with DGCU card

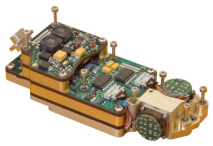
2-axis Digital Gyro Control Unit

LRS-2000

2-axis Analog Rate Sensor Assembly

LRS-2001

3-axis Digital Rate Sensor Assembly

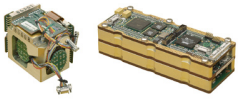


LRS-2003

2-axis Digital Rate Sensor Assembly

LR-2000

Digital Inertial Measurement Unit with micro-electro-mechanical accelerometers



For more information, please contact:

Northrop Grumman
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21240 Burbank Boulevard
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www.northropgrumman.com

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THE VALUE OF PERFORMANCE.

NORTHROP GRUMMAN

E.8. Exemple de gyromètres MEMS

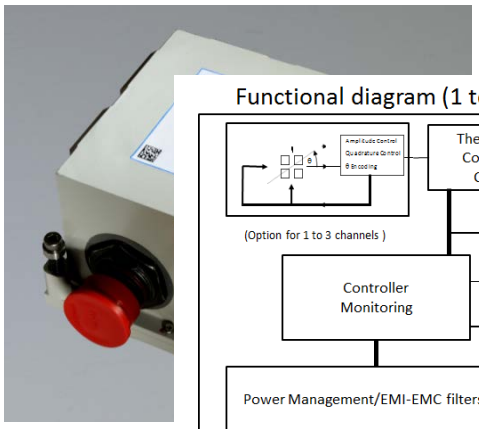
Documentation d'un gyromètre MEMS type diapason. Sa stabilité de 0.15°/m lui permet d'être dans la gamme navigation même si il n'est pas tout à fait suffisamment précis pour trouver le Nord de manière autonome.

SAFRAN

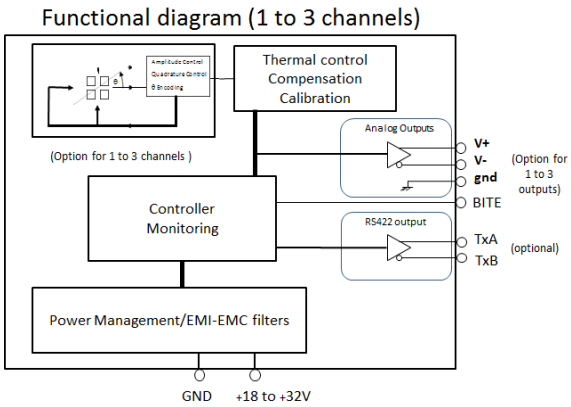
Colibrys GYRO
Gyrometer Module

GM1000Px - DATASHEET

GM1000Px Multi axis vibrating rate gyro package family:
GM1000Px is a unit family of Single (P1), Dual (P2) or Three (P3) axis vibrating gyro's housed in a common hermetic package. Each unit is factory calibrated and compensated for temperature effects to provide high accuracy differential analogue output voltages.
The units are powered by a single 0/18 to 32 Vdc supply and is equipped with EMI/EMC filters (according to Mil Std 1275E).
On request, digital outputs can be offered.
The suited low cost alternative to FOG gyros in a compact package.



Functional Block Diagram



Key features

	GM1060Px	GM1100Px	GM1120Px	GM1180Px	GM1250Px	Units
Measurement Range[1]	**+/- 60**	**+/- 100**	**+/- 120**	**+/- 180**	**+/- 250**	**°/sec**
Scale factor (Analogue output - differential):	+/- 0,166	+/- 0,100	+/- 0,083	+/- 0,055	+/- 0,040	V/°/sec
Scale factor sensitivity (- 50°C to 85°C)	2500					ppm, 1σ
Bias stability (Allan variance method) [2]	0,15					°/h
Noise: Random walk[2]: Within 0,1 to 100Hz:	 0,005 0,015					 °/√h °/sec rms
Bandwidth	>100					Hz
Power supply	18 to 32					Vdc
Consumption	P1:<3W P2:<4W P3:<5W					W typical
Temperature (operating)	-50, +85					°C
Vibration (5, 2000Hz)	Mil Std 810 Method 514.6-II					
Shock	Mil Std 810 Method 516.6-I					

(1) Any other value available on request from 30 to 250°/sec.
(2) Analogue output, 2σ.

Featured Applications (non-exhaustive)

Naval and Land weapon platforms
Unmanned Aerial vehicles (UAV's) control

Aircraft Flight Control
Fire control Systems
Tactical Training Simulators
Sights, optical and infrared line of sight
Gyro-stabilized gimbals
Naval and Land remote weapon systems
Antenna stabilization
Sonars stabilization
Ship anti-roll systems

Autonomous underwater vehicles (AUV's) control
Automotive testing
Tilting trains
Robotics

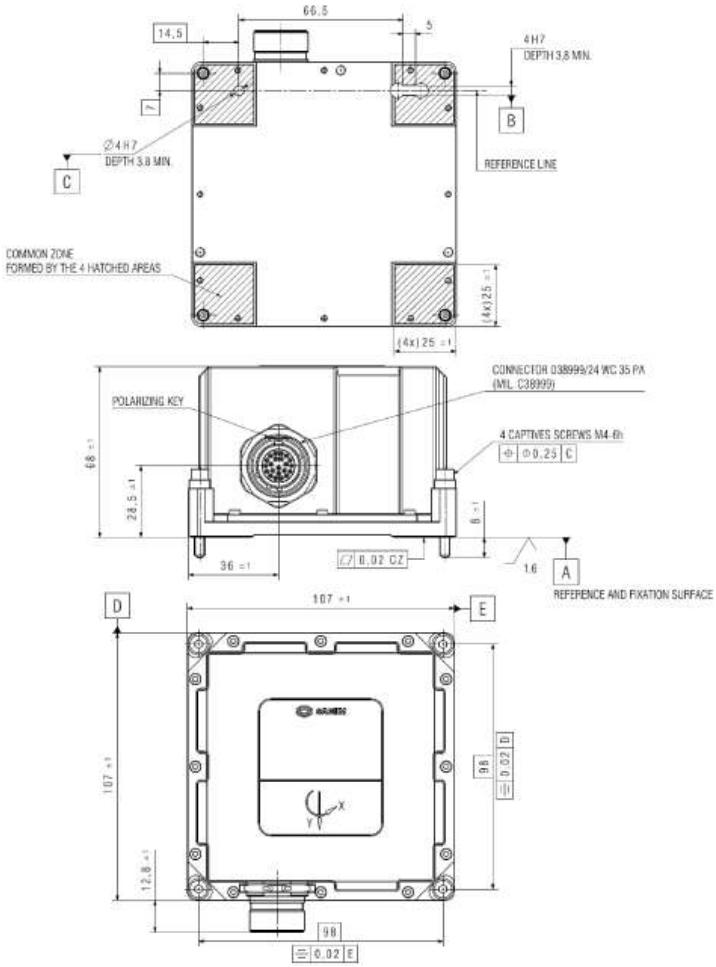
Colibrys GYRO
Gyrometer Module

The all new GM1000Px Multi Axis Vibrating Rate gyro package represents Safran Colibrys's breakthrough gyro technology enabling an ultra-low noise and exceptional Allan variance curve that has performance commensurable with much more expensive Fog gyros.

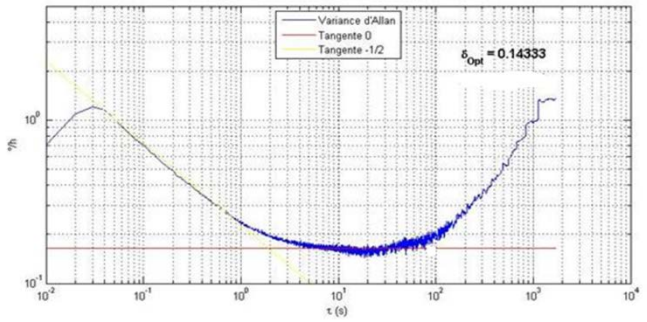
The unit is highly durable and can withstand environmental vibrations and shock typically associated with stabilisation and aerospace requirements. Its already proven operational MTBF reaches 1 000 000 hours.

The GM1000.Px is ideal when very low noise, excellent bias over temperature performance, low power consumption, light weight and rugged durability, low price are desired.

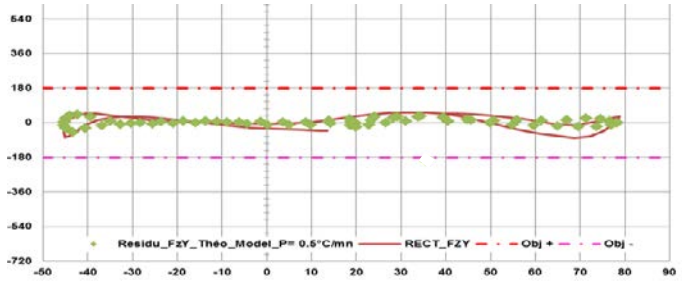
Mechanical Interface (mm)



Allan Variance Curve



Bias over temperature range



Bias (°/h)

Temperature (°C)

PIN	DESIGNATION
1	SUPPLY +18 to 32V
2	SUPPLY +18 to 32V
3	SUPPLY 0/(18 to 32V)
4	SUPPLY 0/(18 to 32V)
5	PRESENCE CHECK (option)
6	PRESENCE CHECK (option)
7	X-AXIS P (for GM1000.P1, P2 and P3)
8	X-AXIS N (for GM1000.P1, P2 and P3)
9	X AXIS SHIELD (connected to signal ground in the gyro)
10	Y-AXIS P (for GM1000.P2 and P3 only)
11	Y-AXIS N (for GM1000.P2 and P3 only)
12	Y AXIS SHIELD (connected to signal ground in the gyro)
13	NOT TO BE USED (SAGEM TEST)
14	GYRO OK (BITE)
15	NOT TO BE USED (SAGEM TEST)
16	SUPPLY SHIELD
17	MECHANICAL GROUND
18	GROUND REFERENCE FOR BITE (PIN14)
19	Z-AXIS P (for GM1000.P3 only)
20	Z-AXIS N (for GM1000.P3 only)
21	Y AXIS SHIELD (connected to signal ground in the gyro)
22	NOT TO BE USED (SAGEM TEST)

E.9. Exemple de gyromètres FOG

Documentation d'un gyromètre FOG

EMCORE-Hawkeye™ EG-1300 Lithium-Niobate Fiber Optic Gyroscope (FOG)

DATASHEET | JULY 2018 NAVIGATION SYSTEMS

Applications

- Navigational Grade Applications
- Unmanned Aerial Vehicle (UAV) Guidance
- Missile Guidance
- Aeronautics and Aviation
- Robotics

Features

- Fully-Integrated Optics and Electronics
- Advanced Optics and FPGA Electronics for Higher Accuracy, Lower Noise and Greater Efficiency
- EMCORE-Hawkeye™ FPGA-Based Closed-Loop Design for Improved Drift Stability, Higher Linearity, and Greater Flexibility
- Precise Navigation (1 mile/hour without GPS)
- Fast, Precise Gyrocompassing to 1 Milliradian
- Bandwidth to 500 Hz
- Separate Electronics and Sensor Modules
- More Economical than Competing Systems

U.S. Patent No. 7,746,476; 8,773,665; 8,798,405; 8,823,946

Suitable for Demanding Applications

EMCORE's Fiber Optic Gyroscope (FOG) technology is designed for fast, accurate navigation and gyrocompassing, and low-noise line-of-sight stabilization. Our long-standing leadership in the development of highly-accurate defense and military grade fiber optic components and systems has paved the way for the development of more accurate and economical fiber optic gyro components. EMCORE's FOGs are setting the new benchmark for tactical and navigational grade gyros for a wide variety of guidance, navigation and aeronautics applications.

The EMCORE-Hawkeye™ EG-1300 Fiber Optic Gyro features fully-integrated optics and electronics, and is a superior device in regards to weight and form-factor for navigational applications. Its advanced integrated optics and closed-loop Field Programmable Gate Array (FPGA) electronics deliver much higher accuracy, lower noise and greater efficiency than competing technologies. In addition, the EG-1300 can be calibrated internally for better thermal effect and has both digital and analog outputs, along with separation of the electronics from the FOG's sensing coil assembly to accommodate the widest variety of installation parameters.

EMCORE's EG-1300 is the clear choice when selecting a precision solid-state gyroscope component for navigational grade applications.

Performance Specifications

Parameter	EG-1300
Gyro Performance	
Fiber Optic Gyro Type	Closed-Loop
Input Rate (maximum)	±343°/sec
Bias In-Run Stability (25 °C)	Digital: ≤0.001 deg/hr, 1σ (max)
Bias (25 °C)	0.01 deg/hr
Bias vs. Temp (≤ 1 °C/min); no compensation	Digital: <5°/hr, 1σ
Noise	0.001°/√ hr
Scale Factor Non-Linearity (max rate, 25 °C)	≤50 ppm, 1σ
Scale Factor vs. Temp. (≤ 1 °C/min); with compensation	≤50 ppm, 1σ
ARW (Angle Random Walk) (25 °C)	Digital: ≤0.001°/√hr
Bandwidth (-3 dB)	Digital: 500 Hz
Electrical/Mechanical	
Initialization Time (valid data)	≤0.3 secs
Data Interface	Asynchronous Digital Output
Data Rate	30K samples/sec data rate (16 bit data)
Sensor Dimensions	3.6" D x 1.3" 91.44 mm x 33.02 mm
Electronics Dimensions	3.2" x 3.2" x 0.8" 81.2 mm x 81.2 mm x 20.3 mm
Weight, Max	**1 Axis:** 14.5 oz
Power Consumption, Max (typical)	**1 Axis:** 5.0W (1.5W)
Input Voltage	+5V

P +1 626-293-3400 E navigation-sales@emcore.com W www.emcore.com

EMCORE-Hawkeye™ EG-1300 Lithium Niobate Fiber Optic Gyroscope (FOG)

Performance Specifications (continued)

Parameter	EG-1300
Environmental	
Temperature: Operating	-40 °C to +75 °C (-40 °F to +167 °F)
Shock: Operating	250 g, 1 msec
Vibration: Operating	12 g rms 20-2000 Hz
Performance Physical	
Number of Axes	1 Axis
Housing	Anodized Aluminum
MTBF	100,000 hr

Scale Compared to U.S. Quarter

MADE IN USA

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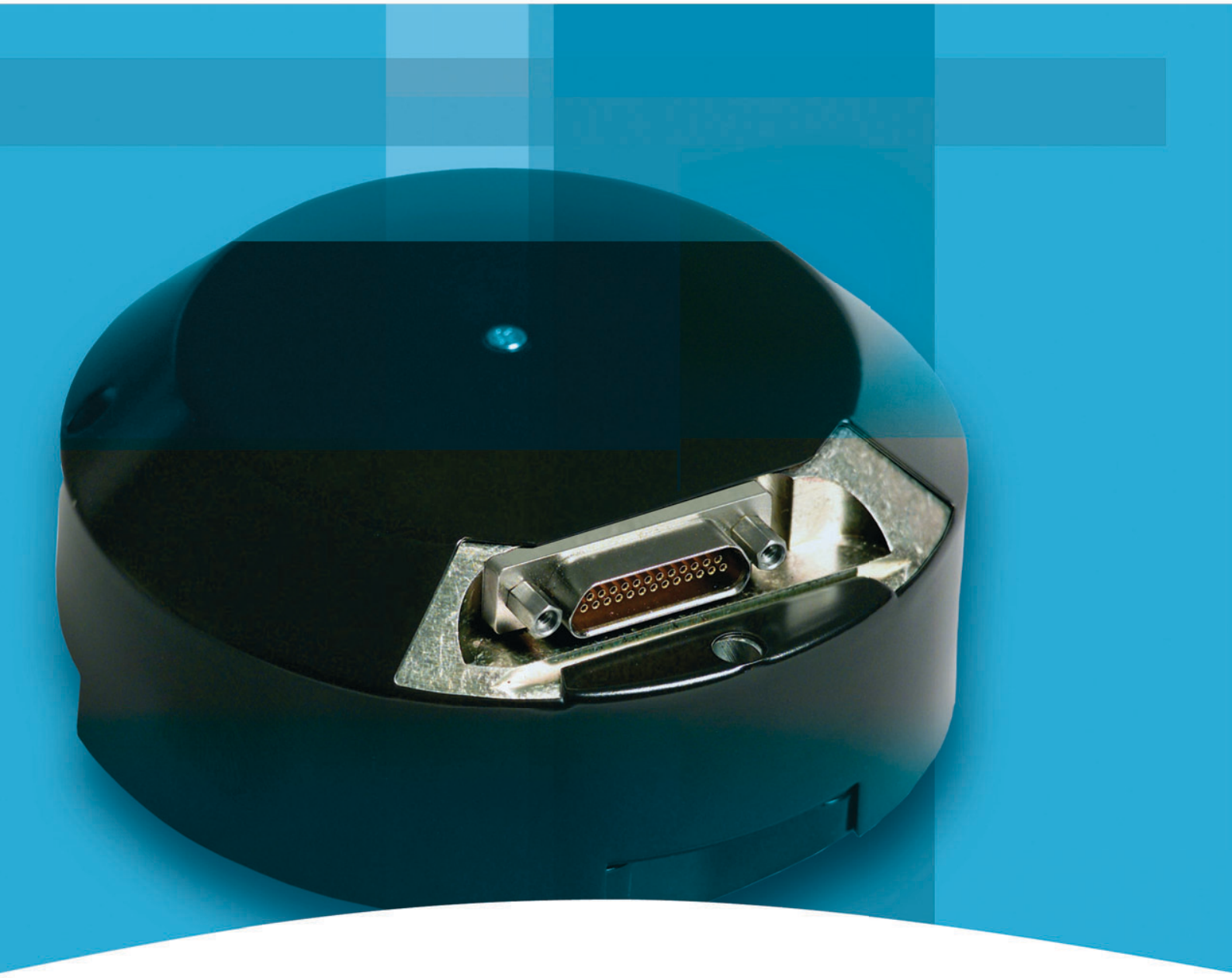
E.10. Exemple de gyromètres RLG

Documentation d'un gyromètre RLG d'application militaire

GG1320AN Digital Laser Gyro



Affordable and advanced sensing technology combined with unmatched production capabilities to meet the needs of customers throughout the world

Honeywell

GG1320AN Digital Laser Gyro

The Honeywell GG1320 Digital Laser Gyro is an affordable single axis inertial sensor with the electronics and ring laser gyro packaged into an easy to use compact unit. Its digital I/O enables integration into almost any system, which is illustrated by its use in a variety of applications including inertial navigation and platform pointing and stabilization. This industry standard navigation grade gyro benefits from Honeywell's four decades of ring laser gyro development. The result is a reliable and cost effective sensor for inertial sensing requiring accuracy and integrity.

System Specifications*

Size	Height 1.77" (4.5 cm) Diameter 3.45" (8.8 cm)	Bias Stability • 0.0035 deg/hr (typical)	
Weight	1 lb. (454 grams)	Angular Random Walk (ARW) • 0.0035 deg/root-hour (typical)	
Start-Up Time	1 second (typical)	Magnetic Environment, Operating	0.002°/hr/gauss
Shock (Op & Non-Op) (See below)	22 g, half sine, 11 millisecond	Altitude, Operating	-20,000 ft. to +80,000 ft. (-610 m to +21,336 m)
Temperature Range • -65°F to +185°F (Operating) -54°C to 85°C • -65°F to +200°F (Non-Operating) -54°C to 93.3°C		Scale Factor – Corrected • Linearity • 30-day Stability	1,164,352 ±18 pulses/rev. 5.0 ppm of full scale 5.0 ppm rms
Power	15 Vdc, 1.6 Watts nominal 5 Vdc, 0.375 Watts nominal	Sample Frequency Latency	2,000 Hz (typical use) 5,000 Hz (maximum) 168 micro-seconds
Interface	RS-422, 25 pin micro "D" Asynchronous, 1 MHz, 8 Bit	Rate Input	900 deg/ sec (maximum)

*** Please contact Honeywell for additional capabilities**

Random Vibration, Operating

Freq Range (Hz)	Level (g2/Hz)
20	0.73
40	5.27
110	5.27
390	0.002
2000	0.002

Shock

100g, ½ sin, 8 millisecond

For additional information, please contact us at:

Email: SM&MInquiries@Honeywell.com

Honeywell Aerospace
1944 E Sky Harbor Circle
Phoenix, AZ 85034
North America: 1-800-601-3099
International: 1-602-365-3099
www.honeywell.com

E.11. Exemple de pingers et transpondeurs

Extrait de la documentation de pingers et transpondeurs.

Pingers are used to mark underwater equipment or locations. They are generally about the size of a flashlight and can be attached to any mooring. The unit pings continuously when in the water. To recover a mooring, a diver or ROV is sent with a device to "listen" for, and home-in on, the pinger sound.

Transponders offer a versatile array of subsea acoustic markers for relocation, which respond when interrogated.

TELEDYNE BENTHOS
Everywhereyoulook™

PINGERS

ALP-365 is an advanced acoustic device designed for versatility in the offshore environment. Its electronics are protected by a rugged aluminum housing to insure long life under extreme conditions. Water activated.

ALP-365/EL offers all the same features and user options as the standard ALP-365 but with extended battery life. Using six 9V alkaline or lithium batteries, it can operate up to 180 days in extreme conditions. Water activated.

TRANSPONDERS

SPECIFICATIONS

Frequency	25 to 40 kHz in .5 kHz increments (user selectable)	25 to 40 kHz in .5 kHz increments (user selectable)
Acoustic Output re 1μPa@1m (Acoustic Power)	162 dB (.125W) 168 dB (.5W) 174 dB (2W) 177 dB (5W)	162 dB (.125W) 168 dB (.5W) 174 dB (2W) 177 dB (5W)
Pulse Length	4 ms	4 ms
Pulse Repetition	2 pulse/sec, 1 pulse/sec, or 1 pulse/2 sec (user selectable)	2 pulse/sec, 1 pulse/sec, or 1 pulse/2 sec (user selectable)
Housing	Aluminum	Aluminum
Weight in Air	.68 kg (1.5 lbs)	1.0 kg (2.25 lbs)
Dimensions	Length: 18.42 cm (7.25 in); Diameter 5.08 cm (2.0 in)	Length: 30.2 cm (11.88 in); Diameter 5.08 cm (2.0 in)
Power Source	Two 9V alkaline or two 9V lithium batteries. Customer supplied	Six 9V alkaline or six 9V lithium batteries. Customer supplied
Battery Life	Pulse repetition dependent. 0.125W: 20-26 days 9V alkaline; 45-60 days 9V lithium 0.5W: 10-20 days 9V alkaline; 20-45 days 9V lithium 2W: 3-10 days 9V alkaline; 6-20 days 9V lithium 5W: 1-4 days 9V alkaline; 2-8 days 9V lithium	Pulse repetition dependent. 0.125W: 60-78 days 9V alkaline; 135-180 days 9V lithium 0.5W: 30-60 days 9V alkaline; 60-135 days 9V lithium 2W: 9-30 days 9V alkaline; 18-60 days 9V lithium 5W: 3-12 days 9V alkaline; 6-24 days 9V lithium
Depth Rating	750 m (2,460 ft)	750 m (2,460 ft)
Notes		

UAT-376 is a general purpose, acoustic ranging/bearing device for underwater applications. Operating in the mid-range frequency band of 20- 35 kHz, it is designed to be used with a variety of diver, ROV/AUV, and ship-installed acoustic interrogator applications.	**UAT-376/EL** is a general purpose, acoustic ranging device for underwater applications. The stretch housing design accommodates additional batteries for longer deployments.	**DRI-267** Dive Ranger Interrogator employs advanced acoustic technology to guide users to underwater sites marked with underwater acoustic transponders. Designed primarily for divers, it can also be converted to a surface unit by using the optional ACU-266 Surface Conversion Kit. (Contact Benthos for information on ACU-266).	**ACU-266** Surface Conversion Kit allows the operator to locate and track up to 7 different transponders from the surface when coupled with the DRI-267. Includes rugged aluminum staff assembly, harness and LCD that displays even in sunlit conditions.
			
Receive: 26 kHz; Transmit: 25, 27, 28, 29, 30, 31, 32 kHz	Receive: 26 kHz; Transmit: 25, 27, 28, 29, 30, 31, 32 kHz	Receive: 25, 27, 28, 29, 30, 31, 32 kHz (user selectable) Transmit: 26 kHz	Receive: 25, 27, 28, 29, 30, 31, 32 kHz (user selectable) Transmit: 26 kHz
180 dB (8W)	180 dB (8W)	184 dB (20W)	n/a
5 ms	5 ms	5 ms	n/a
Receiver turn-around time: 20 ms from interrogation; transmit lockout time: 246 ms	Receiver turn-around time: 20ms from interrogation; transmit lockout time: 246 ms	1 pulse/sec or 1 pulse/2 sec (user selectable)	1 pulse/sec or 1 pulse/2 sec (user selectable)
Aluminum	Aluminum	PVC	ABS plastic alloy
.68 kg (1.5 lbs)	1 kg (2.25 lbs)	3.4 kg (7.5 lbs)	1.58 kg (3.5 lbs)
Length: 18.42 cm (7.25 in); Diameter: 5.08 cm (2.00 in)	Length: 30.2 cm (11.88 in); Diameter: 5.08 cm (2.00 in)	Length: 30.5 cm (12.0 in); Diameter: 11.4 cm (4.5 in)	Length: 21.6 cm (8.5 in) Width: 15.2 cm (6.0 in) Depth: 7.6 cm (3.0 in)
Two 9V alkaline or 9V lithium batteries	Six 9V alkaline batteries or 9V lithium batteries	10.8 V rechargeable NiCad battery pack	10.8 V rechargeable NiCad battery pack
Alkaline: 4 months or 150,000 replies Lithium: 8 months or 300,000 replies	Alkaline: 12 months or 450,000 replies Lithium: 24 months or 900,000 replies	12 hours per 12-hour charge	8 hours per 12-hour charge
750 m (2,460 ft)	750 m (2,460 ft)	183 m (600 ft)	n/a
		24 kHz receive frequency available	RS-232 interface at 2400 bps. LCD display has 8 user selectable contrast settings

E.12. Exemple de transpondeurs et largeurs acoustiques

Documentation d'une série de transpondeurs utilisables en base longue.

OCEANO MF - TRANSPONDERS

ACOUSTIC MF - TRANSPONDER RANGE

iXBlue provides a wide range of medium frequency transponders to operate with RAMSES (medium frequency) and GAPS USBL systems. It includes transponders for shallow water application (export free) to full ocean depth versions, reduced size for small vehicles or full size with long battery life, releasable or expendable, and optional features for easier integration.

FEATURES

- Full range of products
- Option available for user configuration
- Releasable or expendable
- Low power consumption with off-the-shelf or rechargeable batteries

BENEFITS

- Dedicated transponders for all applications
- High performance, increased flexibility
- For use as autonomous beacons or on subsea vehicles
- Long-term deployment and large ping capacity

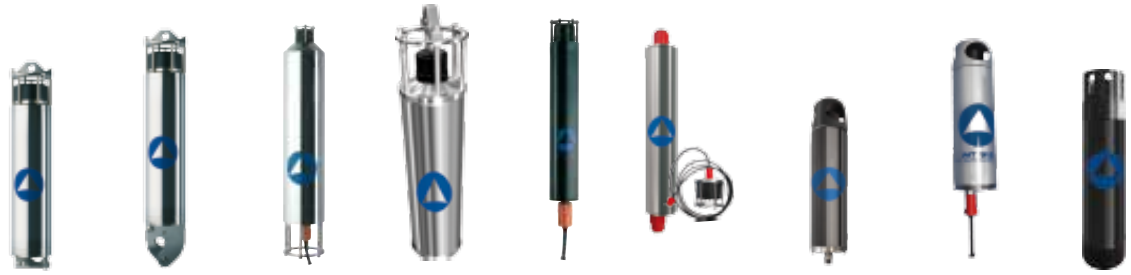
APPLICATIONS

- For use with **iXBlue**'s medium frequency positioning systems • ROV tracking
- AUV tracking • Tow fish tracking • Marine construction • Structure monitoring
- DP • Diver tracking

IXBLUE
DEEP INSIGHT. SHARPER SENSES.

OCEANO MF-TRANSPONDERS

TECHNICAL SPECIFICATIONS



Product name	RTA 2500 Light / MF	RTA 2500 Universal / MF	ET 862S-R	ETA 62S	MT 832E-R	MT 862S / HD-R	MT 912S-R	MT 932S-R	MTA02C
Depth rating (m)	6 000	6 000	6 000	6 000	3 000	6 000	1 000	3 000	300
Interrogation mode	Tone / WB	Tone / WB	Tone	Tone / WB	Tone	Tone	Tone	Tone	WB
Load characteristics (RL/SWL, tons)	0.5 / 2.5	2.5 / 2.5	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Construction (optional)	Duplex SS (titanium)	Duplex SS (titanium)	Duplex SS	Duplex SS (titanium)	Aluminium	Duplex SS	Stainless steel	Stainless steel	Composite
Weight (air, water) kg	24 / 17.5	27 / 20.7	25.5 / 16	21 / 15	2.8 / 1.2	5 / 3.5	4.4 / 2.3	5.7 / 3.8	3.9 / 1.4
Size (OD x length) mm	625 x 126	725 x 126	712 x 130	574 x 130	500 x 70	490 x 70	370 x 91	368 x 91	396 x 98

COMMON FEATURES

Operating frequency	20 - 30 kHz
Sound pressure level	191 ± 4 dB ref. 1µPa @ 1m
Receiver sensitivity	95 ± 5 dB ref. 1µPa @ 1m
Radiation pattern	Omni-directional
Signal coding	Transponder mode: Chirp - Command: secure RZ 2-state FSK

PRODUCT DESIGNATION

Product type XX	Series X	Depth X	Frequency X	Load (RL) XX	Construction X	(main) options XX / XX...
AR acoustic release	**8** tone interrogation	**1** 1 000 m	**1** LF band	**C** 500 kg	**S** stainless steel	**R** responder plug
RT recoverable transponder	**9** miniature beacon	**3** 3 000 m	**2** MF band	**B2** 2 500 kg	**G** glass	**HD** remote hydrophone
ET expendable transponder	**A** full wideband	**6** 6 000 m		**D** 5 000 kg	**T** titanium	**P** pressure sensor
MT miniature transponder					**E** aluminium	**DIR** directional transducer

Eg: OCEANO MT932S / HD-R
Miniature transponder, stainless steel, 3 000 m WD, with remote transducer head and electric plug

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E.13. Exemple de système base longue

Documentation d'un transpondeur instrumenté pour LBL.

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Datasheet

Compatt 6 – USBL/LBL Transponder and Modem

Description

The Compatt 6 transponder is fully compatible with all 6G® equipment and Sonardyne's latest 6G LBL and USBL systems.

Compatt 6 offers significant time saving using faster and more robust Sonardyne Wideband®2 acoustic ranging and telemetry protocols. This makes any system operating with Compatt 6 significantly easier to operate therefore de-risking operations, reducing vessel time and reducing training requirements for offshore personnel.

Sonardyne Wideband 2 advanced signal processing offers improved acoustic performance in challenging conditions, longer range, improved multipath rejection around structures and real-time range diagnostics for quality control. Sonardyne Wideband 2 also reduces the interference to and from adjacent Sonardyne and other acoustic positioning systems.

The integrated communications and navigation technology allows the transponder to be used as a multi-purpose modem, autonomous data logger and navigation reference transponder.

The Type 8300 Compatt 6 is the standard length version and is based on the field proven mechanics of Compatt 5 with improvements to the end cap closure mechanisms. The design offers the perfect balance between size, acoustic output and battery life. Several depth ratings are available: 3000 m, 5000 m and 7000 m, all hard anodised aluminium alloy with protective polyurethane sleeve.

Typical Applications

- Long baseline positioning
- Spool piece metrology
- Pipeline lay-down
- Subsea structure placement

Key Features

- MF frequency band utilising Sonardyne Wideband 2 ranging and telemetry protocols
- Dramatically faster and easier to set-up, calibrate and operate
- More robust performance in shallow water and reverberant environments around structures etc
- Real time diagnostics available on ranges to enable quality control
- Reduced mutual interference to further improve simultaneous ops
- Advanced multi-user / multi-vessel capability
- More than 500 unique Sonardyne Wideband 1 and 2 addresses
- Sonardyne Wideband 1 and HPR 400 navigation compatible
- Automatic power-down if not used for a programmable period
- Integrated modem mode with data rates ranging from 100 to 9000 bits per second in multiple frequency bands
- Highly reliable release mechanism
- Omni or directional transducer
- Standard sensors – temperature, pressure and MEMS inclinometer
- Optional sensors – Paroscientific DigiQuartz pressure sensor, inclinometer and sound velocity
- Battery disconnect fob allows quick battery disconnection.
- Field proven.

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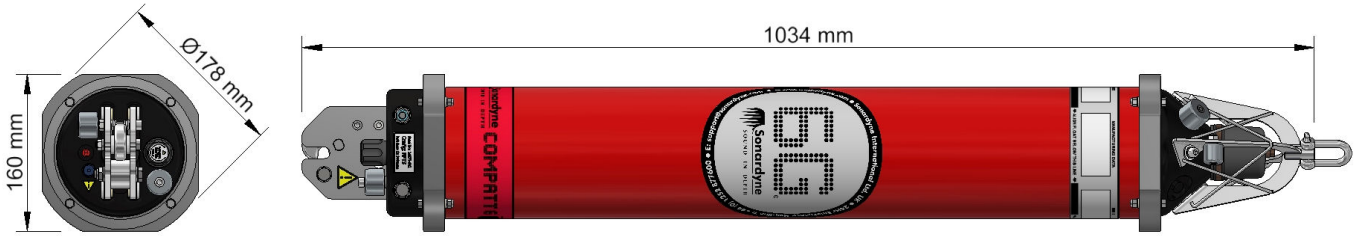
Specifications

Compatt 6 – USBL/LBL Transponder and Modem



3,000 Depth Rated MF Omni Version Shown (8300-3111)

Feature		Type 8300-3111	Type 8300-3113	Type 8300-5213
Depth Rating		3,000 metres	3,000 metres	5,000 metres
Operating Frequency		MF (19–34 kHz)	MF (19–34 kHz)	MF (19–34 kHz)
Transducer Beam Shape		Omni-directional	Directional	Directional
Transmit Source Level (dB re 1 µPa @ 1 m)		187-196 dB (4 Levels)	190-202 dB (4 Levels)	190-202 dB (4 Levels)
Tone Equivalent Energy (TEE)*		193-202 dB	196-208 dB	196-208 dB
Receive Sensitivity (dB re 1 µPa)		90-120 dB (7 Levels)	80-120 dB (7 Levels)	80-120 dB (7 Levels)
Ranging Precision		Better than 15 mm	Better than 15 mm	Better than 15 mm
Number of Unique Addresses Wideband 1 & 2		>500	>500	>500
Battery Life (Listening)	Alkaline	833 Days	833 Days	833 Days
	Lithium	1390 Days	1390 Days	1390 Days
External Power Supply		24 V	24 V	24 V
Safe Working Load (4:1)		250 kg	250 kg	250 kg
Operating Temperature		-5 to 40°C	-5 to 40°C	-5 to 40°C
Storage Temperature		-20 to 55°C	-20 to 55°C	-20 to 55°C
Maximum Dimensions (Length x Diameter)	Without Sensor Guard	1034 x 178 mm	1018 x 178 mm	1018 x 178 mm
	With Sensor Guard	1034 x 200 mm	1018 x 200 mm	1018 x 200 mm
Weight in Air/Water**		23.8/11.8 kg	27.0/14.0 kg	29.0/15.0 kg
End Cap Sensors and Options				
Temperature (±0.1°C)		Standard	Standard	Standard
Tilt Switch (±30-45°)		Standard	Standard	Standard
Strain Gauge Pressure Sensor (±0.1%)		Standard	Standard	Standard
High Precision Strain Gauge (±0.01%) Presens or Keller		Optional	Optional	Optional
Paroscientific DigiQuartz Pressure Sensor 1350 m, 2000 m, 4130 m, 6800 m (±0.01%)		Optional	Optional	Optional
Inclinometer (Tilt sensor) Range ±90°, Accuracy: ±1°		Standard	Standard	Standard
High Accuracy Inclinometer Range: ±90°, Accuracy: ±0.05° over 0 - ±15°; ±0.2° over 0 - ±45°		Optional	Optional	Optional
Sound Velocity Sensor ±0.02 m/s accuracy under calibration conditions		Optional	Optional	Optional
Release Mechanism		Standard	Standard	Standard
Power for External Sensors		Standard	Standard	Standard
Gyro Input		Standard	Standard	Standard

*TEE – WBv2+ signals are 4x the duration of Sonardyne tone signals (WBv1 & WBv2 are 2x). The TEE figure shows the operational performance when comparing wideband and tone systems.

**Estimated Weights.

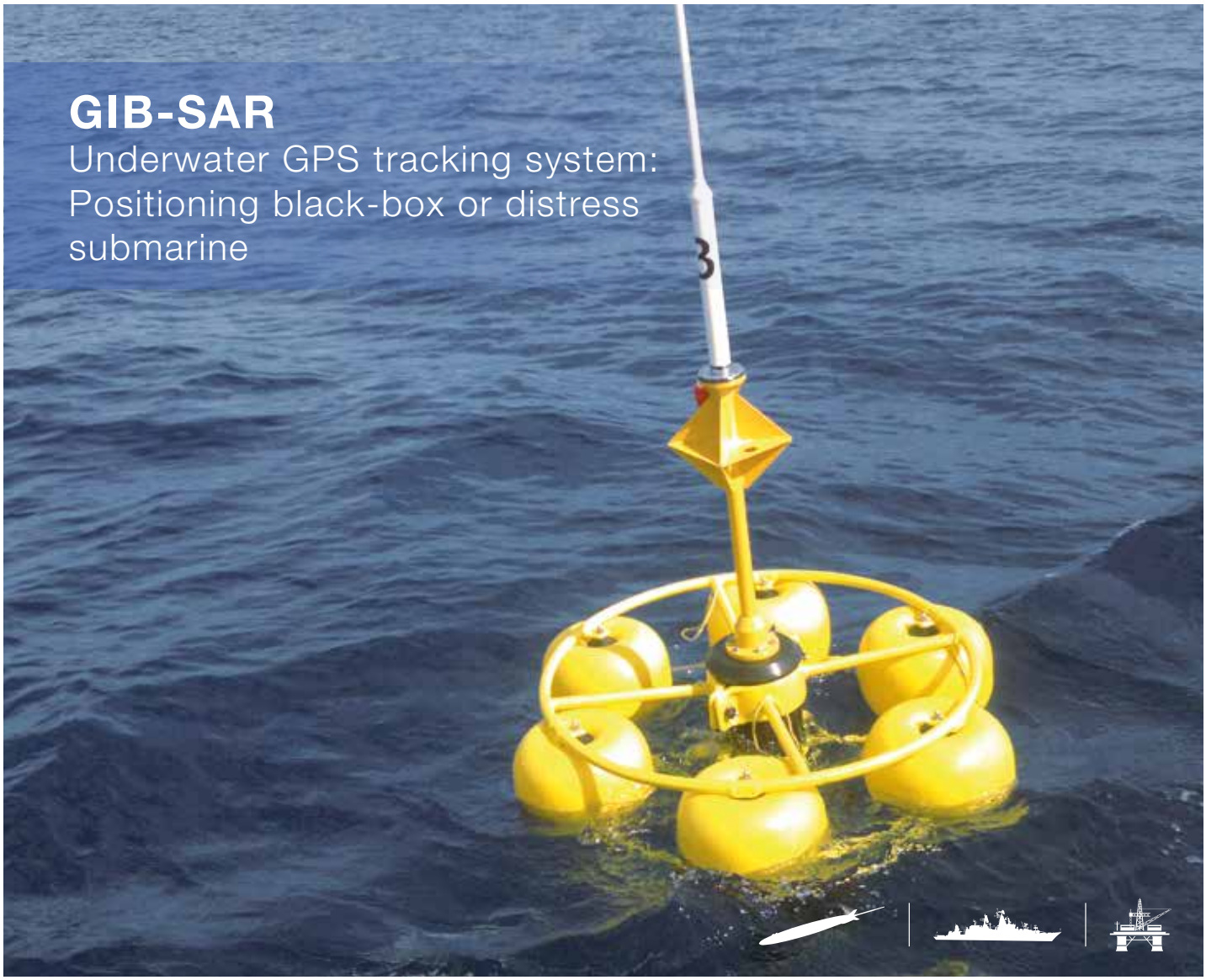
COMPANY WITH QUALITY SYSTEM CERTIFIED BY DNV GL = ISO 9001 =

E.14. Exemple de système base longue inversée

Documentation d'un système base longue inversée type "GIB"

ALSEAMAR
ALCEN

innovation & services at sea



GIB-SAR

Underwater GPS tracking system: Positioning black-box or distress submarine

By combining 4 buoys and a deck unit which can be installed either on a small boat or on large vessel, ALSEAMAR has designed an accurate positioning system that is very easy to deploy and perfectly fitted for underwater positioning in shallow as in deep water, even with rough sea conditions.

KEY BENEFITS

- Real-time 3D tracking in longitude & latitude in D-GPS mode with a metric accuracy & depth
- Very wide tracking area: up to 2Nm x 2Nm
- Fast installation and deployment (< 1h)
- No calibration
- High repetition rate and real-time Quality Control
- Long autonomy (many days)

GENERAL PRINCIPLE

In order to save time, navies consider as a major key of success to accurately localize DISSUB prior to MOSHIP arrival on site.

Based on ALSEAMAR's expertise in fast aircraft's black boxes relocation, ALSEAMAR proposes a suite of equipment flown to the accident site to be operated by a 3 men scout team.

ALSEAMAR equipment can be deployed from a fast patrol boat or any ship of opportunity mobilized in the nearest harbor.

Within few hours upon arrival on the search area, DISSUB is localized in longitude and latitude with a metric accuracy, DISSUB's depth is then measured using an echo-sounder.

Further a portable underwater telephone is used to communicate with the DISSUB's crew for information exchanges, relayed to SUBOPAUTH in real time.

Upon arrival on site, MOSHIP enters in dynamic positioning mode right above the DISSUB coordinates given by the GIB-SAR.

SYSTEM COMPONENTS

- 4 Buoys
- 4 hydrophones with 30 m cables
- 1 Pinger exercise
- 1 Deck Unit composed of:
  1 Junction Box (Jbox)
  1 Aerial box
  1 PC with AQUATIC software

SPECIFICATIONS

Positioning accuracy:	1 m @ 1 s
Radio range:	5 km with antenna at 3 meters high above sea level
Acoustic range:	Typical: 5 km @ 11 kHz - 3 km @ 32 kHz
Coverage area:	2 NMiles x 2 NMiles x 600 m depth
Number of vehicles:	Up to 5 simultaneously

BUOYS TECHNICAL DATA

Radio modem:	380 - 450 MHz – 1 W
Battery life:	40 hours – Charging time 5 hours max
Size:	2.5 m height – diameter: 1 m (1.3 m height when folded)
Weight:	29 kg
Number of acoustic channels:	5 max.
GPS unit:	Compatible with WAAS/EGNOS
Sea state:	≤ 4

OPTIONS

Long autonomy:	Up to 80 hours (in operation)
Additional buoys:	Up to 6 additional buoys

GIB-SAR SYSTEM REFERENCES

The French MoD (DGA) used the GIB System since 2004

The UK MoD - Salvage Marine Operation used this system since 2011

The Royal Malaisian Navy used this system since 2012 on the Diving Support Vessel MEGA BAKTI

FT_GIB-SAR_IndA

E.15. Exemple de système base ultra-courte

Extrait de la documentation d'un système hybride USBL / INS permettant d'avoir un USBL calibré en usine.

Gaps

High performance USBL positioning system

Gaps is a high performance Ultra Short Baseline positioning and communication system for locating and communicating subsea assets. It combines an USBL antenna and a fiber-optic inertial navigation system (INS) in the same housing. USBL calibration on the field is not required anymore. Advanced acoustic techniques including wideband signals ensure maximum performance in most difficult conditions. Its unique 3D acoustic array enables tracking and communication from the deep sea to extremely shallow water, and even at angles above horizontal.

FEATURES

- Compact, all-in-one INS and USBL communication solution
- High grade INS for ultimate performance
- Provide absolute georeferenced position for the beacon
- Compatible with all major navigation suites
- Easy interface with subsea INS (iXblue and third party)
- DP mode : L/USBL/INS (PRS, MRU & Gyro in one equipment)
- More than 500 available acoustic channels
- Unified iXblue web interface
- 3D display software included (DELPH RoadMap)
- 3D acoustic array geometry
- Wideband modulation
- iUSBL (optional)

BENEFITS

- Rapid deployment
- Operational cost savings
- Pre-calibrated
- Easy to install
- Easy to operate
- Accurate positioning
- Robust performance
- Flexible deployment operations
- Horizontal tracking
- Wireless subsea communication with beacons

APPLICATIONS

Oil & Gas

Structure placement, ROV navigation, AUV & glider operations, towfish tracking, cable/pipe laying, diver tracking, exploration, drilling, mining, DP, seabed crawler, touch down positioning, mattress lay, plough/trench positioning, Out Of Straightness, BSR positioning, seismic (streamer, nodes, OBC), rig move, anchor positioning, riser positioning

Defence

Diver tracking, AUV tracking, underhull inspection, imagery, mine counter measure

Scientists

ROV, AUV, gliders and towfish tracking

2017-03-DS-Gaps

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iXblue

GAPS TECHNICAL SPECIFICATIONS

Positioning Accuracy [1]

	CEP50
[2] SNR = 0 dB	0.53% x Slant range
[2] SNR = 10 dB	0.17% x Slant range
[2] SNR = 20 dB	0.06% x Slant range

Range / Bearing Accuracy [3]

	RMS / STD DEV / 1 sigma (68%)
SNR = 0 dB	0.02 m / 0.30°
SNR = 10 dB	0.02 m / 0.09°
SNR = 20 dB	0.02 m / 0.03°

Performance [4]

Operating range	> 4,000 m
Coverage	200 deg below acoustic array
Operating frequency	21.5 kHz to 30.5 kHz MFSK (chirp)
Position refresh rate	1 to 15 s (depends on range) - 10 Hz with predictive filter
Nb of channels	> 500

Mechanical[5]

Housing	Carbon fiber painted
Weight in air / water	16 kg / -7 kg (positive buoyancy)
Overal dimension HxØ	638 mm x 296 mm - min gate valve required: 300 mm / 12"
Depth rate	25 m standard / 100 m non destructive

Environments [6]

Operating and Storage temperatures	-5 °C / +35 °C -40 °C / +70 °C
EMC	89 / 336 / EEC – EN 60945

Interfaces

Power supply range	100 to 240 VAC / 50~60Hz or 24/36 VDC - 30 W
Control / command	Ethernet with WEB-based user interface
Input / output ports	4 Ethernet and 4 serial (232 / 422 / 485)
Synchronisation IN	1 PPS and 1 external trigger
Synchronisation OUT	2 triggers
Display	Delph RoadMap 3D display software provided - Compatible with most of navigation software

(1) In vertical conditions. Including GPS error of 0.1 m. Sound velocity profile compensated. Transponder transmit level=191 dB ref µPa @ 1 m. Slant range of 1 000 m.
(2) SNR is input signal to noise ratio
(3) In vertical conditions. Responder mode.
(4) For a surface noise level below 67dB ref µPa/Transponder transmit level = 191dB ref µPa @ 1 m / vertical conditions.
(5) iUSBL optional
(6) NF X10-812

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iXblue

Acoustic Communication (NEW)

Data link for AUVs and ROVs	
Simultaneous positioning and communication	
Half-duplex (Gaps head to beacon / beacon to Gaps head)	
Data rate	500 bits/s (burst)
Doppler	+/- 6 knots

GAPS BOX TECHNICAL SPECIFICATIONS

Dimensions	233 mm x 330 mm x 94 mm
Weight	4.6 kg
Operating and Storage temperatures	-5°C to +50°C -40°C to +80°C

INERTIAL NAVIGATION SYSTEM SPECIFICATIONS

Performance [1]

Position accuracy with GPS	Three times better than GPS accuracy
No aiding for 2 min / 5 min	3 m / 20 m (CEP50)
Pure inertial mode	0.6 nm / hour (CEP50)
Heading accuracy	0.01 deg secant latitude RMS
Roll and pitch dynamic accuracy (no aiding)	0.01 deg RMS
Heave accuracy (Smart Heave) [2]	2.5 cm or 2.5 % RMS

(1) Secant latitude = 1 / cosine latitude
(2) Whichever is greater for periods up to 30 seconds. Smart heave is delayed by 100 s fixed value.
Real-time heave accuracy is 5 cm or 5% whichever is greater.

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E.16. Exemple de système DVL à tranducteurs

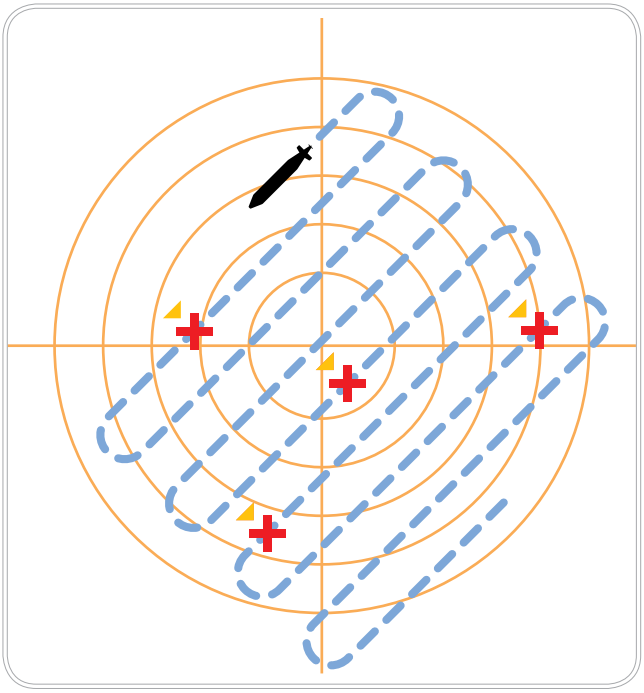
Documentation d'un DVL à transducteurs "classiques".

Teledyne RD Instruments

Workhorse Navigator

Doppler Velocity Log (DVL)

Precision Navigation for the Marine Environment



The WORKHORSE NAVIGATOR is the industry's first choice for precision navigation applications. Teledyne RDI's highly acclaimed Doppler Velocity Log (DVL) provides precise velocity and altitude updates for a wide variety of underwater tasks.

The highly flexible design allows the unit to be used in a standalone configuration or integrated with other navigation systems.

The compact and powerful Workhorse Navigator provides:

- Broadband processing technology, providing users with both short and long-term high-precision velocity data
- Reliable, accurate high-rate navigation and positioning data
- Proven bottom detection algorithms, and single ping bottom location, for robust and reliable bottom tracking over indeterminate terrain
- Superior low-altitude bottom tracking capability
- Real-time current profiling data

PRODUCT FEATURES

Navigator Full Suite of Capabilities:

- Bottom track velocity
- Water track velocity
- Altitude: 4 individual measurements
- Error velocity (data quality indicator)
- Temperature
- Heading/Tilt
- Acoustic echo intensity
- Pressure and depth (optional)
- Current profiling (optional)

Navigator Applications:

- Subsea vehicle and surface vessel navigation
- Hydrographic, geophysical, and oceanographic survey positioning data
- LBL and USBL position aiding
- Spool piece metrology
- Inertial navigation correction and integration
- Cable burial operations
- Deep water positioning
- Station keeping and autopilot control
- Pipeline touchdown monitoring
- Dredge spoils, plume, and sediment tracking

A Teledyne Marine Company

TELEDYNE RD INSTRUMENTS Everywhereyoulook™

Workhorse Navigator

Doppler Velocity Log (DVL)

TECHNICAL SPECIFICATIONS

			WHN 300	WHN 600	WHN 1200
Bottom Velocity	Single-ping precision				
	Std dev at 1m/s[1]		±0.4cm/s	±0.3cm/s	±0.3cm/s
	Std dev at 3m/s[1]		±0.7cm/s	±0.5cm/s	±0.5cm/s
	Std dev at 5m/s[1]		±0.9cm/s	±0.7cm/s	±0.7cm/s
	Long-term accuracy		±0.4%±0.2cm/s	±0.2%±0.1cm/s	±0.2%±0.1cm/s
	Minimum altitude[2]		1.0m	0.7m	0.5m (0.25 optional)
	Maximum altitude[2]		200m	90m	25m
Parameters	Velocity range[3]		±10m/s	±10m/s	±10m/s
	Velocity resolution		0.1cm/s	0.1cm/s	0.1cm/s
	Ping rate		7Hz max	7Hz max	7Hz max
Water Reference Velocity	Accuracy		±0.4% ±0.2cm/s	±0.3% ±0.2cm/s	±0.2% ±0.1cm/s
	Layer size		selectable	selectable	selectable
	Minimum range		1.9m	1.2m	0.8m
	Maximum range		110m	50m	15m
Environmental	Operating temperature		-5 to 45°C	-5 to 45°C	-5 to 45°C
	Storage temperature		-30 to 60°C	-30 to 60°C	-30 to 60°C
	Depth rating		3000m or 6000m	3000m or 6000m	3000m or 6000m
	Weight in air:	3000m	15.8kg	15.8kg	12.4kg
		6000m	20.1kg	20.1kg	18.0kg
	Weight in water:	3000m	8.8kg	8.8kg	6.1kg
		6000m	13.6kg	13.6kg	12.1kg
Power	DC input		20–50VDC, external supply (48VDC typical)		
	Current		0.4A minimum power supply capability		
	Transmit[4] Peak power @ 24VDC		66w	21w	8w
	Average power (typical)		8w	3w	3w
Standard Sensors	Compass		±2° @ 60° dip, 0.5g		
	Tilt		±0.5° up to ±15°		
	Temperature		-5° to 45°C		
Hardware	Configuration		4-beam Janus array convex transducer, 30° beam angle		
	Communications		NMEA0183, ASCII, or binary outputs at 1200–115,200 baud user-selectable; serial port is switch-selectable for RS232 or RS422		
	Trigger inputs		1) ASCII; 2) RDS3; 3) low latency		
Options	• Current profiling firmware upgrade • Integrated pressure sensor (±0.25% full scale) • 25m serial/DC/computer cable • 5m serial/DC/computer cable • Internal memory cards (2GB max) • Enhanced low altitude bottom tracking for model 1200				
Dimensions	WHN 300/600: Height 244.5mm, diameter 225.2mm; WHN 1200: Height 242.9mm, diameter 201.9mm *(line drawings available upon request)*				

1 Standard deviation refers to single-ping horizontal velocity, specified at half the maximum altitude.
2 @5°C and 35 ppt, 42VDC.
3 Maximum bottom-tracking range may be reduced due to flow noise at high speed and/or cavitation.
4 @ 15% duty cycle at peak power (standby 1mW).

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E.17. Exemple de système DVL à formation de voies

Documentation d'un DVL à formation de voies.

Teledyne RD Instruments

Pathfinder

600 kHz Phased Array DVL

Small in Size– Big on Performance

Teledyne RD Instruments' new **Pathfinder DVL** is precisely what our customers have been waiting for! This new highly compact 600 kHz DVL is small in size and *huge* on value. Derived from Teledyne RD Instrumets' long-standing, highly reliable DVL technology, this system promises to deliver the precision navigation performance you've come to expect from Teledyne RDI, at a price point, size, and weight that's ideally suited for your next application.

Utilizing Teledyne RDI's proven **state-of-the-art electronics**, the Pathfinder DVL provides an array of advanced internal algorithms and features you'd typically expect to find only in higher-end solutions. With up to 150 m of bottom tracking, in up to 300 m of water, the Pathfinder 600 delivers a solid, value-priced solution for vehicles ranging from small inspection class ROVs to large diameter AUVs.

Utilizing Teledyne RDI's **proven bottom-detection** algorithms and single-ping bottom-location accuracy with its broadband velocity processing technology, the Pathfinder provides users with **highly reliable** precision velocity data for navigation and position control, even over indeterminate terrain.

The Pathfinder DVL is available off-the-shelf in a self-contained or OEM configuration, providing you with a footprint and flexibility that's right for your unique vehicle requirements.

PRODUCT HIGHLIGHTS

- **Small but mighty:** Dramatically reduced size and weight allows Pathfinder to be installed on board the smallest vehicles with minimal impact on system payload.
- **Budget minded:** Priced for smaller budgets, without the need to compromise on performance.
- **Proven Performance / Reliability:** Building upon Teledyne RDI's vast experience with DVL technology and performance, Pathfinder offers a proven, reliable solution to ensure the success of your mission.
- **New optional XRT** (Extended Range Tracking) delivers 50% increase in bottom tracking range
- **Phased Array:** Unique phased array transducer design delivers enhanced position accuracy at a reduced size, eliminates the need for speed of sound correction, and reduces drag on your vehicle.
- **Flexible Design:** Self-contained or OEM package options available to meet your unique vehicle needs.
- **Versatile:** Upgradeable to include Acoustic Doppler Current Profiling (ADCP) capability.
- **Ethernet Compatibility:** Plug-n-play with today's interfaces.

Pathfinder Doppler Velocity Log

600 kHz Phased Array DVL

TECHNICAL SPECIFICATIONS

		600 kHz
Bottom Tracking	Maximum Altitude[1,2]	89 m (150 m optional)
	Minimum Altitude	0.2 m (<20 cm altitude mode available)
	Velocity Range[3]	±9 m/s or +16 m/s upon request
	Long Term Accuracy[4]	±0.2% ±0.1 cm/s
	Long Term Accuracy[5,7]	±1.15% ±0.1 cm/s
	Precision @ 1 m/s	±0.5 cm/s @ ½ alt.
	Precision @ 3 m/s	±1.5 cm/s @ ½ alt.
	Precision @ 5 m/s	±2.3 cm/s @ ½ alt.
	Resolution	0.01 mm/s (0.1 cm/s default)
Water Profiling	Maximum Ping Rate[6]	12 Hz
	Maximum Range[1,2]	47 m
	Minimum Range	1.9 m
	Velocity Range[3]	±12 m/s
	Long Term Accuracy	±0.3% ±0.1 cm/s
	Precision @ 1 m/s	±7.5 cm/s@2 m bin
	Precision @ 3 m/s	±7.5 cm/s@2 m bin
	Precision @ 5 m/s	±7.7 cm/s@2m bin
	Resolution	1 mm/s.
	Cell Sizes	0.1 m–4 m
Acoustic	Center Frequency	614.4 kHz
	Source Level (re 1 µPa)	215 dB@1 m
	1-Way Beam Width	2.2°
	Number of Beams	4-phased array
	Beam Angle (nominal)	30°
	Bandwidth (nominal)	6.25% of center freq.
Environmental	Maximum Operating Depth	300, 1000 m
	Operating Temperature	-5°C to 45°C
	Storage Temperature	-30°C to 60°C
	Weight in Air (OEM/SC)	1.15/1.9 kg
	Weight in Water	0.7 kg
Internal Sensors	Leak Detection	Dual Up & Down in SC / In Transducer in OEM.
	Health Monitor	Transducer Health, Operating Time
	Temperature Sensor	
Power	Average Power (@ 24 VDC)	2.6 W (3.4 W with Ethernet enabled)
	Quiescent Power	1.1 W (2 W with Ethernet enabled)
	Input Voltage (VDC)	10.7 - 36 VDC
	Surge Current	<4 A
Communications	Ethernet & RS232	
Dimensions (in)	9 x 4 x 2.8 SC (L x W x H) • 4.58 x 3.38 x 2.18 OEM Electronic (L x W x H) • 3.295 x 1.75 Transducer (D x H)	

1. @5°C and 35 ppt, salinity, @ max V.
2. Maximum range may be reduced due to flow noise.
3. When mounted with beam @ 45°. Also, for platforms with forward velocity higher than reverse (or vice versa), the maximum velocity can be increased to [-2 m/s -> +16 m/s] for bottom track via firmware modification.
4. ECCN 6A001.
5. ECCN 6A991.
6. @ 5% of maximum altitude
7. Max speed = ±1.6 m/s (<0.35 m altitude) & ±9 m/s (≥0.35 m altitude) No Tilt.

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E.18. Exemple de système CVL

Documentation d'un CVL.

AquaTrak™

High Accuracy Correlation Velocity Log (CVL)

The AquaTrak™ CVL provides greater precision and accuracy than a 1200kHz with the range exceeding a 300kHz DVL.

With a wide single vertical beam AquaTrak™ can be recess mounted on a vehicle to avoid impact damage without any degradation in performance, making it suitable for all underwater vehicle applications.

The AquaTrak™ Correlation Velocity Log (CVL) estimates along track and across track speed over the ground using coherent pulses in a single vertical sonar beam. It is designed as a direct drop-in replacement for a Doppler Velocity Log (DVL) but offers improved performance over a wide operating envelope from a single sensor.

The broad beam of a CVL is achieved using a relatively low frequency, which results in reduced acoustic absorption, coupled with strong seabed echoes from the vertical beam providing increased sonar range and higher accuracy than DVLs of a similar size.

AquaTrak™ is able to maintain navigation precision even at zero velocity and unlike DVLs which rely on measuring the Doppler Shift, a speed of sound measurement is not required by the AquaTrak™ CVL to calculate velocity, therefore reducing the overall error budget.

Benefits

- Extended operating range of 0.5m to 300m
- Greater accuracy than a 1200kHz DVL
- Longer range than a 300kHz DVL
- Velocity estimate independent of speed of sound
- High accuracy data in hover manoeuvres
- Robust bottom tracking independent of altitude
- Recessed mounting to avoid impact damage

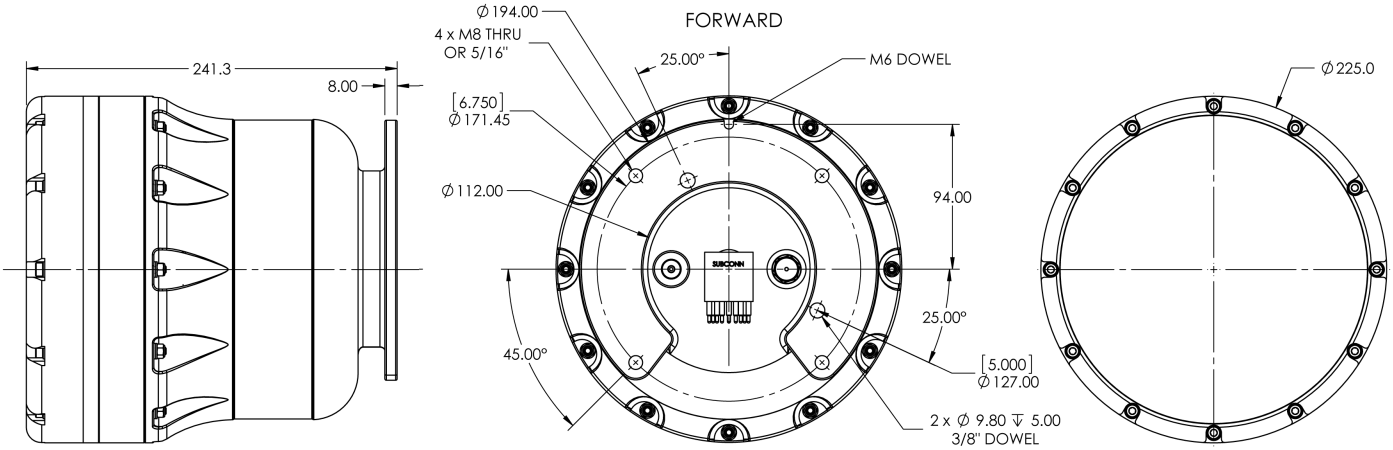
Features

- Compact size – direct replacement for DVL
- 3000m depth rating
- Concurrent serial and Ethernet data outputs
- 150kHz operating frequency for reduced interference
- Standard PD format outputs

Applications

- ROV and AUV navigtaion
- Towed vehicle navigation
- Inertial navigation correction and integration

Specification



All dimensions are in mm, not to scale

Specifications	
Operating frequency	150kHz
Min / Max Range	0.5 to 300m
Long Term Accuracy	±0.1% ±0.1cm·s^{-1}
Bottom Velocity Precision	±0.3cm·s^{-1} at 3m·s^{-1}
Operation Speed	0 to 20 knots (0 to 10 m·s^{-1})

Physical Properties	
Weight in air	14.5kg
Weight in water	6.9kg
Materials	Aluminum, Hard Anodized Type III, with sacrificial anode
Depth rating	3000m
Dimensions	241 x 225mm (height x diameter)
Temperatures	Operating: -5°C to +40°C Storage: -10°C to +50°C

Electrical and Communications	
Power requirement	10-12W average (23W maximum @ 300m altitude and maximum update rate)
Protocols	Ethernet RS232
Data Output Rate	10Hz maximum
Output Formats	NMEA0183 (RS232), UDP/TCP, standard PD 4 / 6 / 11 messages
Connector options	Subconn DLPBH13M 7 Pin option available

Export Details	
EU DUAL USE	6A001b.1.b
US ECCN	6A001b.1.b

Specifications subject to change according to a policy of continual development.

Document: 0737-SOM-00001, Issue: 03

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Bibliographie

[Bei+15] J. Beitia et al. «Quartz pendulous accelerometers for navigation and tactical grade systems». In : **2015 DGON Inertial Sensors and Systems Symposium (ISS)**. Sept. 2015, p. 1-20. doi : 10.1109/InertialSensors.2015.7314256.