CATALOGUE

STANDARD TRANSDUCERS AND HYDROPHONES

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Version CAT13999-1

Introduction

CONTENTS AND SCOPE OF THIS CATALOGUE

Thank you for your interest in RESON transducers and hydrophones. This catalogue presents our line of standard transducers and hydrophones for use in underwater acoustics. The transducers fall within the following main categories:

1000 series
Hemispherical, broad band. Typical applications are for Transponders, Pingers and Acoustic Telemetry.

2000 series
Directional low/mid frequencies. Typical applications are for Echosounders and Side Scan Systems.

3000 series
Directional, high frequency. Typical applications are for Sound Velocity Probes, NDT.

4000 series
Omnidirectional. Typical applications are for Reference Hydrophones, Reference Projectors, Sonar Arrays and Positioning Systems.

Our catalogue has been designed to facilitate your choice of relevant transducers for your application needs in a quick and straight-forward manner. Detailed specifications will be found in Section 3 and 4 of this catalogue, while a quick guide is presented in the following overviews and entries:

RESON main office in Denmark

Table I
Applications reference list, page 7.

Table II
Short form specifications for transducers and hydrophones, page 9.

In the Short Form Specifications, the following terms and abbreviations are used for general categorisation of RESON transducers:

Type:
The transducers are categorised according to their general function as hydrophones and/or projectors.

Hydro:
The transducer may be used as a passive hydrophone, (i.e. sound receiver in liquid).

Proj:
The transducer may be used as a projector, (i.e. sound source in liquid).

Frequency:
Catagorisation according to the serial resonant frequency of the transducers or, for the 4000 series, the maximum usable frequency.

Depth:
While RESON transducers are survival tested to greater depths, the figures quoted are maximum operating depths in meters.

Beam pattern:
The beam patterns or directional response of the transducers are shown according to the categories below. Where applicable, opening angles are quoted as -3dB angles in degrees at the resonant frequency of the transducers (or at the stated frequency of the 4000 series).

Conical:
Transducers with conical beam patterns possess opening angles as shown in the vertical directional response column.

Omni/Hemi:
Transducers in this category have omnidirectional or hemispherical beam patterns.

Narrow:
Transducers in this category have an opening angle of less than 10° in either the horizontal or the vertical plane.

Horiz.:
Figures in this column are horizontal opening angles for transducers which do not have a conical beam pattern.

Vert.:
Figures in this column are vertical opening angles for all transducers including those with conical beam patterns.

Power:
In general, values quoted are maximum electrical power loads in Watts with a duty cycle of max. 1% at the resonant frequency. However, for hydrophones which can be used as calibrated projectors, the values quoted are the maximum voltage that may be used over the whole frequency band.

Weight:
Values shown are dry weight in kilograms. This weight includes the cable, where this is supplied as standard.

Housing:
Materials and standard cable lengths are shown. Cables may be supplied in lengths to suit individual requirements.

Documentation:
Possible documentation includes plots of Impedance (Z), Receiving response (RR), Transmitting response (TR),
Horizontal directional response (DR-H) and Vertical directional response (DR-V). These columns indicate standard and optional test documentation available for each transducer. Documentation shown in brackets is optional. For all transducers a Certificate of Conformity may be supplied upon request.

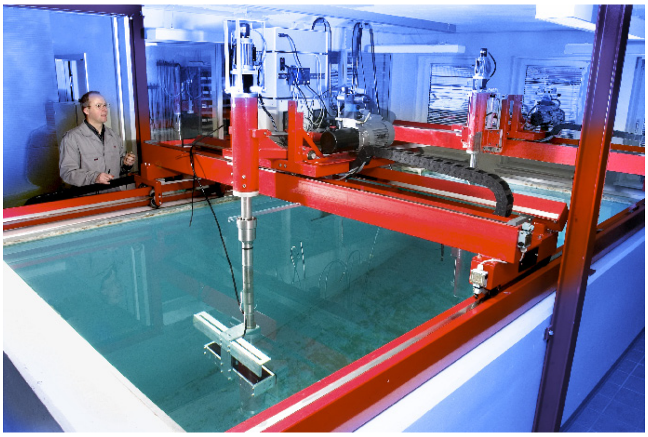
We also welcome enquiries on purpose-designed transducers in larger quantities to meet customer-specific needs. For presentation and quantification of your specific requirements, please refer to our Transducer and Hydrophone Questionnaire, which you will find on our home page at www.reson.com.

CALIBRATION METHOD

RESON's acoustic test facility is a completely integrated package to document all acoustic products in the frequency range 3kHz to 5MHz. It includes an advanced report generator for: Directional response plots, Transmitting/Receiving response plots, Impe-dance/ Admittance plots plus Reciprocity Calibration. The test facility further encompasses high pressure tanks with pressure ranges up to 700 bar.

The standard calibration method using a reference is performed on virtually all of the transducers and hydrophones in this catalogue. The reference hydrophones used in the standard calibration method have all been reciprocity calibrated. In this method three hydrophones are set up equidistant from each other and are measured. This method is available on all our of standard reference hydrophones as an option.

In order to avoid reflections in the tank, pulsegated measurements are made. Voltage, current and impedance are all measured within the same gated pulse. The pulse length is only limited by its wavelength and the size of the tank. At RESON A/S, the calibration tank is 4.5 x 2.5 x 3 m.


Complete calibration test facility at RESON in Denmark

For the most exacting applications, RESON also provides calibrations traceable to national standards established at the National Physical Laboratory, UK.

Introduction

INTERPRETATION OF CALIBRATION PLOTS

Directional Response Plot
The directional response plot shows the ratio between the acoustic power in a selected direction and the acoustic power of a simple source emitting the same power as the directive source. (Dimensionless).

Response Plot
The response plot utilises the "comparison method" to measure the response (transmitting and receiving) of the transducer or hydrophone. This is performed against a reference hydrophone, and a plot of the response against frequency over the selected frequency range is produced. The receiving response is determined in dB re V/μPa, and the transmitting response in dB re 1 μPa/V at 1 metre.

Impedance Plot
The impedance plot shows the input impedance of a transducer used as a projector. A plot of the impedance (showing real and imaginary parts separately) against frequency over the selected frequency range is produced. The impedance is measured using a burst signal. This avoids the creation of standing waves in the test tank which distort the measurement.

Certified assemblers are trained in a wide variety of flexible manufacturing processes for both high and low volume productions.

COMPANY BACKGROUND

RESON was founded in 1976 and has since grown to become one of the global leaders in design and manufacture of underwater acoustic sensors and multidisciplinary measuring systems. The corporate headquarters are located in Denmark, and wholly owned subsidiaries have been established in California; United Kingdom; Germany; South Africa; Singapore; The Netherlands; and in Italy. Quality is a key word for all RESON activities, and all standard products are produced, documented and tested according to our ISO 9001: 2000 quality system.

High pressure test tank. Pressure range up to 700 bar.

CAPABILITIES

RESONs line of advanced, high quality products, from transducers to real-time, multi-beam profiling and imaging sonar systems, is based upon a continuing research and development effort. RESON spends some 30% of its annual turnover on R&D covering technologies such as acoustic and finite element transducer modelling, signal processing, software and electronics hardware. These activities are carried out, in many cases, in collaboration with universities and other research establishments both nationally and worldwide.

Introduction

Over the last years, RESON has been the industrial partner in a considerable number of R&D projects sponsored by the European Community.
This collaboration has resulted in the development of new reference hydrophones and has included studies on European acoustic calibration facilities.

The RESON R&D and quality assurance groups are staffed by engineers and technicians highly qualified in all the pertinent engineering disciplines, from acoustics to mechanical and electronic engineering. The certified production assemblers are trained in a wide variety of flexible manufacturing processes to cover both high and low volume productions.

RESOURCES AND FACILITIES

All RESON transducers and other products are manufactured and tested to meet the most stringent demands for quality, reliability and durability.

In order to meet these standards, RESON has invested in the latest technology and resources to support design, development, production and quality management.

These include:

- Computer aided design workstations.
- Automatic acoustic test tank (RESONs own design for on-site high precision acoustic calibration, including advanced facilities for data acquisition, storage and presentation.
- High-pressure tanks with pressure ranges up to 700 bars.
- Full testing facilities and laboratories for testing, quality assurance and production, in accordance to our ISO 9001: 2000 quality system.

WARRANTY

All RESON products are sold with a twelve month warranty covering any defects in materials and workmanship or failure to meet the given tolerances and specifications.

If a product upon inspection by RESON or its authorised representatives is found to be defective, excepting damage or fair wear and tear, RESON, at the company's discretion, will repair or replace the product free of charge. Transportation costs shall be to the account of the Customer.

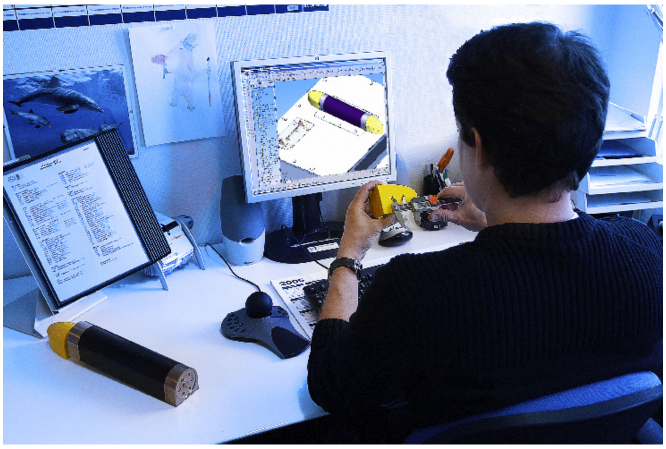
RESON shall not be liable for any loss or damage arising out of or in connection with the use of its products.

TECHNICAL SERVICE

RESON operates a full technical service function for inspection, adjustment and repair of all its standard products.

Service contracts are available, ensuring RESONs customers optimum utilization, maintenance and performance of their RESON products.

Also, RESONs service function undertakes assistance pertaining to on-site trouble shooting, installation and training.



Technical service function for inspection, adjustment and repair of all standard products.

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Table I

Applications Reference List

Product No.	TC 1026	TC 1037	TC 2003	TC 2024	TC 2111	TC 2122	TC 2178	TC 3021	TC 3027	TC 4013	TC 4014	TC 4032	TC 4033	TC 4034	TC 4035	TC 4037	TC 4038	TC 4040	TC 4042
Underwater positioning and navigation, long base line																			
Acoustictelemetry																			
Underwater telephonesystems		●																	
Distress pingers																			
Pinger/Transponder systems																			
Pinger location																			
Echo sounding systems		●	●	●	●	●	●												
Pulse echo measurement									●										
Side scan systems		●																	
Submarine/bottom/ mine equipment		●									●		●						
Subbottomprofiling		●																	
Sound velocity meters								●	●										
High resolution distance measurements				●															
Calibration									●	●			●	●			●	●	
Reference measurements (Conformance)										●	●	●	●	●	●		●	●	●
Reference projectors										●			●	●			●	●	
Ship, flow and turbolent noise measurements												●		●		●		●	●
Low noise measurements												●			●	●			●
Acoustic near field measurements														●	●		●		
Audio recording										●		●	●			●		●	●
Laboratory application										●	●		●	●	●		●	●	
Dolphins and whales										●	●	●	●	●				●	●
High frequency measurements											●			●	●		●		
Offshore structure monitoring										●	●		●			●			●
Marine biology											●		●	●				●	●

Table II

Short Form Specifications

Model	Type		Resonance Frequency / Usable Band			Depth (m)			Beam (°)				
	Hydro	Proj	High	Medium	Low	High	Medium	Low	Omni/Hemi	Conical	Narrow	Horizontal	Vertical
TC1026	●	●		36kHz		6000						Omni	±35°fromhori.plan
TC1037	●	●			6kHz		600			●			80
TC2003				200kHz				30		●			2.6
TC2024	●	●		200kHz				30		●	●		9.5
TC2111				200kHz				30		●			18
TC2122				33/200kHz				30		●	●		20/9
TC2178	●	●		33/200kHz				30		●	●		20/9
TC3021	●	●	2000kHz				700			●	●		2.2
TC3027	●	●	1000kHz				500			●	●		5.8
TC4013	●	●		1Hz-170kHz			700		●			Omni	270 at 200kHz
TC4014	●		15Hz-470kHz				900		●			Omni	270 at 200kHz
TC4032	●			5Hz-120kHz			600		●			Omnito100kHz	270 at 15kHz
TC4033	●	●		1Hz-160kHz			900		●			Omni	270 at 100kHz
TC4034	●	●	1Hz-470kHz				900		●			Omni	270 at 300kHz
TC4035	●	●	10kHz-800kHz						●			Omni	120 at 250kHz
TC4037	●			1Hz-100kHz		1500			●			Omni	270 at 40kHz
TC4038	●	●	10Hz-800kHz					20	●			Omni	
TC4040	●	●		1Hz-120lHz				400	●			Omni	
TC4042	●			5Hz-85kHz			1000		●			Omni	270 at 40kHz

RESON

Table II

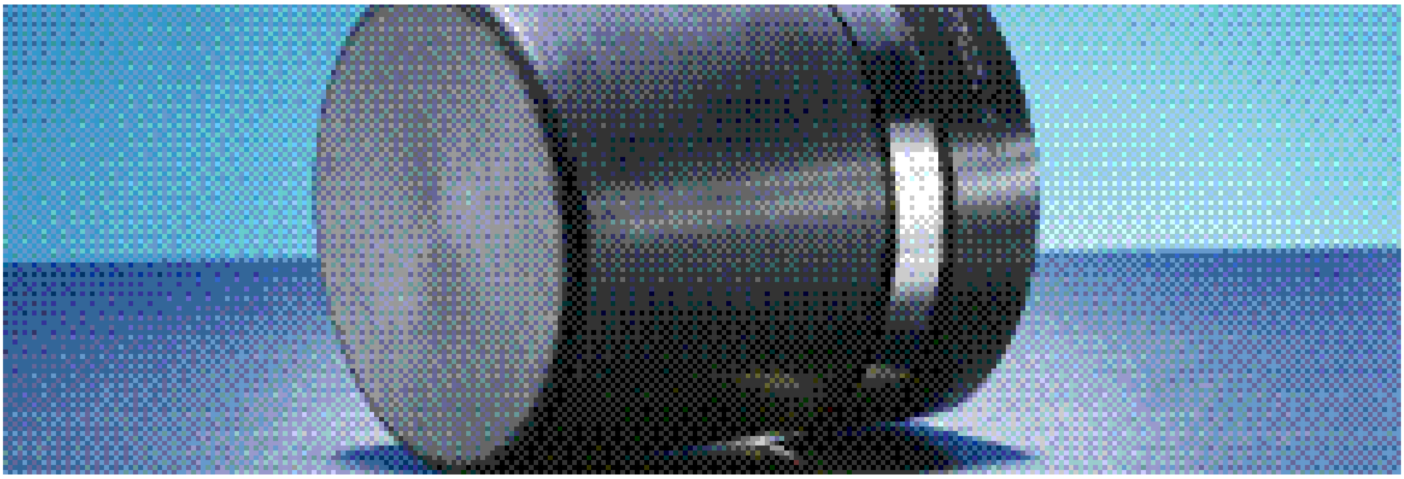
Short Form Specifications

Model	Power		Dimensions (mm)		Weight (kg)	Housing			Documentation					Page
	High	Low	Max Length	Max Width	Dry	Type	Active Surface	Cable Length (m)	Z	RR	TR		DR-V	
TC1026		100W	100	107	0.5	Stainless	Chloroprene	Optional	•	•	•	•	•	11
TC1037		400W	198	115.5	5.8	Stainless	Chloroprene	Optional	•	•	•	•		13
TC2003	1500W		66	260	7.1	PVC	PVC	18	•	•	•	•		15
TC2024		450W	61	110	2.3	PVC	PVC	20	•	•	•	•		17
TC2111		50W	50	31.8	0.4	PVC	PVC	10	•	•	•	•		19
TC2122	1000/450W		130	180	5.0	PVC	PVC	33	•	•	•	•	•	21
TC2178	1000/450W		320	151	9.7	PVC	PVC	18	•	•	•	•	•	23
TC3021		10W	32	30	0.075	PVC	EP	1.5	•	•	•	•		25
TC3027		5W	32	30	0.045	PVC	EP	1.5	•	•	•	•		27
TC4013		100Vrms	50	9.5	0.075	Stainless	NBR	6	•	•	•	•		29
TC4014		12-24VDC	273	38	0.650	Alu-bronzo	NBR	Optional		•		•	•	31
TC4032		12-24VDC	284.5	38	0.720	Alu-bronzo	NBR	Optional		•		•	•	35
TC4033		100Vrms	138	25	1.5	Alu-bronzo	NBR	10	•	•	•	•	•	37
TC4034		100Vrms	138	16	1.6	Alu-bronzo	NBR	10	•	•	•	•	•	39
TC4035			168	10	0.410	Stainless	NBR	Optional	•	•	•	•	•	41
TC4037		10-24VDC	75	36	0.086	Titanium	NBR			•		•	•	43
TC4038		100Vrms	58	4	0.020	Stainless	PU	2		•		•	•	45
TC4040		100Vrms	120	21	1.600	Titanium	NBR	10	•	•	•	•		47
TC4042			220	36	0.45	Alu-bronze	NBR			•		•	•	49

RESON

Transducer TC1026

High Power Communications Transducer

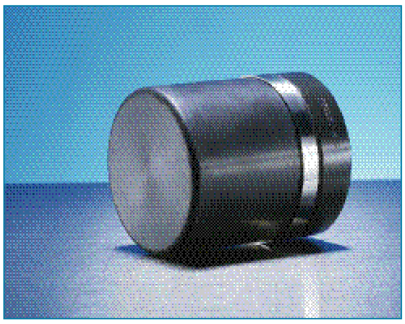


TC1026

- **36 kHz compact**
- **High efficiency ceramic**
- **Easy to install**
- **Long life time**

The TC1026 is a high power communication transducer for long/short base line measurement, pinger/transponder systems, acoustic telemetry systems and telephone systems.

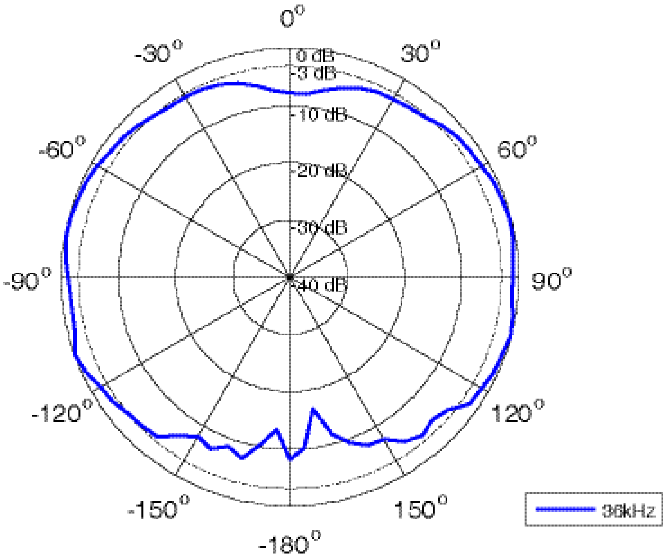
TECHNICAL SPECIFICATIONS	
Resonant frequency:	36kHz ±2kHz (34-38kHz)
Transmitting sensitivity:	137dB ±3dB at 36kHz (re µPa/V at 1m)
Receiving sensitivity:	-193dB ±3dB at 36kHz (re 1V/µPa)
Impedance:	630ohm ±10% 81° phase ± 10% at 36kHz
Vertical directivity pattern:	Typically ±35° from horizontal plane
Horizontal directivity pattern:	Omnidirectional
Max input power: (1% duty cycle)	100W
Operating depth:	6000m
Survival depth:	6000m
Operating temperature range:	-2° to +30°C
Storage temperature range:	-30° to +70°C
Cable (Optional)	Two single wires
Housing:	Special formulated NBR
Weight (air) incl. cable:	0.5kg



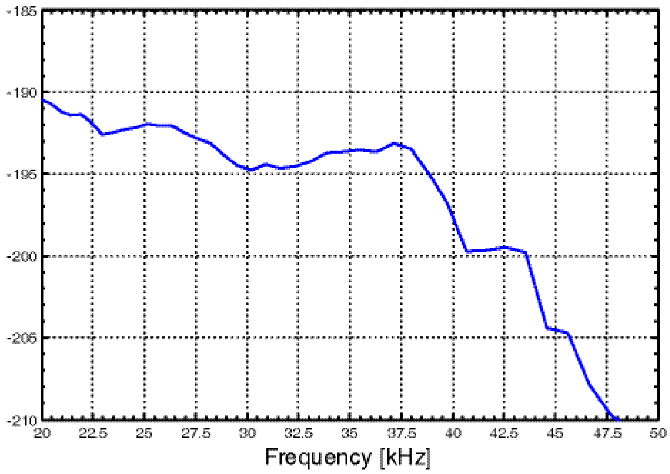
Transducer TC1026

High Power Communications Transducer

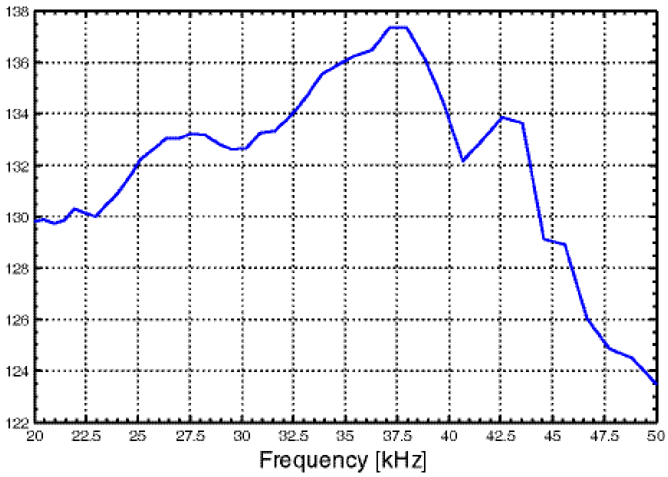
Vertical Directivity Pattern



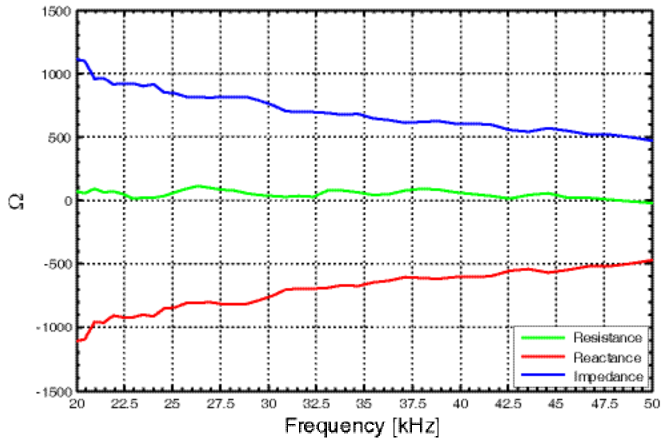
Receiving Sensitivity [dB re 1V/μPa @ 1m]

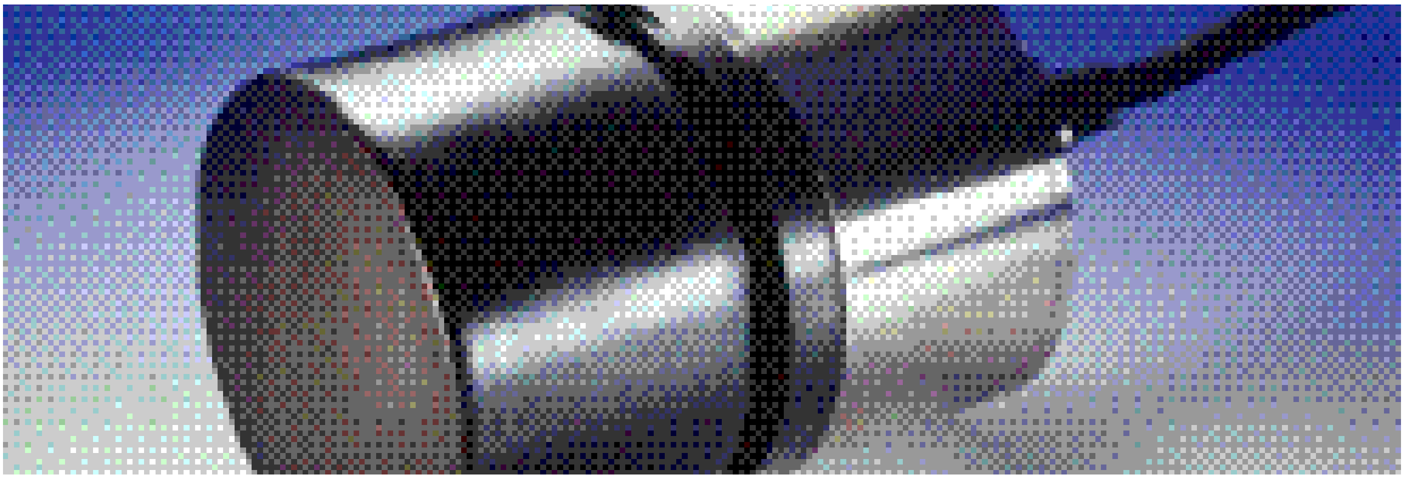


Transmitting Sensitivity [dB re 1μPa/V @ 1m]



Impedance





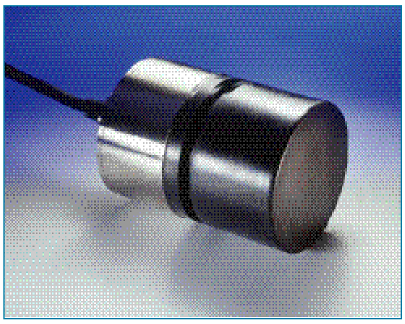
TC1037

- **High performance low frequency transducer**
- **Ideal for installation due to steel housing and threaded guide**
- **Optional cabletermination TL8038**

The TC1037 is a rugged directional transducer with low frequency.
It is specifically designed for underwater telephone systems. Can be used as a building block in special long range sonars or in sub bottom penetration single or multibeam systems.

TECHNICAL SPECIFICATIONS	
Usable frequency band:	6kHz to 15kHz
Transmitting sensitivity:	145dB ±3dB at 7,3kHz (re µPa/V at 1m)
Receiving sensitivity:	-169dB ±3dB at 7,3kHz (re 1V/µPa)
Impedance:	860ohm ±250ohm at 7,3kHz
Beam shape:	Conical
Beam width:	80°at 8kHz
Max input power:	400W (1% duty cycle)
Operating depth:	600m
Survival depth:	800m
Operating temperature range:	-2°C to +35°C
Storage temperature range:	-40°C to +70°C
Cable (Optional)	Connector and 9m cable, pigtail
Housing:	Special formulated NBR
Weight (air) incl. cable:	5,8kg

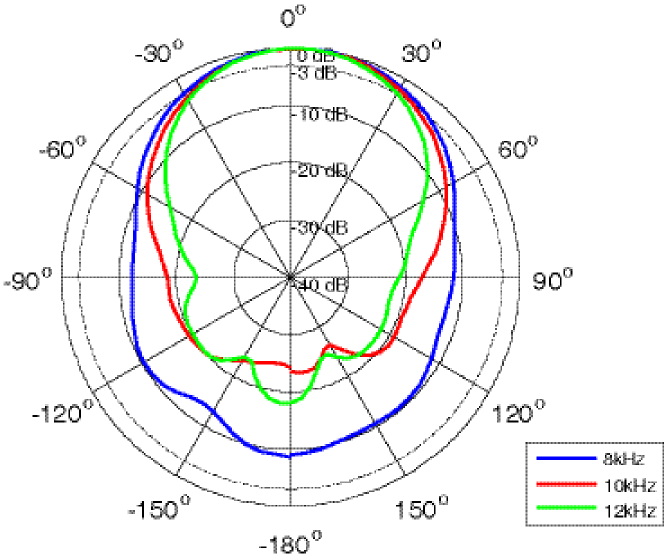
Please note that this product requires a minimum quantity per order



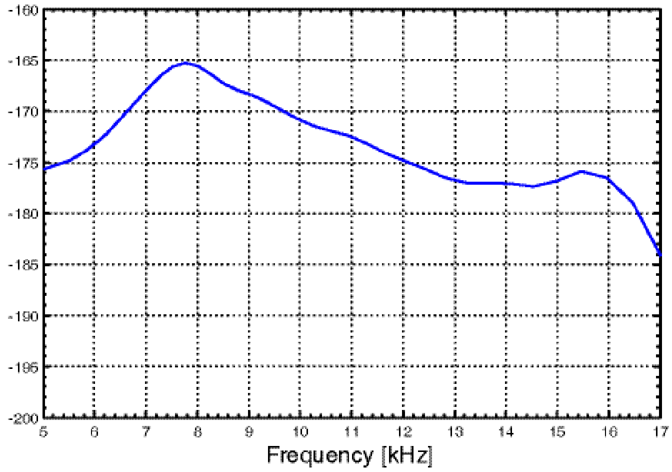
Transducer TC1037

Directional Telephone Transducer

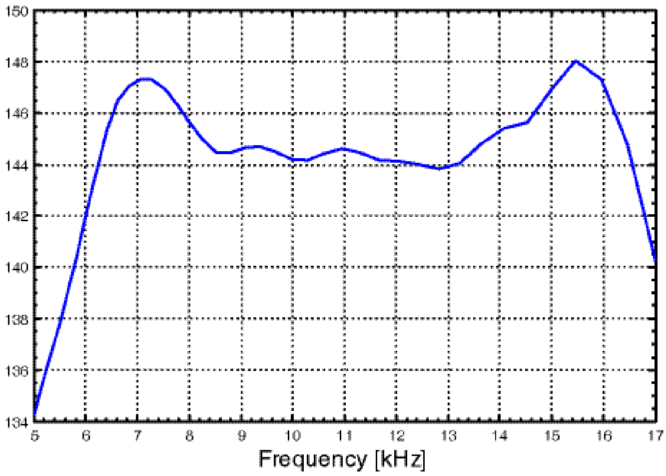
Horizontal Directivity Pattern



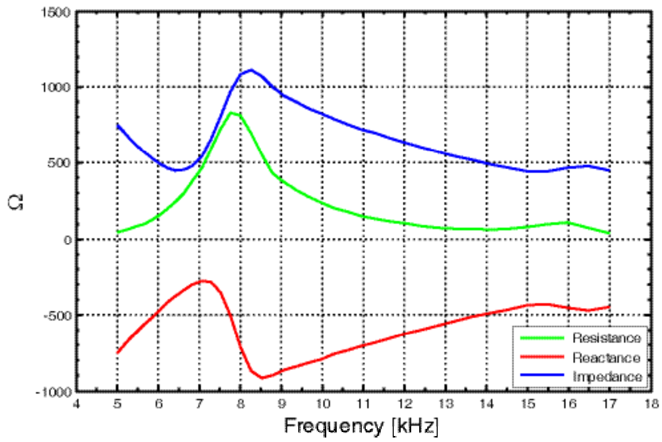
Receiving Sensitivity [dB re 1V/μPa @ 1m]



Transmitting Sensitivity [dB re 1μPa/V @ 1m]



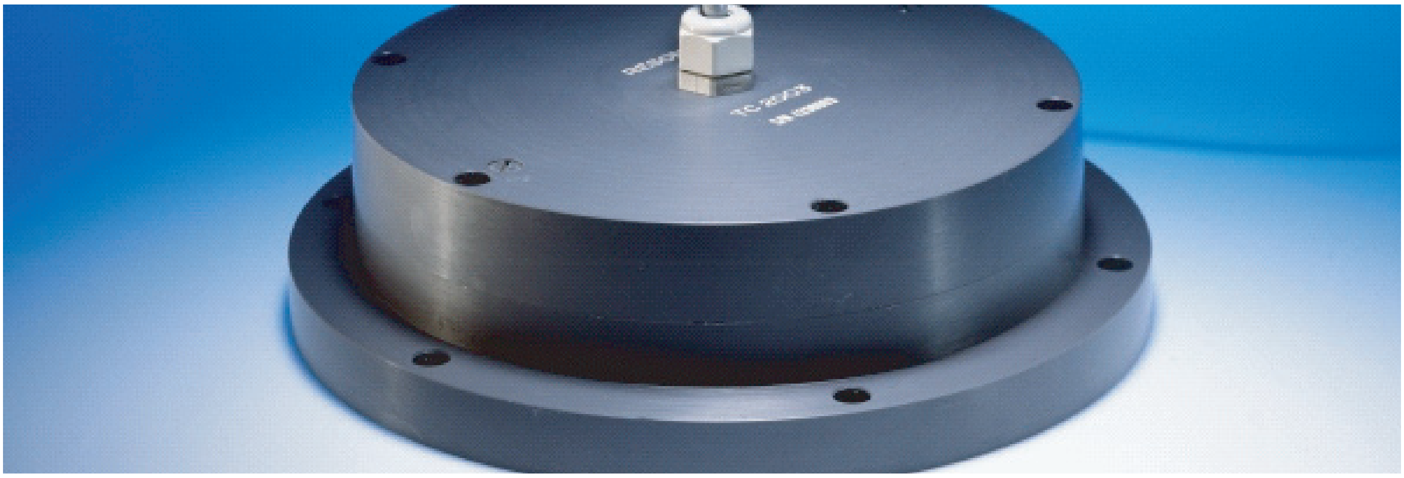
Impedance



RESON

Transducer TC2003

Narrow Beam Hydrographic Transducer

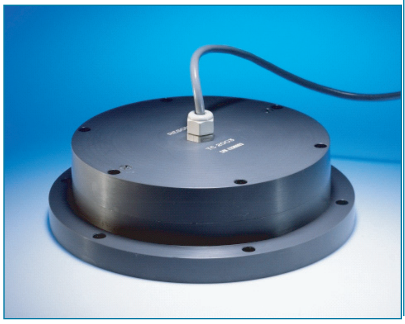


TC2003

- Narrow conical beam
- High power input
- Low weight

Narrow beam transducer for precise bottom recognition Ideal for all echo sounders working in the frequency band from 190–210kHz.

TECHNICAL SPECIFICATIONS	
Resonant Frequency:	200kHz ±10kHz
Transmitting Sensitivity:	180dB ±3dB at 200kHz (dB re μPa/V @ 1m)
Receiving Sensitivity:	-180 dB ±3dB at 200kHz (dB re V/μPa)
Impedance:	100ohm ±30ohm
Beam width:	3.0° ± 0.2, Conical
Max input power:	1500W at 1% duty power
Operating depth:	30m
Survival depth:	50m
Operating temperature range:	-2°C to +30°C
Storage temperature range:	-30°C to +50°C
Weight with cable:	7.1kg
Cable:	18m FALMAT Type FM091003-1602A, 2x1 (Twisted pair) PUR Jacket, WATER BLOCK 2*1 (O.D. 9.3mm) - pigtail

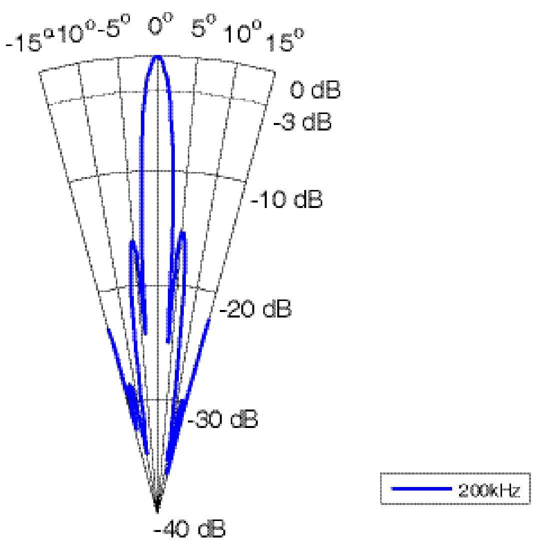


RESON

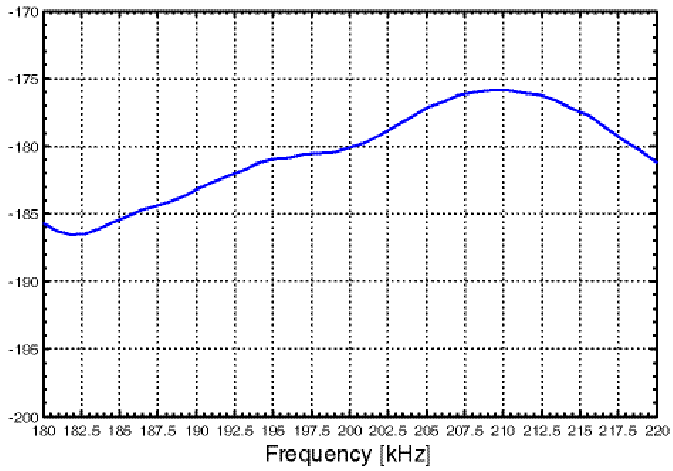
Transducer TC2003

Narrow Beam Hydrographic Transducer

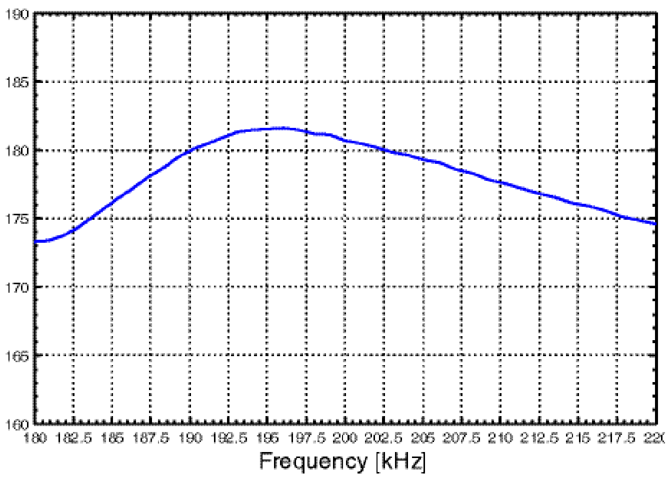
Horizontal Directivity Pattern



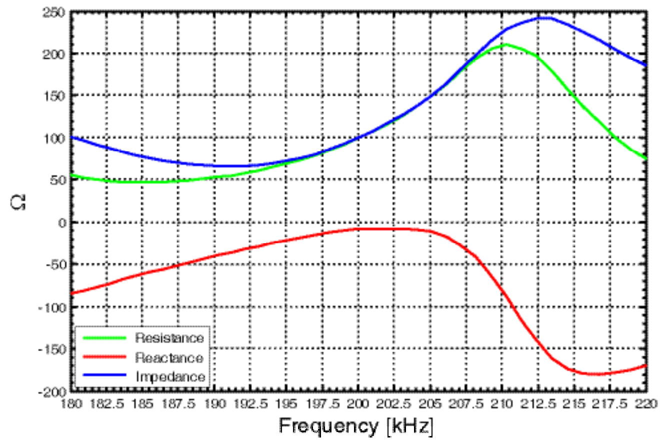
Receiving Sensitivity [dB re 1V/μPa @ 1m]



Transmitting Sensitivity [dB re 1μPa/V @ 1m]



Impedance



RESON

Transducer TC2024

Survey Transducer for Echosounder

TC2024

- 200kHz transducer
- Compact design
- Excellent performance
- Robust piezo ceramic
- Electrical compatible with most echosounder systems

General purpose 200kHz echosounder transducer for shallow water applications: 0-100m

The TC2024 is ideal for navigation, hydrographic echosounding in shallow waters, and high resolution distance measurements.

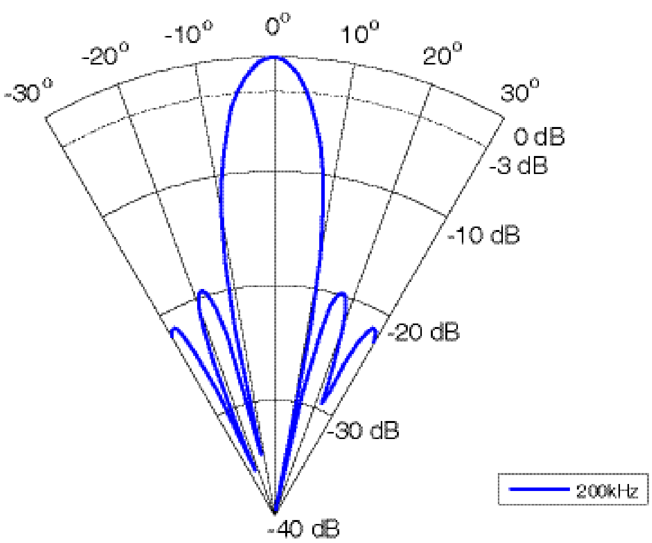
For outboard mounting, RESON steel housing mounts are available. The standard housing of the TC2024 is also compatible with ATLAS SW 6014 mounts.

TECHNICAL SPECIFICATIONS	
Resonant Frequency:	200kHz ± 10kHz
Transmitting Sensitivity:	173dB ±3dB re 1μPa/V at 1m
Receiving Sensitivity:	-187dB ±3dB re 1V/μPa
Impedance :	100ohm ± 30ohm at 200kHz
Beam width:	9.5° ± 1°, Conical
Max input power:	450W at 1% duty cycle
Operating depth:	30m
Survival depth:	50m
Operating temperature range:	-2°C to +30°C
Storage Temperature:	-30°C to +50°C
Housing:	PVC
Weight (air) incl. Cable:	2.3kg
Cable (length and type):	20m FALMAT Type FM091003-1602A, 2x1 (Twisted pair) PUR Jacket, WATER BLOCK 2*1 (O.D. 9.3mm) - pigtail

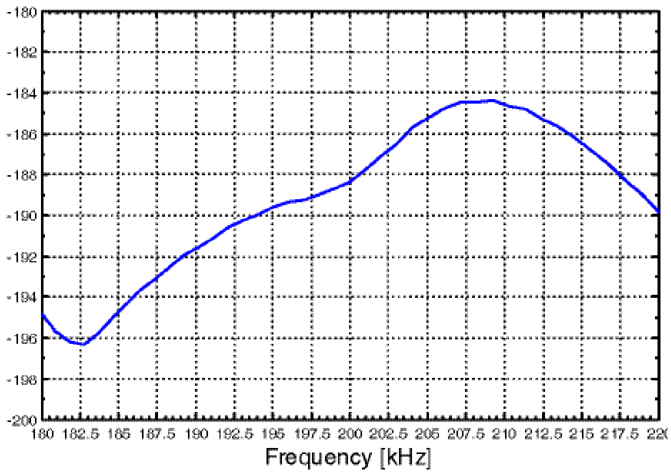
Transducer TC2024

Survey Transducer for Echosounder

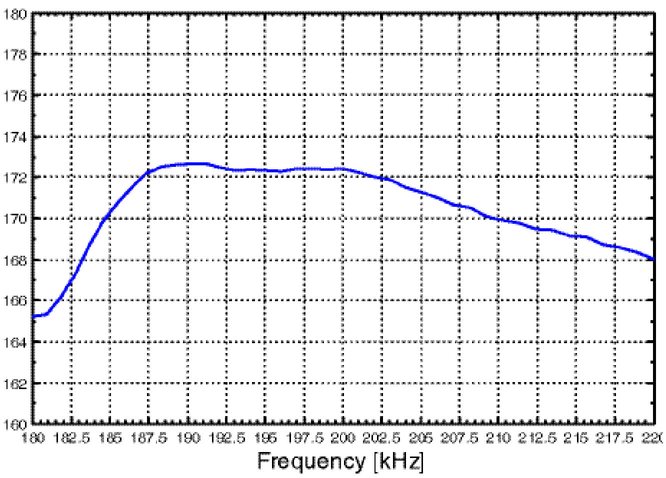
Horizontal Directivity Pattern



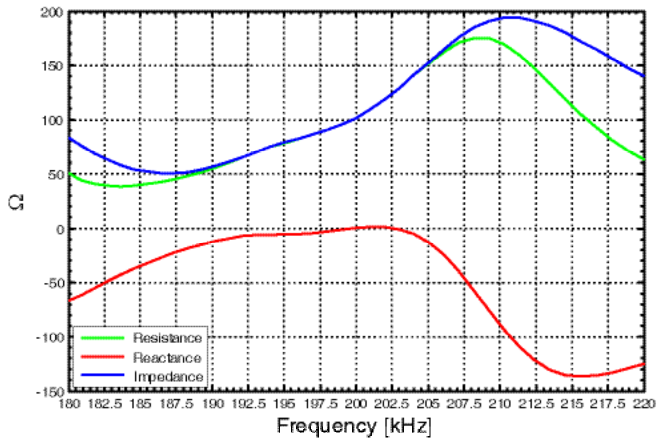
Receiving Sensitivity [dB re 1V/μPa @ 1m]



Transmitting Sensitivity [dB re 1μPa/V @ 1m]

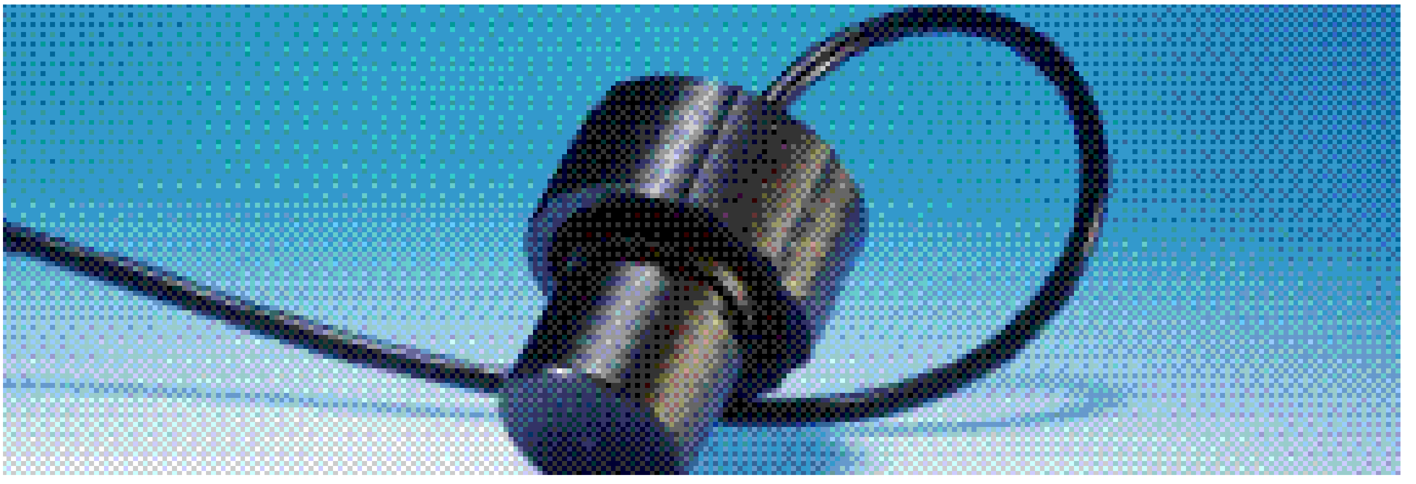


Impedance



Transducer TC2111

Compact Echosounder Transducer

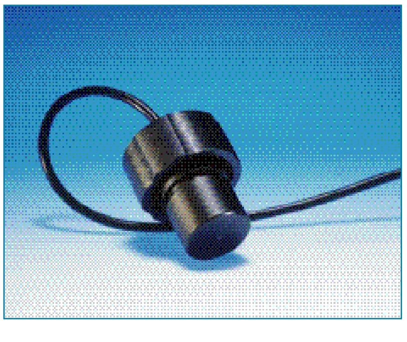


TC2111

- **Small compact design**
- **Good piezo ceramics**

Compact echo sounder transducer

TECHNICAL SPECIFICATIONS	
Resonant Frequency:	200kHz ± 3kHz
Transmitting sensitivity:	163dB ± 3dB (re 1μPa/V at 1m)
Receiving Sensitivity:	-190dB ± 3dB (re 1V/μPa)
Impedance:	200ohm ±60ohm at 200kHz
Beam width:	18° ± 3°
Beam shape:	Conical
Max input power:	50W (at 1% duty cycle)
Operating depth:	30m
Survival depth:	50m
Operating temperature range:	+2°C to +35°C
Storage temperature range:	-30°C to +50°C
Cable (length and type):	10m Coax 2*1 (O.D. 5mm) - pigtail
Weight in air, with cable:	0,4kg
Housing:	PVC with union nut

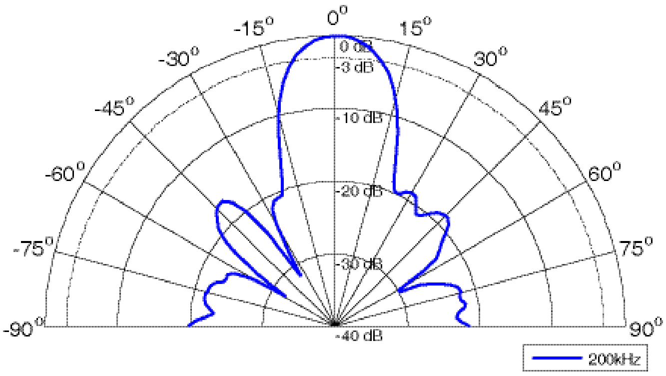


RESON

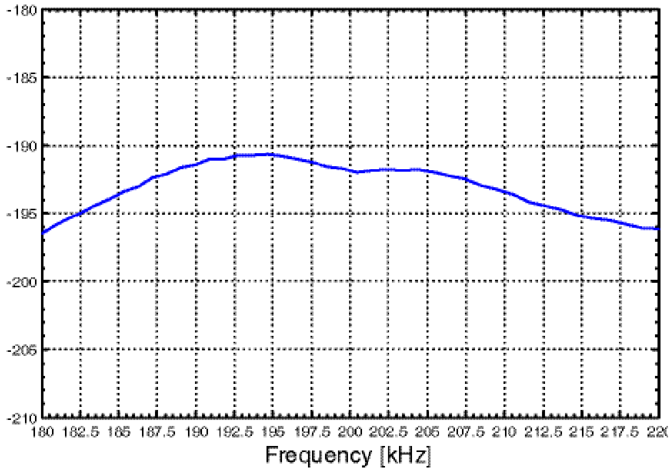
Transducer TC2111

Compact Echosounder Transducer

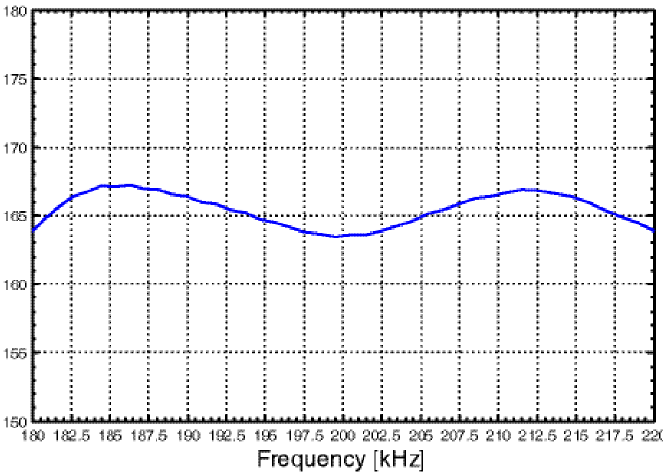
Horizontal Directivity Pattern



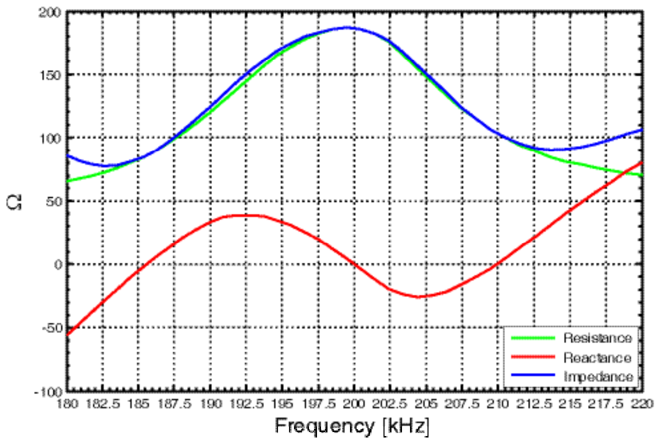
Receiving Sensitivity [dB re 1V/μPa @ 1m]



Transmitting Sensitivity [dB re 1μPa/V @ 1m]



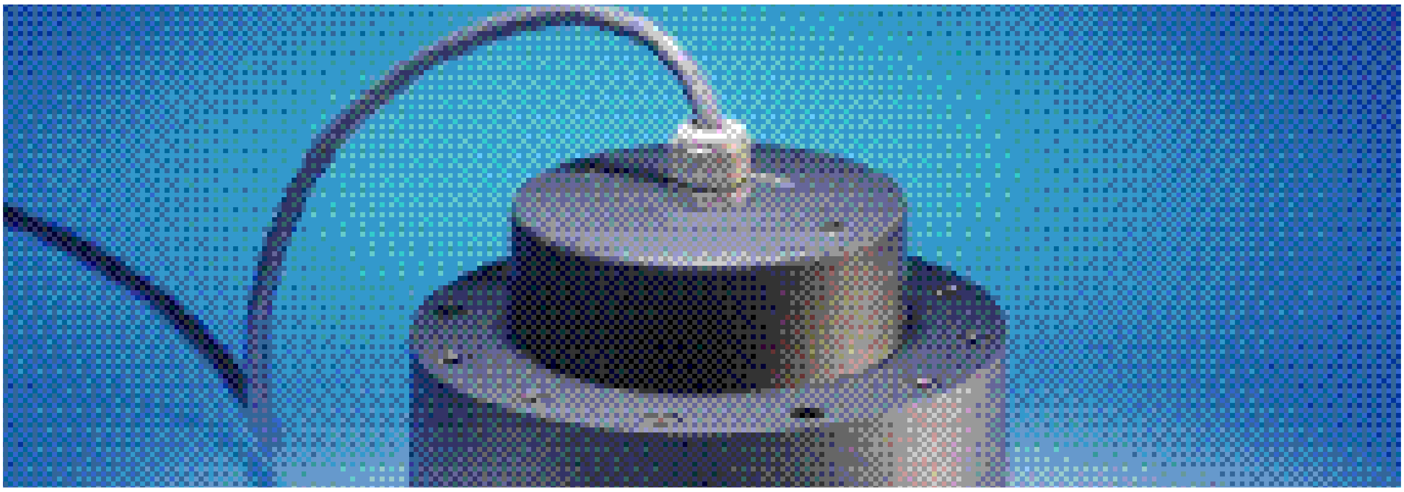
Impedance



RESON

Transducer TC2122

Dual-Frequency Survey Echosounder Transducer

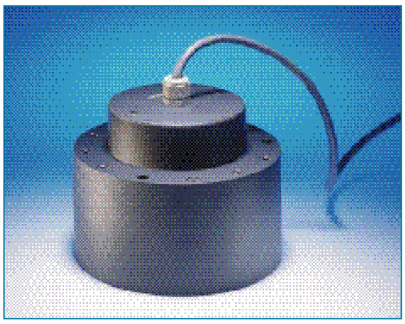


TC2122

- **Narrow beams**
- **High acoustical performance**
- **Compact design**
- **Compatible with ATLAS SW60/28/6029 housing.**
- **Electrical compatible with most 33kHz and 200kHz echosounders.**

Model TC2122 is a 33kHz and 200kHz dual frequency transducer ideal for navigation and hydrographic echosounder systems. The transducer has excellent piezoceramic elements which will ensure the highest reliability and quality in echosounding. The transducer will fit ATLAS SW 60/28/6029 housing and RESON steel housings.

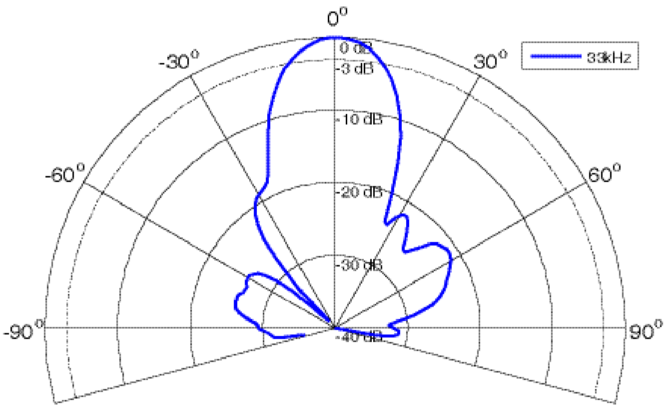
TECHNICAL SPECIFICATIONS	
Resonant Frequency:	33kHz ±2kHz 200kHz ±5kHz
Transmitting sensitivity:	168dB ±3dB at 33KHz 174dB ±3dB at 200KHz (re 1µPa/V at 1m)
Receiving Sensitivity:	-177dB ±3dB at 33KHz -187dB ±3dB at 200KHz (re 1µPa/V)
Impedance:	80ohm ±24ohm at 33kHz and 200kHz
Beam width:	22°±2° at 33KHz 9,5°±1° at 200kHz
Beam shape:	Conical
Max input power:	1000W at 33kHz 450W at 200kHz (at 1% duty cycle)
Operating depth:	30m
Survival depth:	50m
Operating temperature range:	-2°C to +35°C
Storage temperature range:	-30°C to +50°C
Weight in air,with cable:	5kg
Housing:	PVC
Cable (length and type):	33m FALMAT Type FM088095-7, 4x1 (2 x twisted pair) PUR Jacket, WATER BLOCK, Kevlar Braid 800lbs breaking strength (O.D. 11mm) - pigtail



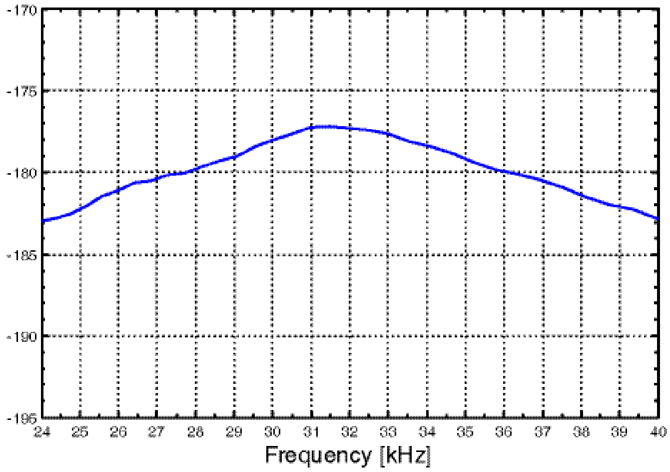
Transducer TC2122

Dual-Frequency Survey Echosounder Transducer

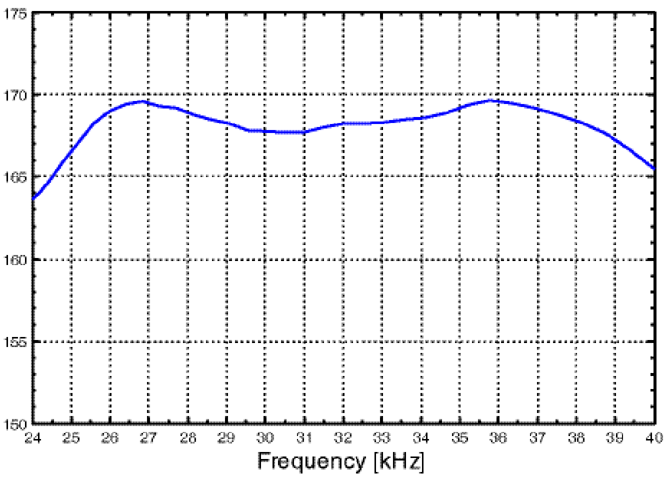
Horizontal Directivity Pattern



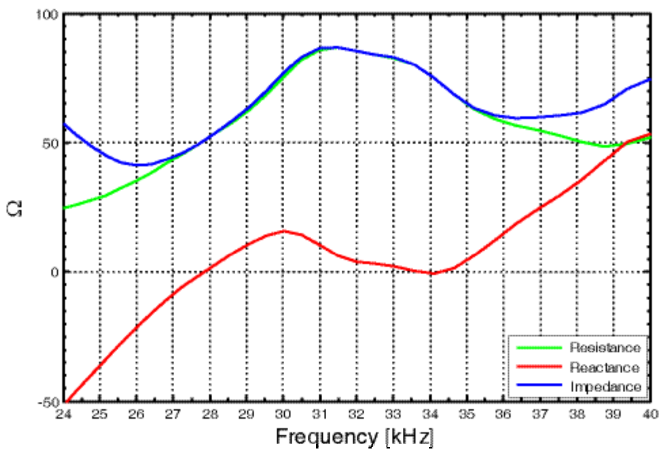
Receiving Sensitivity [dB re 1V/μPa @ 1m]



Transmitting Sensitivity [dB re 1μPa/V @ 1m]



Impedance



RESON

Transducer TC2178

Dual Frequency Transducer

TC2178

- **Hydrodynamic shape**
- **Narrow beams**
- **High acoustical performance**
- **Compact design**
- **Electrical compatible with most 33 kHz and 200 kHz echosounders.**
- **Can be mounted directly on outboard rig.**

Model TC2178 is an optimized and hydrodynamic 33 kHz and 200 kHz dual frequency transducer ideal for navigation and hydrographic echo sounder systems.
The transducer has excellent piezoceramic elements which will ensure the highest reliability and quality in echosounding.

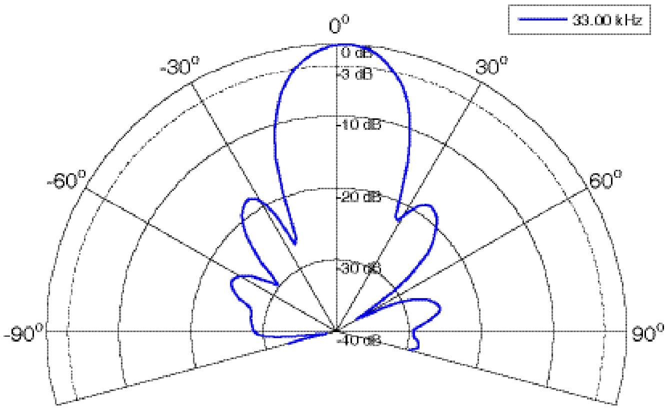
TECHNICAL SPECIFICATIONS	
Resonant Frequency:	33 kHz ±2kHz 200kHz ±5kHz
Transmitting sensitivity:	168dB ±3dB at 33kHz (re 1µPa/V at 1m) 174dB ±3dB at 200kHz (re 1µPa/V at 1m)
Receiving Sensitivity:	-177dB ±3dB at 33kHz (re 1V/µPa) -187dB ±3dB at 200kHz (re 1V/µPa)
Impedance:	80 ohm ±24ohm at 33kHz and 200kHz
Beam width:	22°±2° at 33kHz 9.5°±1° at 200kHz
Beam shape:	Conical
Max input power:	1000 W at 33kHz (at 1% duty cycle) 450 W at 200kHz (at 1% duty cycle)
Operating depth:	30 m
Survival depth:	50 m
Operating temperature range:	-2°C to +35°C
Storage temperature range:	-30°C to +50°C
Weight in air, with cable:	9.7kg
Housing:	PVC
Cable (length and type):	18m FALMAT Type FM088095-7, 4x1 (2 x twisted pair) PUR Jacket, WATER BLOCK, Kevlar Braid 800lbs breaking strength (O.D. 11mm)

- pigtail

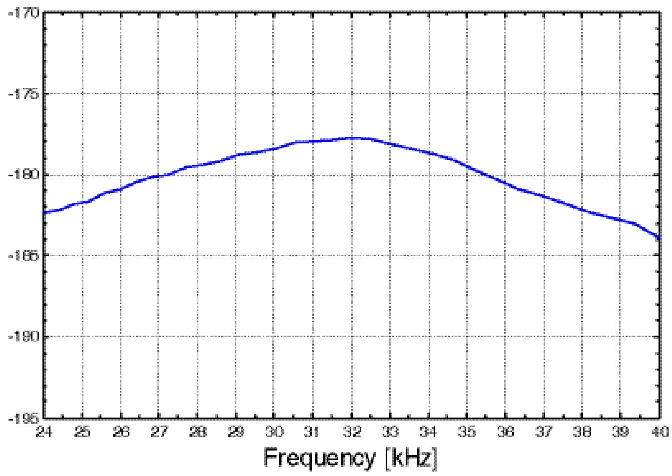
RESON Transducer TC2178

Dual Frequency Transducer

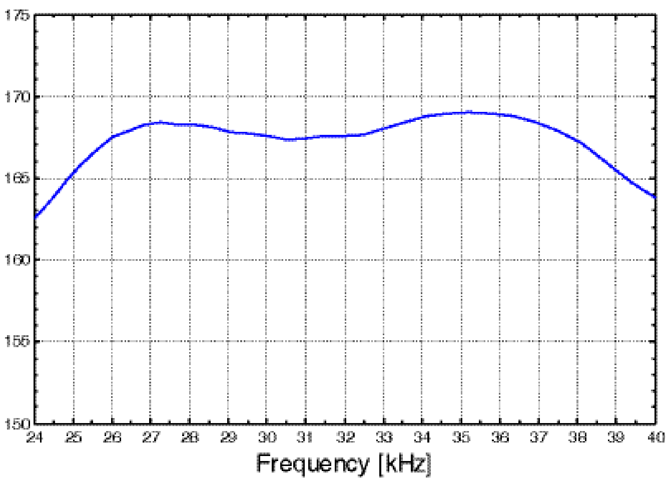
Vertical directivity pattern



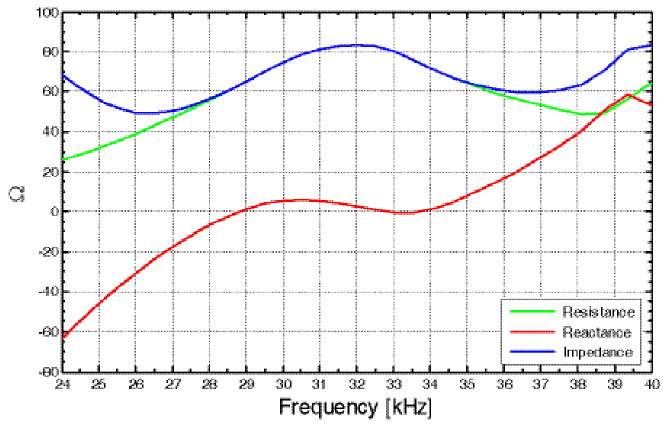
Receiving Sensivity [dB re 1V/μPa @ 1m]



Transmitting sensitivity [dB re 1μPa/V @ 1m]



Impedance



Transducer TC3021

Low Cost Universal 2MHz Transducer

TC3021

- **Depth rating 700m operating**
- **Extreme narrow beam width**

Universal 2MHz transducer ideal for short range high precision sound velocity measurements.

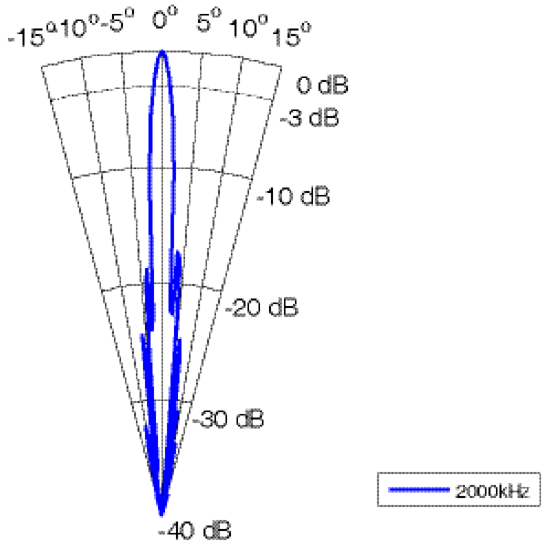
TECHNICAL SPECIFICATIONS	
Resonant Frequency:	2MHz
Transmitting Sensitivity:	184dB ±3dB at 2MHz (re µPa/V at 1m)
Receiving Sensitivity:	-207dB ±3dB at 2MHz (re V/µPa)
Impedance:	23ohm ±11ohm at 2MHz
Phase:	0° ±30°at 2MHz
Beam shape	Conical
Beam width:	2,2°
Side lobe Suppression	Better than -12dB
Max input power:	5W (1% duty cycle)
Operating depth:	700m
Survival depth:	1000m
Operating temperature range:	+2°C to +35°C
Storage temperature range:	-30°C to +50°C
Cable: (Length and type)	1.5m, Coax cable RG 174/u
Housing:	PVC – black
Weight (air) incl. cable:	35g

Please note that this product requires a minimum quantity per order

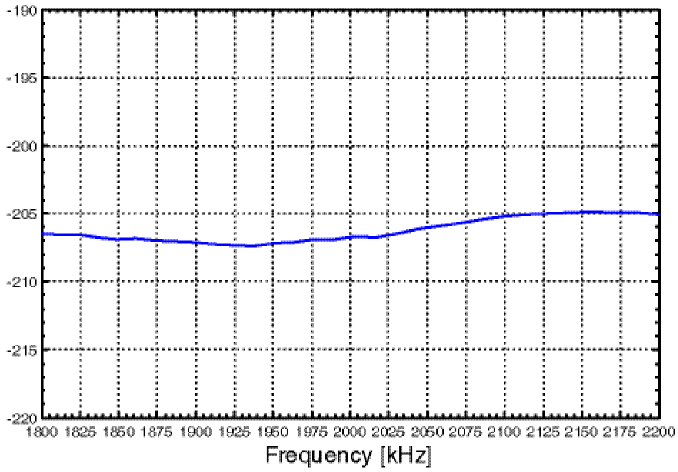
Transducer TC3021

Low Cost Universal 2MHz Transducer

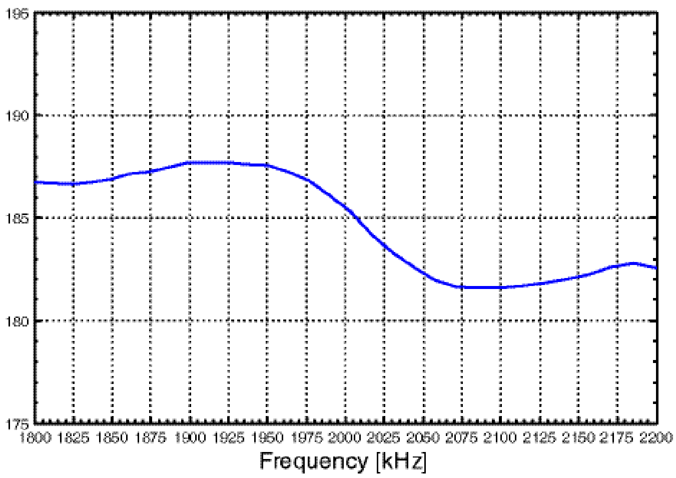
Horizontal directivity pattern



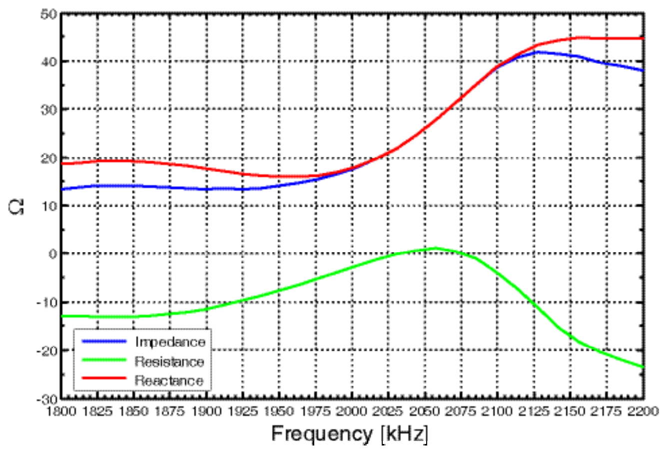
Receiving Sensitivity [dB re 1V/μPa @ 1m]



Transmitting Sensitivity [dB re 1μPa/V @ 1m]



Impedance



Transducer TC3027

Universal 1MHz Transducer

TC3027

- **Side lobe suppression better than -23dB**
- **Small compact housing**
- **Ideal for watertight installation, due two double o-ring seal.**

The TC3027 is a Universal 1MHz transducer ideal for sound velocity measurements and short range applications.

TECHNICAL SPECIFICATIONS	
Resonant Frequency:	1MHz
Transmitting Sensitivity:	170dB ±3dB at 1MHz (re 1µPa/V at 1m)
Receiving Sensitivity:	-201B ±3dB at 1MHz (re 1V/µPa)
Impedance:	140ohm ±30 % at 1MHz
Directivity Pattern:	5.8°
Beam shape:	Conical
Side lobe Suppression:	Better than -23dB
Max input power: (1% duty cycle)	10W
Operating depth:	500m
Survival depth:	800m
Operating temperature range:	-2°C to +50°C
Storage temperature range:	-30°C to +50°C
Cable: (Length and type)	1.5m coax cable RG174/u, pigtail
Housing:	PVC - black
Weight (air) incl. cable:	40g

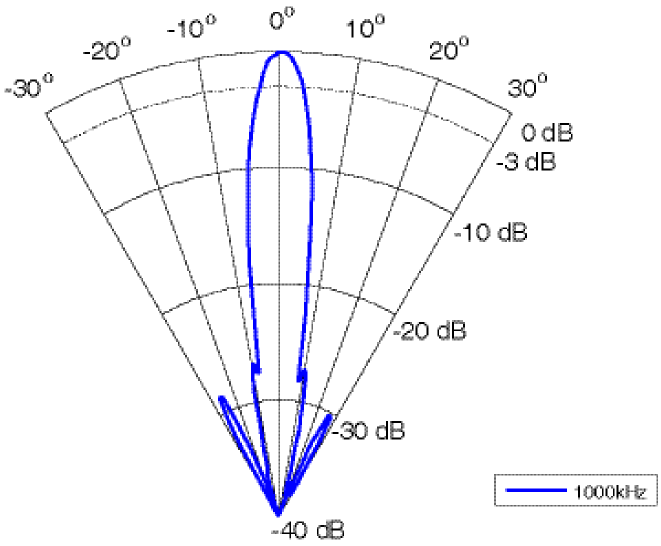
Please note that this product requires a minimum quantity per order

RESON

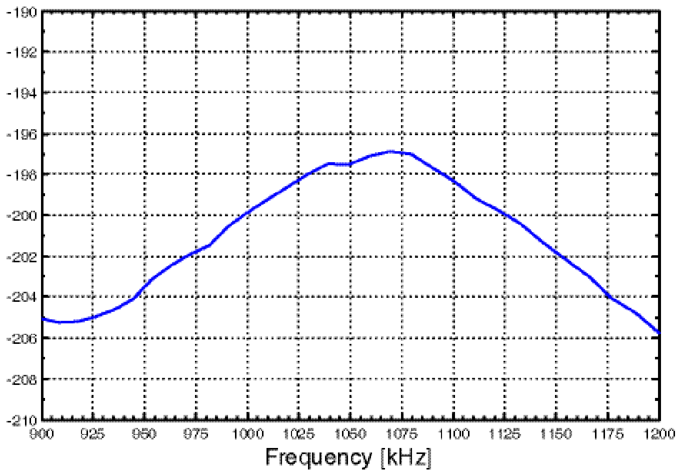
Transducer TC3027

Universal 1MHz Transducer

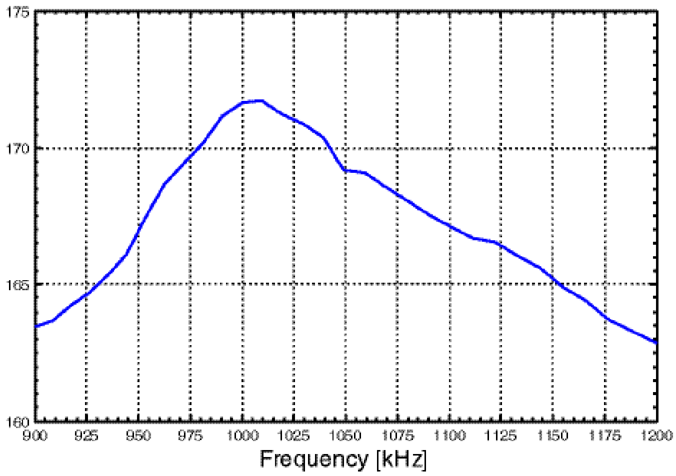
Horizontal directivity pattern



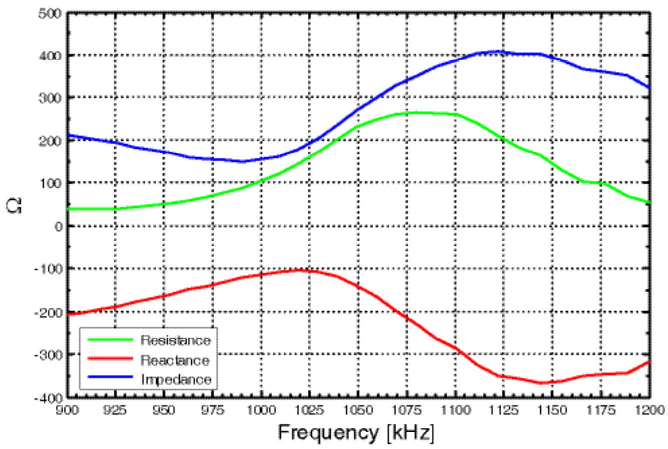
Receiving sensitivity



Transmitting sensitivity

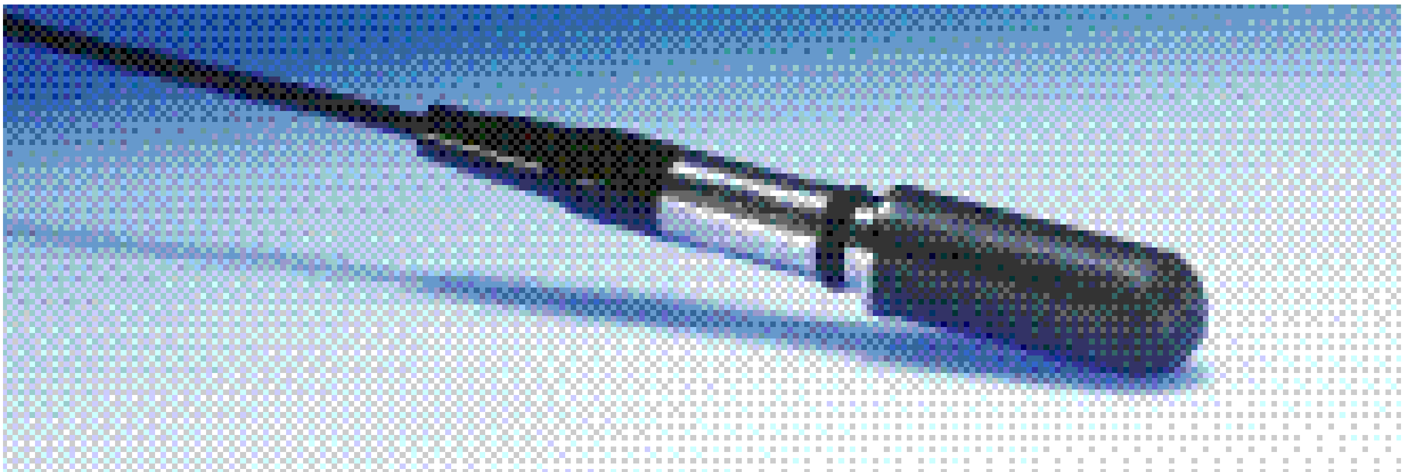


Impedance



Hydrophone TC4013

Miniature Reference Hydrophone

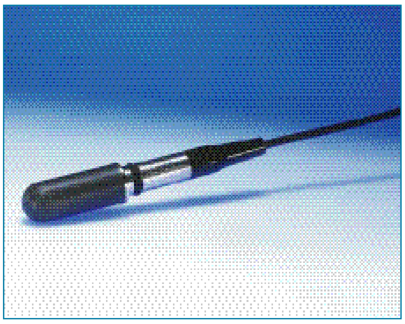


TC4013

- **High sensitivity**
- **Omnidirectional to high frequencies**
- **Broad banded**
- **O-ring sealed mounting**
- **Individually calibrated**

The TC4013 offers a usable frequency range of 1Hz to 170kHz and a high sensitivity relative to its size. It further-more provides uniform omnidirectional sensitivities in both horizontal and vertical planes up to high frequencies.
The TC4013 is an excellent transducer for making absolute sound measure-ments and calibrations within a broad frequency range. It can also be applied as an omnidirectional reference projector.
The overall characteristics makes TC4013 extremely applicable for laboratory as well as industrial uses.

TECHNICAL SPECIFICATIONS	
Usable Frequency range:	1Hz to 170kHz
Receiving Sensitivity:	-211dB ±3dB re 1V/μPa
Transmitting Sensitivity:	130dB ±3dB re 1μPa/V at 1m at 100kHz
Horizontal Directivity Pattern:	Omnidirectional ±2dB at 100kHz
Vertical Directivity Pattern:	270° ±3dB at 100kHz
Nominal capacitance:	3.4nF
Operating depth:	700m
Survival depth:	1000m
Operating temperature range:	-2°C to +80°C
Storage temperature range:	-40°C to +80°C
Weight (in air):	75g
Cable length:	Standard length 6m Optional cable lengths available on request

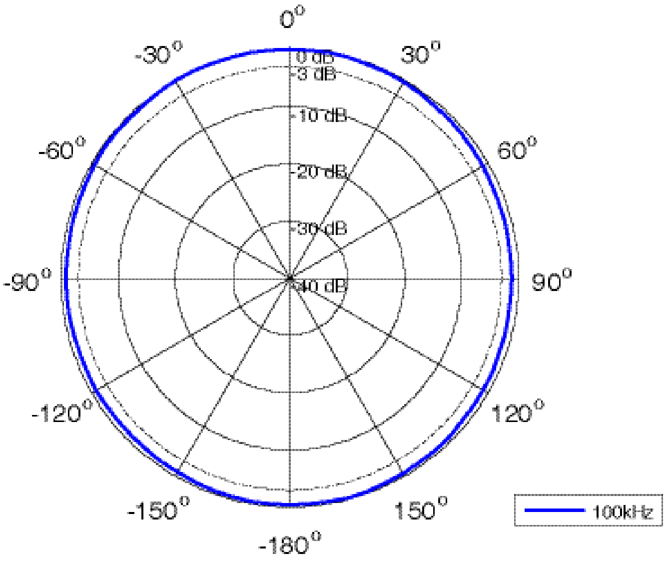


Hydrophone TC4013

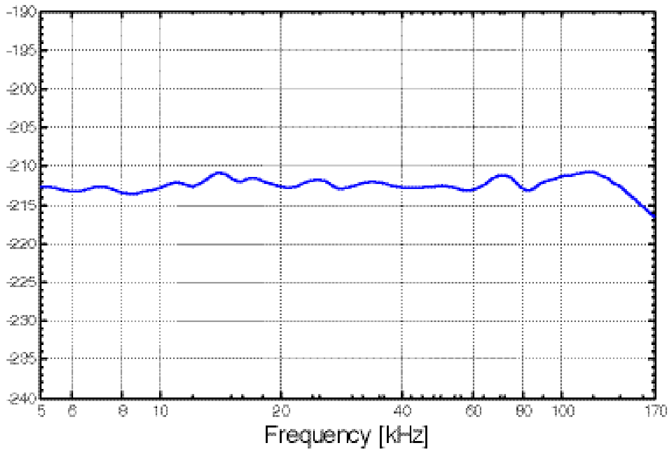
Miniature Reference Hydrophone

RESON

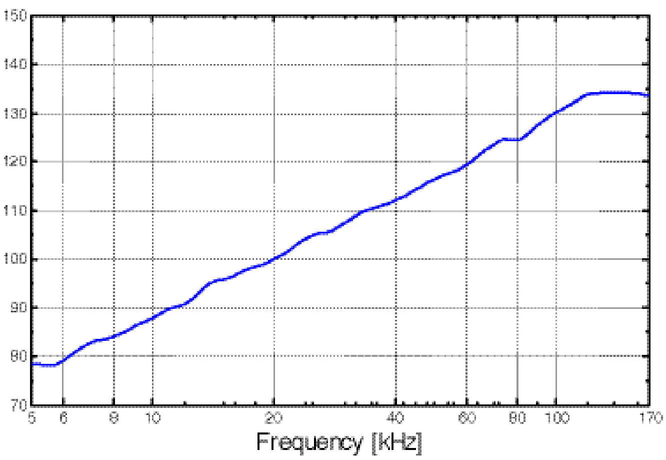
Horizontal directivity pattern



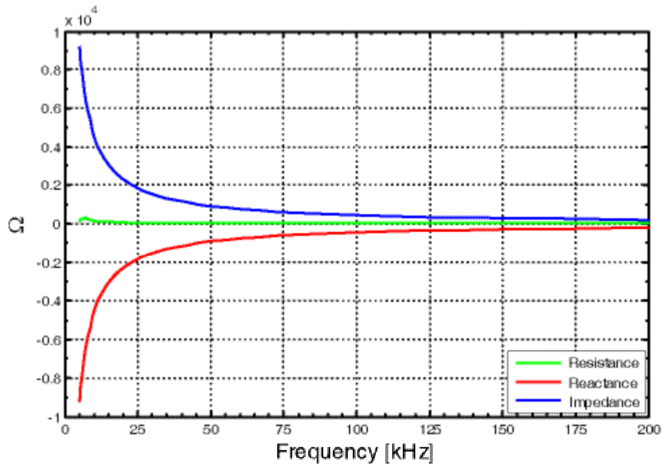
Receiving Sensitivity [dB re 1V/μPa @ 1m]



Transmitting Sensitivity [dB re 1μPa/V @ 1m]



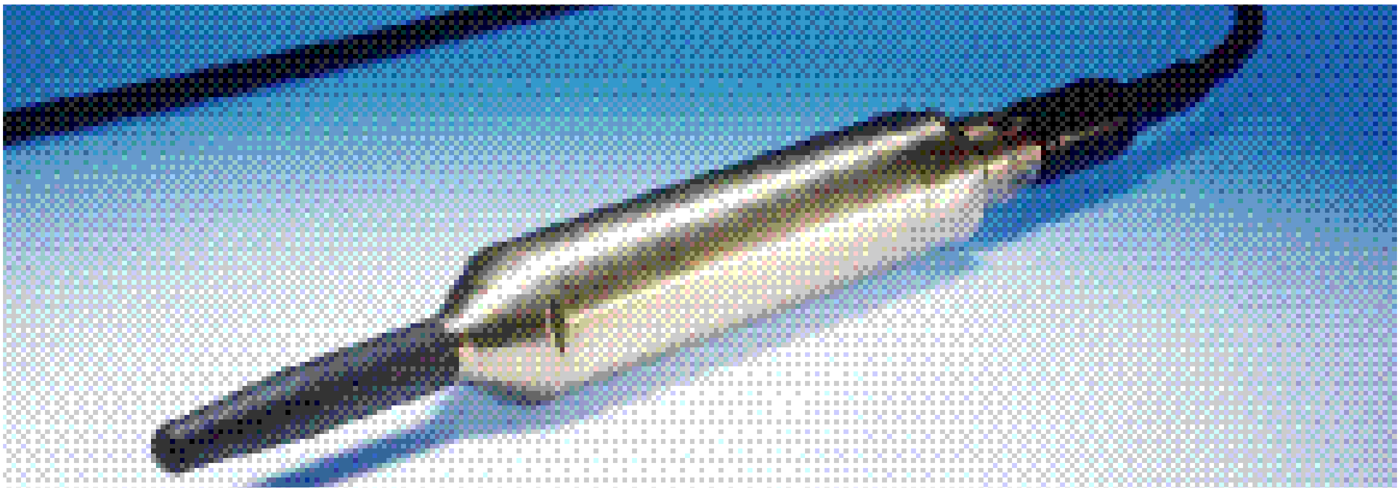
Impedance



RESON

Hydrophone TC4014

Broad Band Spherical Hydrophone



TC4014-5

- **Wide usable frequency range**
- **Omnidirectional in all planes**
- **Built-in low noise preamplifier**
- **Long term stability**
- **Individually calibrated**
- **Available with differential output**

he TC4014-5 broad band spherical hydrophone offers a very wide usable frequency range with excellent omnidirectional characteristics in all planes. The overall receiving characteristics makes the TC4014-5 an ideal transducer for making absolute underwater sound measurements up to 480kHz. The wide frequency range also makes the TC4014-5 perfect for calibration purposes, particularly in higher frequencies.
The TC4014-5 incorporates a low-noise 26dB preamplifier providing signal conditioning for transmission through long underwater cables.

The TC4014-5 features an insert calibration facility, which allows for a reliable test of the hydrophone.
The sensor element is permanently encapsulated in Special formulated NBR to ensure long term reliability. The rubber has been specially compounded to ensure acoustic impedance close to that of water. The hydrophone and connector housing are made of corrosion resistant aluminum-bronze.
TC4014-5 has differential output. The differential output is an advantage where long cables are used in an electrically noisy environment.

TECHNICAL SPECIFICATIONS	
Usable Frequency range:	15Hz to 480kHz
Linear Frequency range:	30Hz to 100kHz ±2dB 25Hz to 250kHz ±3dB
Receiving Sensitivity:	Single ended: -186dB ±3dB re 1V/μPa Diff. out: -180dB ±3dB re 1V/μPa)
Horizontal directivity:	Omnidirectional ±2dB at 100kHz
Vertical directivity:	270° ±2dB at 100kHz
Operating depth:	900m
Survival depth:	1200m
Operating temperature range:	-2°C to +55°C
Storage temperature range:	-40°C to +80°C
Weight in (air):	650g without cable
Max. output voltage:	≥2.8Vrms (at 12VDC)
Preamplifier gain:	26dB
Supply voltage:	12 to 24VDC
High pass filter:	15Hz -3dB
Calibration path attenuation:	at 10kHz 14dB
Current consumption:	<28mA at 12VDC <34 mA at 24VDC
Max. output effect:	50mW

Hydrophone TC4014

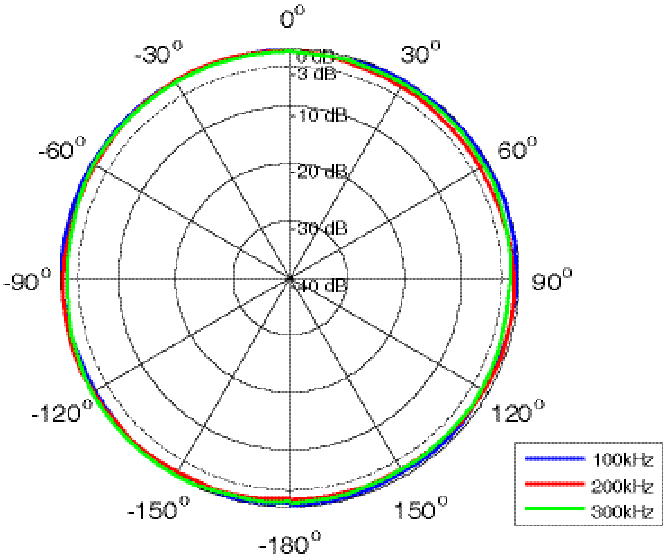
Broad Band Spherical Hydrophone

NBR means Nitrile Rubber
The NBR rubber is first of all resistant to sea and fresh water but also resistant to oil. It is limited resistant to petrol, limited resistant to most acids and will be destroyed by base, strong acids, halogenated hydrocarbons (carbon tetrachloride, trichloroethylene), nitro hydrocarbons (nitrobenzene, aniline), phosphate ester hydraulic fluids, Ketones (MEK, acetone), Ozone and automotive brake fluid.

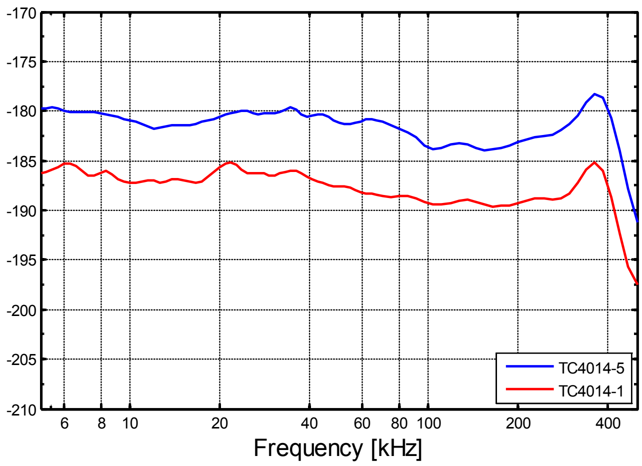
Documentation:
Receiving sensitivity: At 5 kHz to 500 kHz   Sensitivity at ref.: frequencies: 250 Hz

Horizontal directivity: At 100, 200, 300 kHz   Vertical directivity: At 100, 200, 300 kHz

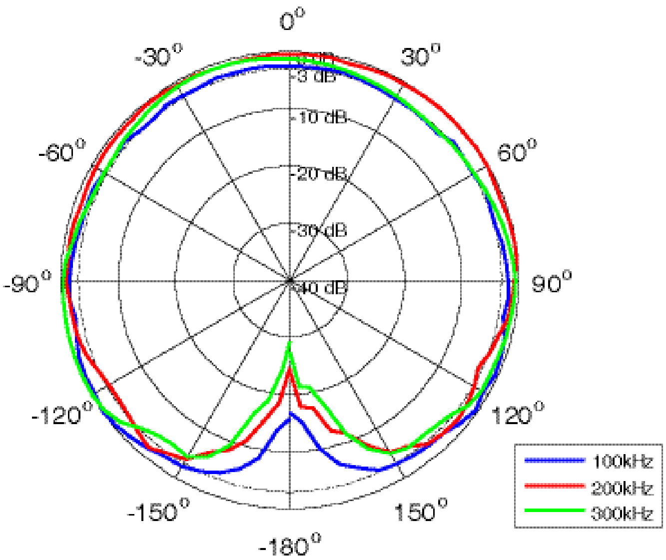
Horizontal directivity pattern



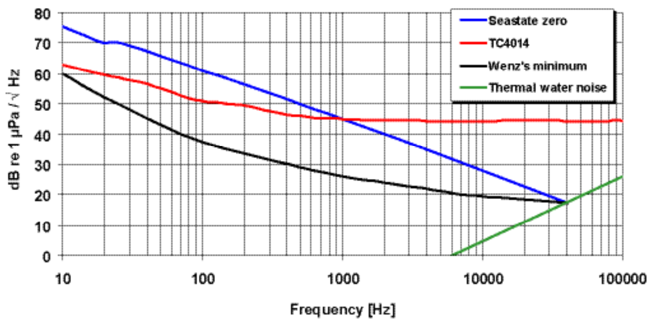
Receiving Sensitivity [dB re 1V/μPa @ 1m]



Vertical directivity pattern



Typical equivalent noise pressure curve

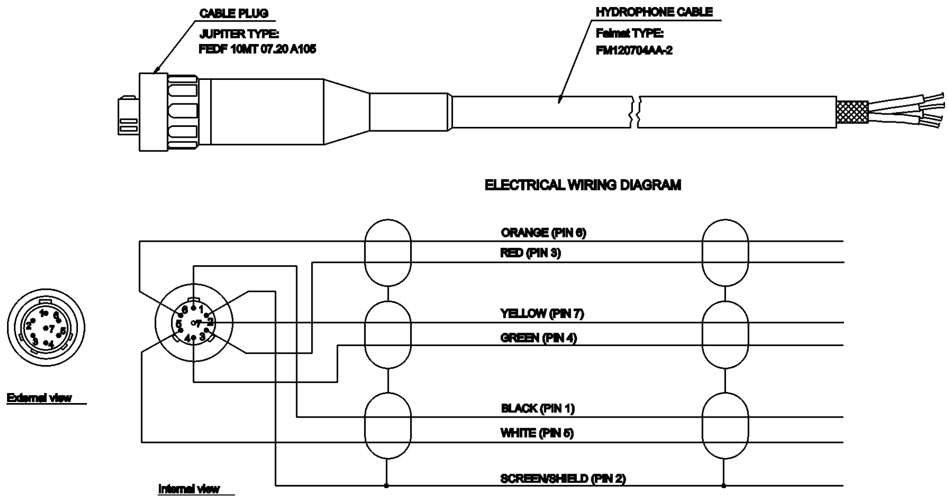


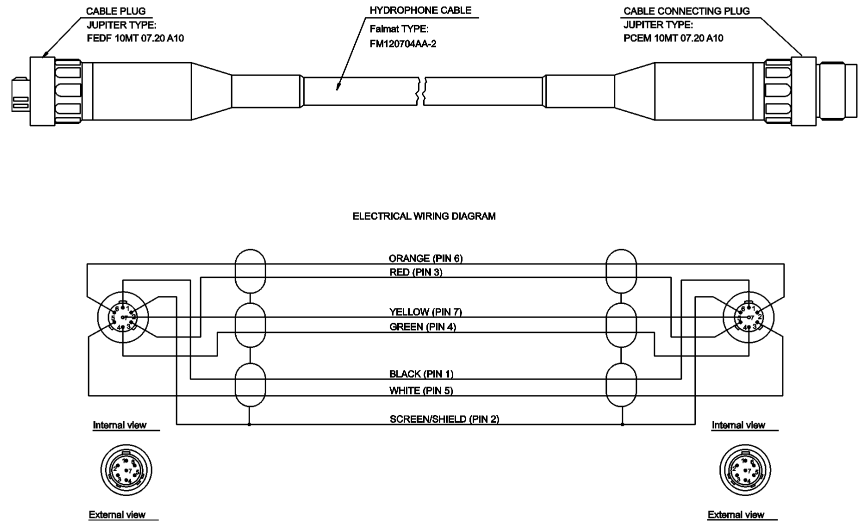
Valid for all versions of TC4014

Hydrophone TC4014
Broad Band Spherical Hydrophone

Accessories for TC4014-5

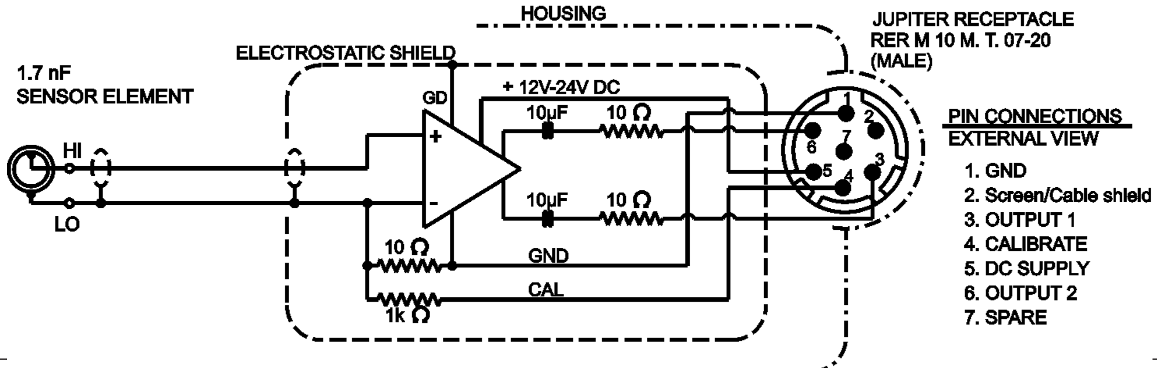
TL8140





TL8142

Electrical Diagram for TC4014-5



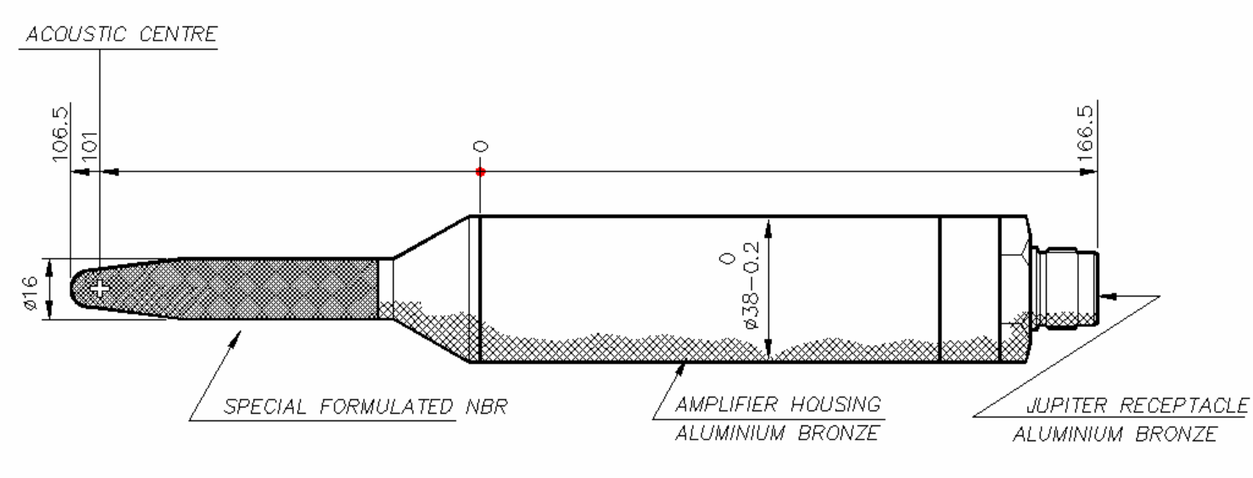
Insert voltage calibration

The TC4014 preamplifier contains an insert calibration circuit. This allows for electrical calibration of the hydrophone. The calibration method is not an absolute calibration but, it provides a reliable method for testing of the hydrophone, especially for hydrophones in fixed remote installations. The insert sine signal simulates the output signal from the sensor element.

To perform an insert calibration, use an appropriate function generator. The applied calibration signal must not exceed 10 Vrms. A higher voltage may damage the calibration resistor. 2 Vrms will be appropriate for insert calibration. The attenuation of the calibration signal is 14dB@10kHz for short cables.

Apply the signal to the calibrate input, connector contact 4. = green wire of cable. Connect generator ground to sine generator ground, and measure the signal on hydrophone output.

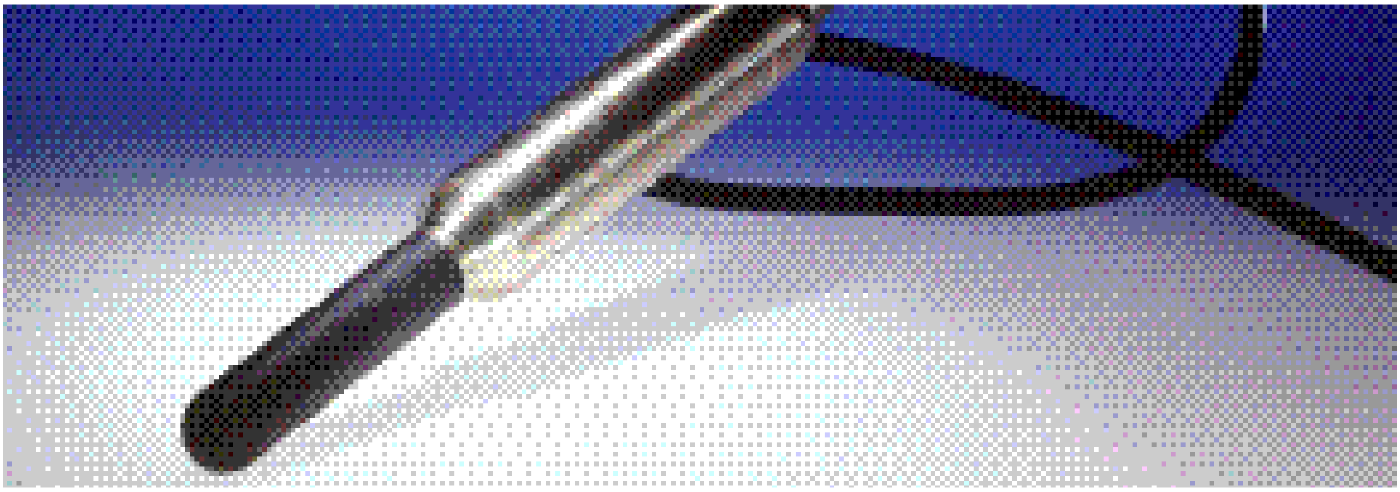
Outline Dimensions



RESON

Hydrophone TC4032

Low Noise Sea-State Zero Hydrophone



TC4032

- **Low noise performance**
- **High sensitivity**
- **Wide frequency range**
- **Flat frequency response**
- **Long term stability**
- **Individually calibrated**

The TC4032 general purpose hydrophone offers a high sensitivity, low noise and a flat frequency response over a wide frequency range.

The high sensitivity and acoustic characteristics makes TC4032 capable of producing absolute sound measurements and detecting even very weak signals at levels below “Sea State 0”.

The TC4032 incorporates an electrostatically shielded highly sensitive piezoelectric element connected to an integral low-noise 10dB preamplifier. The TC4032 preamplifier is capable of driving long cables of more than 1.000 meters, and the preamplifier features an insert calibration facility.
Per default the amplifier is provided with differential output. The differential output is an advantage where long cables are used in an electrically noisy environment. For use in single ended mode: Use positive output pin together with GND.
Versions with different filter characteristics are available: 4032-1 5Hz to 120 kHz, 4032-2 1Hz to 120 kHz and 4032-5 100Hz to 120 kHz.

TECHNICAL SPECIFICATIONS	
Usable Frequency range:	5Hz to120kHz
Linear Frequency range:	15Hz to 40kHz ±2dB 10Hz to 80kHz ±2.5dB
Receiving Sensitivity:	-164dB re 1V/mPa with differential output
Horizontal directivity:	Omnidirectional ±2dB at 100kHz
Vertical directivity:	270° ±2dB at 15kHz
Operating depth:	600m
Survival depth:	700m
Operating temperature range:	-2°C to +55°C
Storage temperature range:	-30°C to +70°C
Weight in Air:	720g without cable
Preamplifi er gain:	10dB
Max. output voltage:	3.5Vrms at 12VDC
Supply voltage:	12 to 24VDC
High pass fi lter:	7Hz -3dB
Quiescent supply current:	≤19mA at 12VDC ≤22mA at 24VDC
Encapsulating material:	Special formulated NBR
Housing material:	Alu Bronze AlCu10Ni5Fe4

Hydrophone TC4032

Low Noise Sea-State Zero Hydrophone

NBR means Nitrile Rubber

The NBR rubber is first of all resistant to sea and fresh water but also resistant to oil. It is limited resistant to petrol, limited resistant to most acids and will be destroyed by base, strong acids, halogenated hydrocarbons (carbon tetrachloride, trichloroethylene), nitro hydrocarbons (nitrobenzene, aniline), phosphate ester hydraulic fluids, Ketones (MEK, acetone), Ozone and automotive brake fluid.

Documentation:

Individually calibration curves: 250 kHz

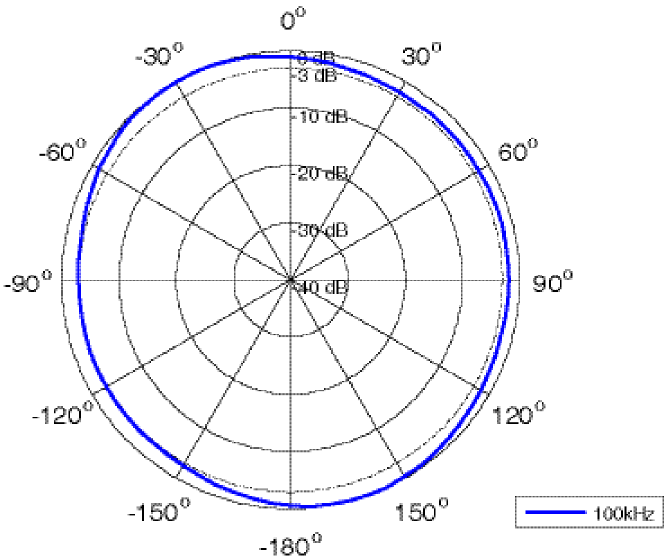
Receiving sensitivity: At 5 kHz to 100 kHz

Vertical directivity: At 15 kHz

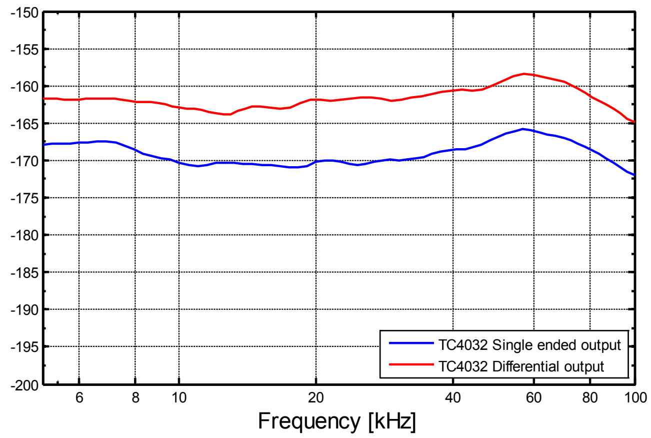
Sensitivity at ref.: frequencies: 250 kHz

Horizontal directivity: At 100 kHz

Horizontal directivity pattern

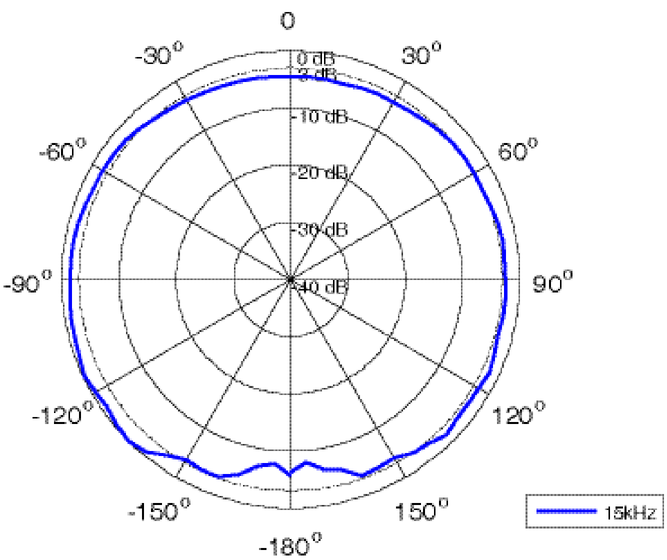


Receiving Sensitivity [dB re 1V/µPa @ 1m]

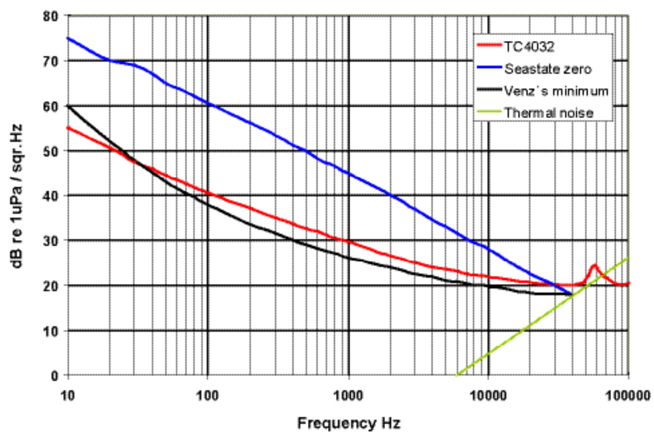


The OCR curve shown above is for single ended output

Vertical directivity pattern



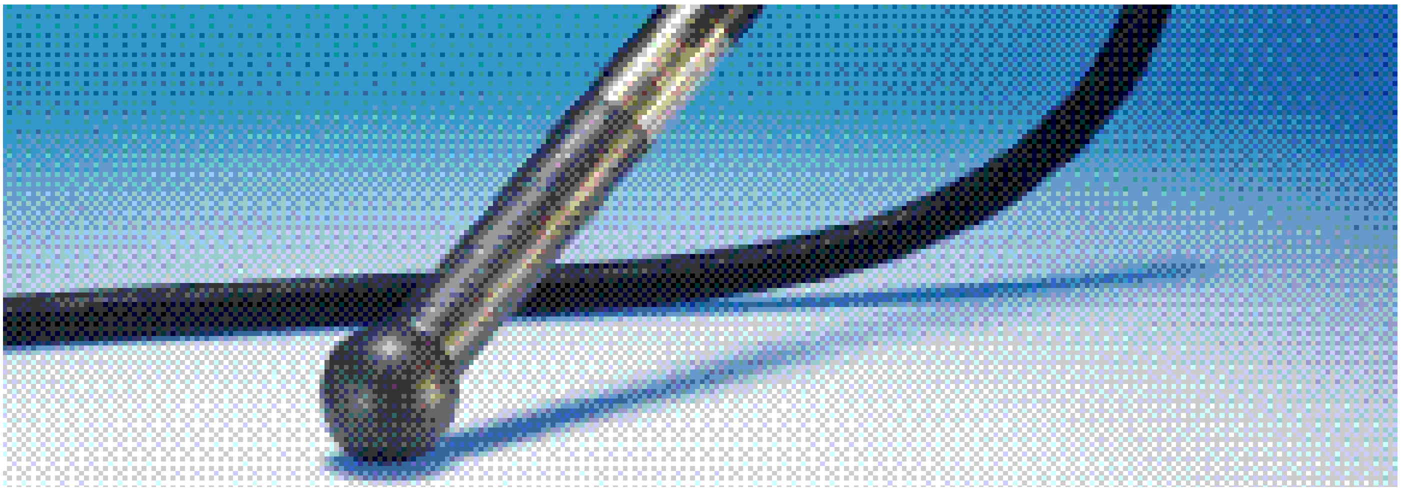
Typical equivalent noise pressure curve



Valid for all versions of TC4032

Hydrophone TC4033

Robust Spherical Reference Hydrophone



TC4033

- **Omnidirectional in the full frequency range**
- **Wide frequency range**
- **Durable construction**
- **Long term stability**
- **Individually calibrated**

The TC4033 provides uniform omnidirectional characteristics within the full frequency range of 1Hz to 140kHz.

The Typical sensitivity of -203dB re 1V/µPa and the capacitance of 7nF, ensure an excellent signal to noise ratio, thereby allowing TC4033 to be used with extension cables with only a limited reduction in sensitivity.

The TC4033 offers excellent acoustic characteristics and durability, which makes it ideal for a wide range of applications and for calibration purposes.

TECHNICAL SPECIFICATIONS	
Usable Frequency range:	1Hz to 140kHz
Linear Frequency range:	1Hz to 80kHz
Receiving Sensitivity:	-203dB ±2dB re 1V/µPa at 250Hz
Transmitting Sensitivity:	144dB ±2dB re 1µPa/V at 1m at 100kHz
Directivity, Horizontal:	Omnidirectional ±2dB at 100kHz
Vertical Directivity:	270°±2dB at 100kHz
Nominal Capacitance:	7,8nF (incl.10m cable)
Operating depth:	900m
Operating Temperature range:	-2°C to +80°C
Storage Temperature range:	-40°C to +80°C
Weight incl. 10m cable, (in air):	1.5kg
Cable (length and type):	Standard 10m shielded pair DSS-2/MIL-C-915. Optional cable length available on request
Connector type:	BNC
Encapsulating material:	Special formulated NBR
Metal body:	Alu bronze AlCu10Ni5Fe4

Hydrophone TC4033

Robust Spherical Reference Hydrophone

Documentation:

Individually calibration curves:

Sensitivity at ref.: frequencies:
250 kHz

Receiving sensitivity:
At 5 kHz to 200 kHz

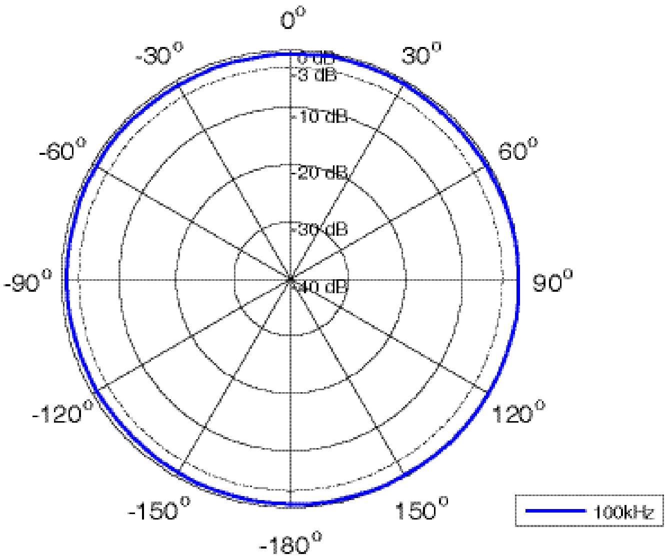
Impedance:
5 kHz to 200kHz

Horizontal directivity:
At 100 kHz

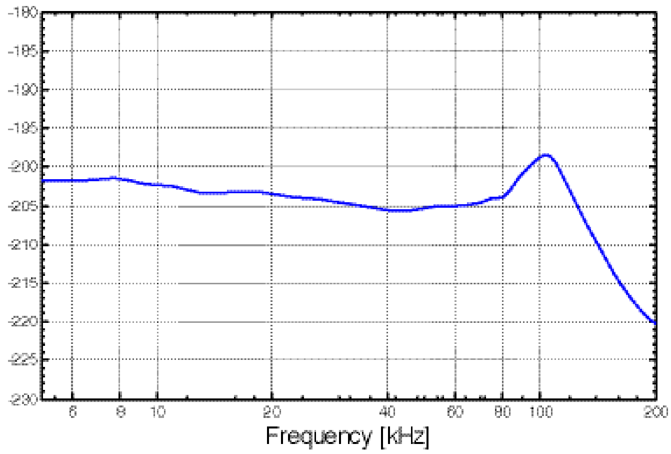
Vertical directivity:
At 100 kHz

Transmitting sensitivity:
5 kHz to 200 kHz

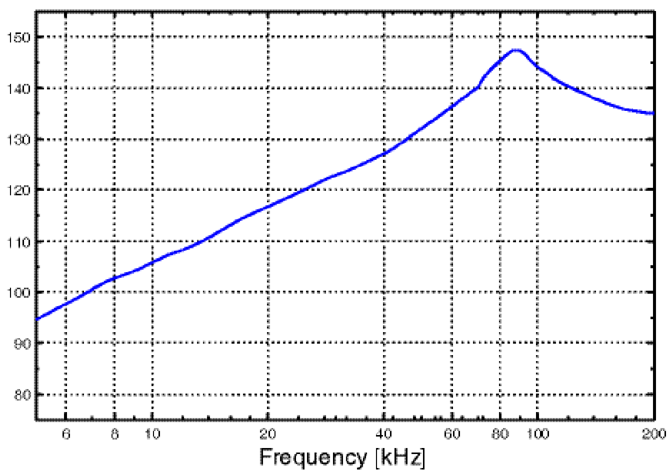
Horizontal directivity pattern



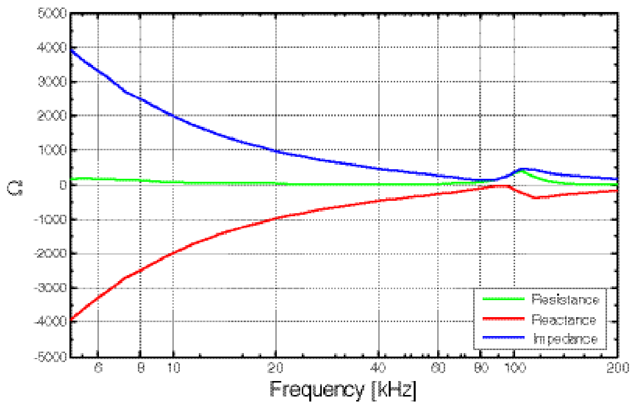
Receiving Sensitivity [dB re 1V/μPa @ 1m]



Transmitting Sensitivity [dB re 1μPa/V @ 1m]



Impedance



Hydrophone TC4034

Ultra Broad-band Spherical

TC4034

- **Omnidirectional in the full frequency range**
- **Long term stability**
- **Extreme Wide frequency range**
- **Durable construction**
- **Individually calibrated**

The TC4034 broad band spherical hydrophone provides uniform omni-directional characteristics over a wide frequency range of 1Hz to 480kHz.

The overall receiving characteristics makes the TC4034 an ideal transducer for making absolute underwater sound measurements up to 480kHz. The wide frequency range also makes the TC4034 perfect for calibration purposes, particularly in higher frequencies.

TECHNICAL SPECIFICATIONS	
Usable Frequency range:	1Hz to 470kHz (+3, -10dB)
Linear Frequency range:	1Hz to 250kHz (+2, -4dB)
Receiving Sensitivity: (re 1V/μPa)	-218dB ±3dB (at 250Hz)
Horizontal directivity:	Omnidirectional ±2dB (at 100kHz)
Transmitting sensitivity:	122dB ±3dB re 1μPa/V at 1m at 100kHz
Vertical directivity:	>270° ±3dB (at 300kHz)
Nominal Capacitance:	3nF
Operating Depth:	900m
Survival Depth:	1000m
Operating Temperature range:	-2°C to +80°C
Storage Temperature range:	-40°C to +80°C
Weight incl. cable,(in air):	1.6 kg
Cable (length and type):	Standard 10m shielded pair DSS-2MIL-C915. Optional cable length available on request
Encapsulating Material:	Special formulated NBR
Metal body:	Alu-bronze AlCu10Ni5Fe4
Connector type:	BNC

RESON

Hydrophone TC4034

Ultra Broad-band Spherical

Documentation:

Vertical directivity:
At 250 kHz 100,200,300 kHz

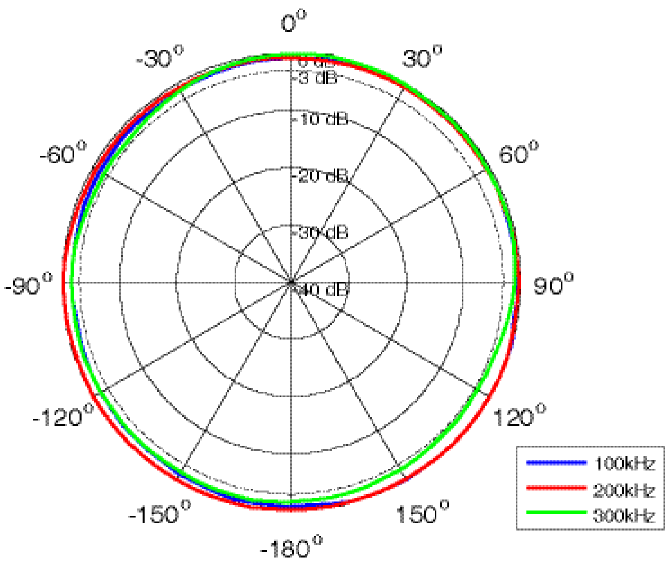
Horizontal directivity:
At 100, 200, 300 kHz

Receiving sensitivity:
5 kHz to 500 kHz

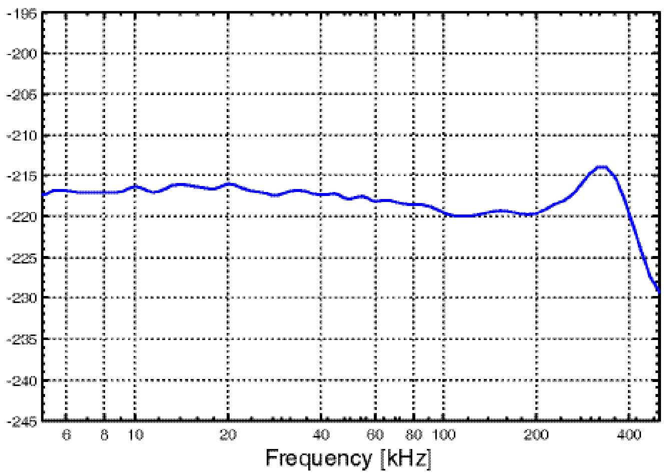
Impedance:
5 kHz to 500 kHz

Transmitting sensitivity:
5 kHz to 500 kHz

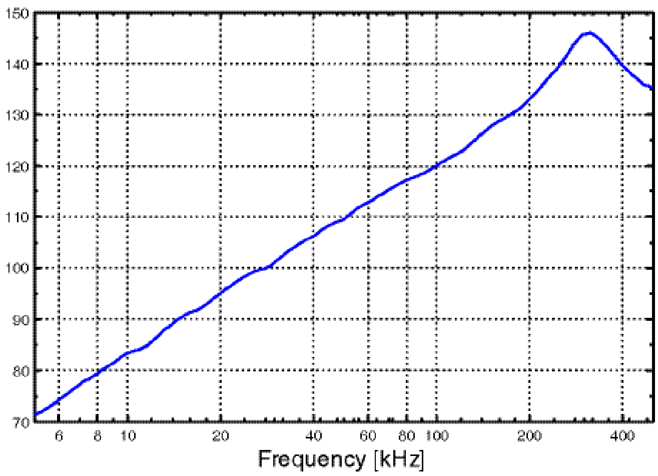
Horizontal directivity pattern



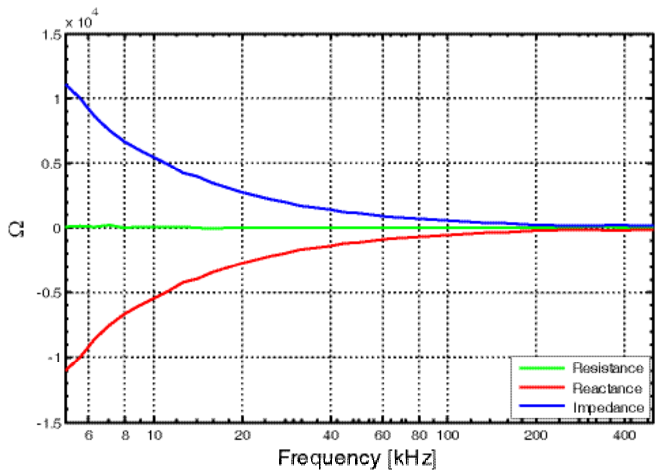
Receiving Sensitivity [dB re 1V/µPa @ 1m]



Transmitting Sensitivity [dB re 1µPa/V @ 1m]



Impedance

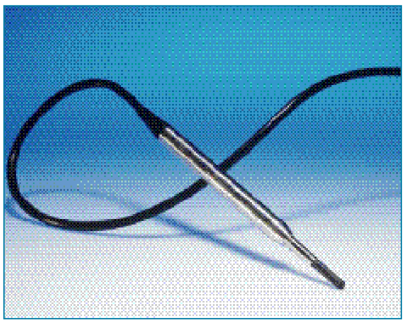


Hydrophone TC4035

Broad Band Miniature Probe Hydrophone

TC4035

- **Reference hydrophone for high frequencies**
- **Linear receiving response from 100kHz to 500kHz**
- **Long term stable sensitivity**
- **Individually calibrated**
- **Calibration as standard reference hydrophone traceable to national standards established at NPL**



The TC4035 is a miniature probe hydrophone specifically designed as a standard reference hydrophone for sound measurements in the frequency range 100 to 500kHz.

The hydrophone incorporates a 10dB low-noise pre-amplifier, which includes an insert calibration circuit for convenient electrical testing of the hydrophone condition. The pre-amp has a drive capability for cable length up to 25 meters.

The hydrophone offers a useable frequency range from 10 to 800kHz with good omnidirectional characteristics in the horizontal and the vertical plane.

TECHNICAL SPECIFICATIONS	
Receiving Sensitivity Typical:	-214dB ±2dB re 1V/µ Pa (at 100kHz)
Linear Frequency Range:	100kHz to 500kHz ±3dB
Usable Frequency Range:	10kHz to 800kHz
Horizontal Directivity:	Omnidirectional ±2dB (at 250kHz)
Vertical Directivity:	60°to 120° ±3dB (at 250kHz)
Operating Pressure:	300m
Survival Pressure	400m
Max. Sound Pressure:	-4dB destortion level 210dB re 1µPa at 12V supply
Equivalent noise:	80dB re 1µPa (√H at 1kHz)
Weight (in air):	410 grams (LEMO receptacle incl.)
Max. Output Voltage :	1Vrms at 12VDC 2Vrms at 24VDC
Operating Temperature Range:	-2°C to +40°C
Storage Temperature Range:	-30°C to +50°C
Supply Voltage:	10VDC to 24VDC
Preamplifier Gain:	10dB
Output Drive Capability:	25m cable at 1M Ohm input
Insert cal. attenuation:	-30dB
Quiescent Current:	15mA at 12VDC 20.5mA at 18VDC
Housing Material:	Stainless Steel AISI 316
Cable:	Standard 10m 4 cond.+ shielded Optional cable lengths available on request
Connector:	LEMO Series E four-pole watertight

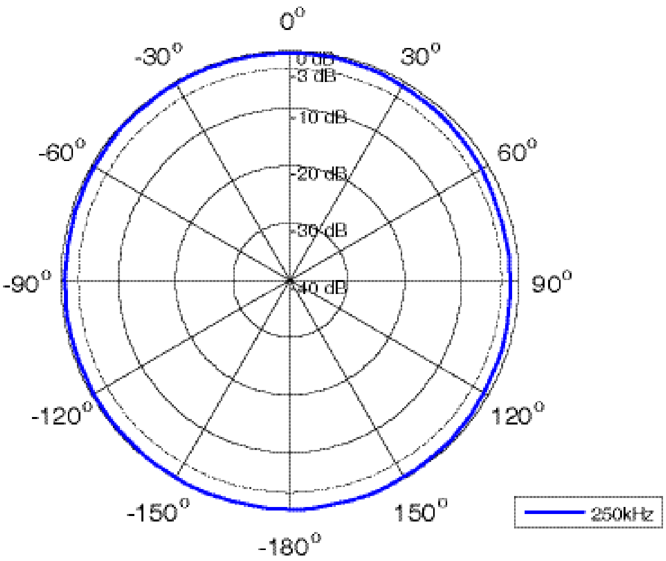
Hydrophone TC4035

Broad Band Miniature Probe Hydrophone

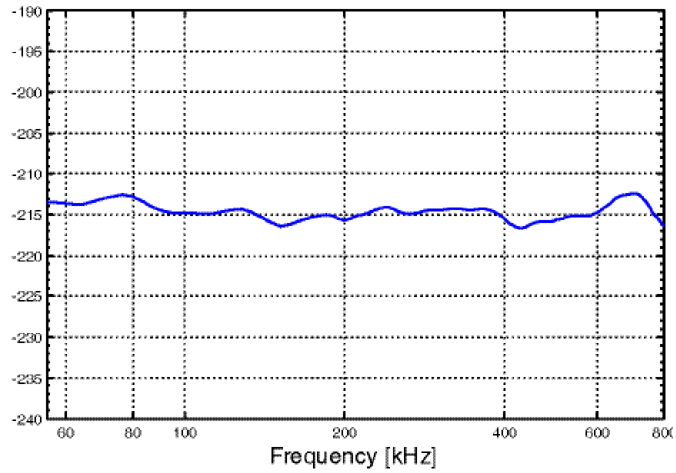
Documentation:

Horizontal directivity:	Receiving sensitivity:	Vertical directivity:
At 250 kHz	50 kHz to 800 kHz	At 250 kHz

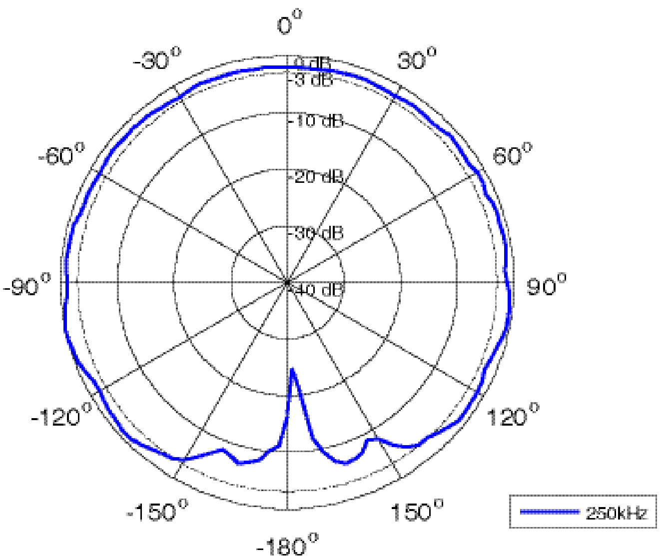
Horizontal directivity pattern



Receiving Sensitivity [dB re 1V/µPa @ 1m]



Vertical directivity pattern



Accessories included: LEMO fixed socket no. ERA.1E.304.CNL

The TC4035 is a high quality hydrophone designed for use as a transfer standard hydrophone. The sensor element has excellent stability over time, - which ensure reliable sensitivity over long periods.

Connecting the TC4035: The TC4035 is supplied with a 4-pole LEMO plug and a receptacle for individual panel mounting.

The EC6073 input module is a universal junction unit for connections of hydrophones. The TC6073 is equipped with the connectors required for: input output, voltage supply and insert calibration signal.

Insert voltage calibration: The insert calibration is an electrical simulation of a signal received from the acoustic sensor element.

Injecting a signal to the calibration line input performs insert calibration. The responding signal received on the hydrophone output terminal is attenuated -30 dB typical.

The recommended max. insert voltage signal for TC4035 is 2 Vpp.

WARNING! Exceeding the recommended calibration voltage may cause damage to the calibration resistor.

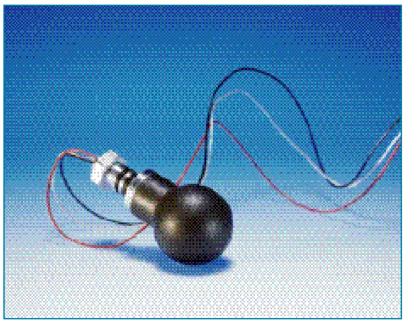
RESON

Hydrophone TC4037

Spherical Reference Hydrophone

TC4037

- **High receiving voltage sensitivity**
- **Differential signal output**
- **Wide useable frequency**
- **Long term stability**
- **Omnidirectional in all planes**
- **Resistant to high static pressure**
- **Individually calibrated**



The TC4037 hydrophone sensor module provides a differential balanced output signal. It has been designed especially for operation with a differential preamplifier.

The use of differential sensor signals offers advantages such as, limitation of DC offset and fluctuation. It further adds 6dB more sensor sensitivity, -reduces noise distortion and makes the sensor less sensitive to vibration, temperature.

The mounting support is equipped with sealing o-rings that allows for convenient waterproof mounting.

TECHNICAL SPECIFICATIONS	
Usable Frequency range:	1Hz to 100kHz
Linear Frequency range:	1Hz to 50kHz ±3dB
Receiving Sensitivity nominal:	-193dB re 1V/μPa at 250Hz (with differential pre-amp 0dB)
Directivity, Horizontal plane:	Omnidirectional ±2dB at 40kHz
Vertical plane:	270° ±3dB at 40kHz
Capacitance nominal:	2 x 4,5 nF
Leakage resistance:	≥1G ohm
Operating temperature range:	-2°C to +55°C (with preamplifier)
Storage temperature range:	-40°C to +80°C
Operating depth:	1500m
Survival depth:	2000m (4037-3 3500m)
Terminating wires:	3 x AWG 22, length 0.5m
Weight in air:	86g.
Encapsulating mat.:	Special formulated NBR
Metal body:	**TC4037-2**: Aluminum alloy Al Mg1Si **TC4037-3:** Promet 12 CuSn 12 Tin bronze

NBR means Nitrile Rubber

The NBR rubber is first of all resistant to sea and fresh water but also resistant to oil. It is limited resistant to petrol, limited resistant to most acids and <u>will be destroyed</u> by base, strong acids, halogenated hydrocarbons (carbon tetrachloride, trichloroethylene), nitro hydrocarbons (nitrobenzene, aniline), phosphate ester hydraulic fluids, Ketones (MEK, acetone), Ozone and automotive brake fluid.

Metal body: TC4037-2 Aluminium alloy Al Mg1Si – If installed on a metal housing it is important that the housing is made of a similar material.

RESON Hydrophone TC4037

Spherical Reference Hydrophone

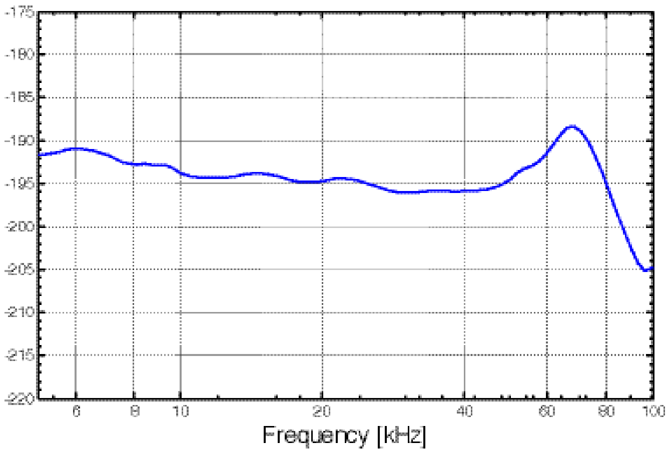
Documentation:

Receiving sensitivity:
5 kHz to 100 kHz

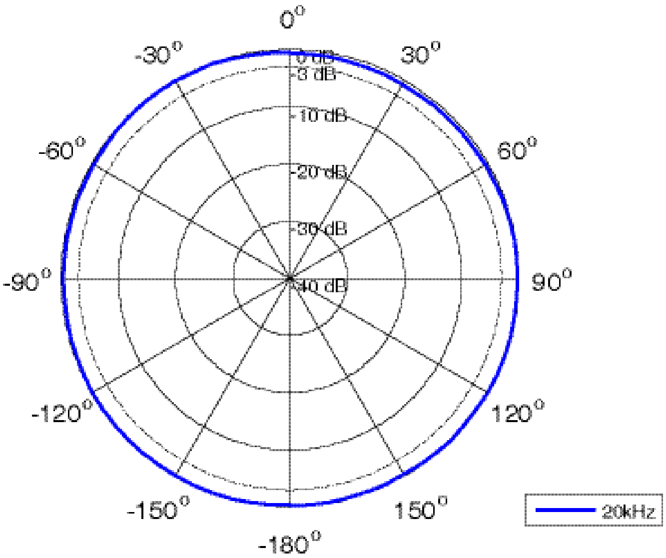
Horizontal directivity:
20 kHz

Vertical directivity:
20 kHz

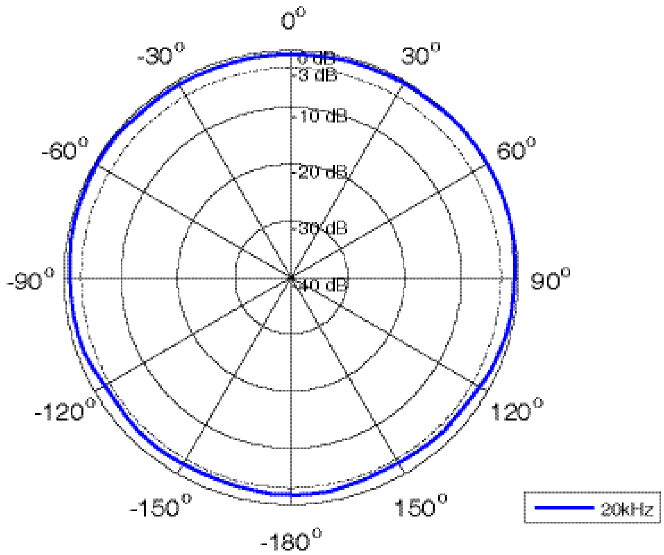
Receiving Sensitivity [dB re 1V/μPa @ 1m]



Horizontal directivity pattern



Vertical directivity pattern



Hydrophone TC4038

Broad Band Miniature Probe Hydrophone

TC4038

- **Reference hydrophone for high frequencies**
- **Linear receiving response from 100kHz to 500kHz**
- **Individually calibrated**
- **Calibration as standard reference hydrophone traceable to national standards established at NPL, UK**

The TC4038 is a miniature probe hydrophone, specifically designed as a standard reference hydrophone for high frequencies in the range: 100kHz to 500kHz.

The TC4038 provides a flat frequency response and omnidirectional characteristics in the specified frequency range. The sensor element has excellent stability, which ensures reliable sensitivity over long periods of time.

Because of its small size, the TC4038 is an ideal hydrophone for acoustic measurements in near fields.

Usable Frequency range:	10kHz - 800kHz
Linear Frequency range:	100 to 500kHz ±3dB
Receiving Sensitivity nominal:	-228dB ±3dB re 1V/µPa (at 100kHz)
Horizontal Directivity Pattern:	Omnidirectional ±2dB (at 100kHz)
Vertical Directivity Pattern:	60°to 120° ±3dB (at 100kHz)
Max. Operating Pressure:	0,2MPa = 2atm
Max. Operating Depth:	20m
Max. Survival Depth:	30m
Equivalent noise:	80dB re 1µPa (with VP1000 Pre-amp √Hz at 1 kHz)
Max. Sound Pressure:	0,3M Pa
Operating Temperature range:	-2°C to +40°C
Storage Temperature range:	-30°C to +50°C
Leakage Resistance:	>2Gohm
Impedance:	100Mohm (Min. input for min. noise down to 10 kHz lower frequency limit)
Weight in Air:	20grams
Cable (length and type):	2m double shielded low noise FEP. Insulated OD 1,65mm

The sensor element is permanently encapsulated in high density polyurethane to ensure long term reliability. The strain relief and outer jacket of the cable is also made of high density polyurethane.

4038 can be used in sea or fresh water.

4038 can be used as a projector but is not designed for it – do not exceed 25Vrms. Duty cycle need to be low around 1%.

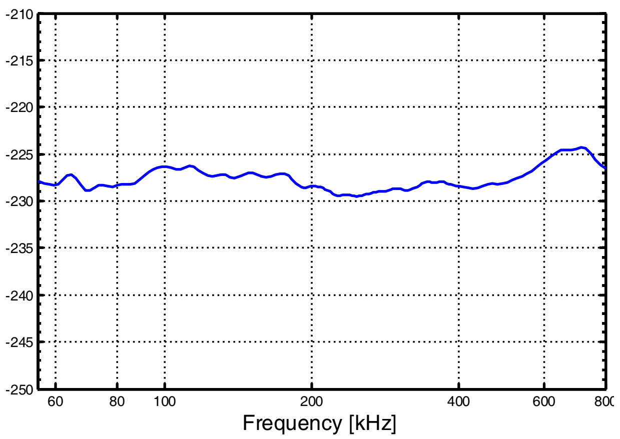
Hydrophone TC4038

Broad Band Miniature Probe Hydrophone

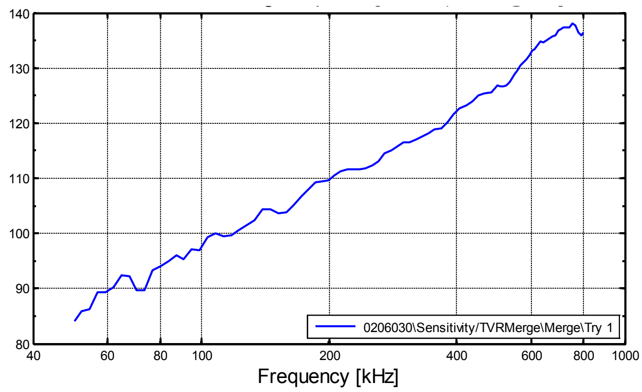
Documentation:

Receiving sensitivity:	Horizontal directivity:	Vertical directivity:
50 kHz to 800 kHz	250 kHz	250 kHz

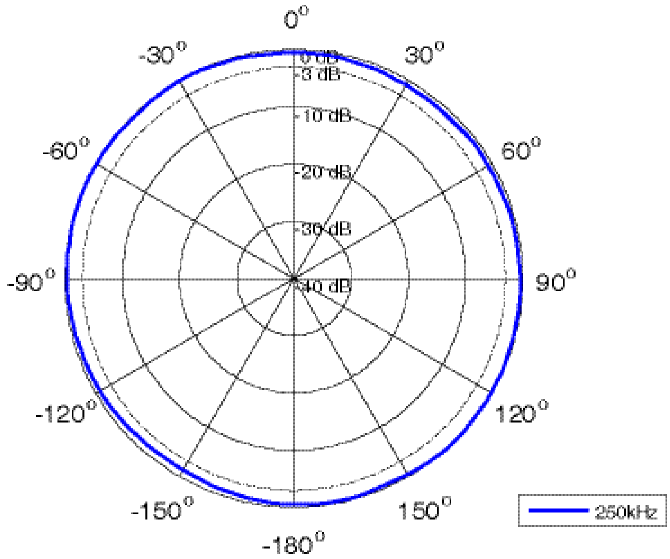
Receiving Sensitivity [dB re 1V/μPa @ 1m]



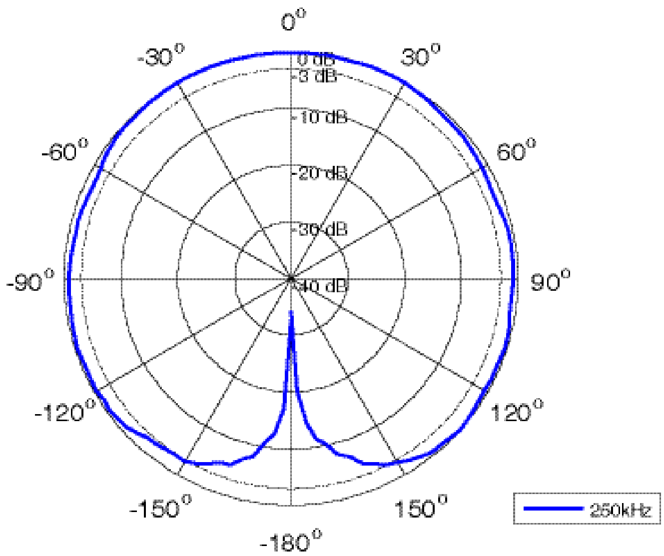
Transmitting Response [dB re 1μPa/V @ 1m]



Horizontal directivity pattern



Vertical directivity pattern



Hydrophone TC4040

Reference Hydrophone

TC4040

- **Wide operating frequency range**
- **Flat response over a wide frequency range**
- **Titanium mounting support**
- **Individually calibrated**
- **Water blocked cable to Mil: C-915**

The TC4040 is an ideal standard reference hydrophone for calibration of transducers, hydrophones and underwater acoustic measurement systems.

The TC4040 offers flat frequency receiving response over a wide frequency range and the relatively high transmitting sensitivity makes it very useful within many areas of underwater acoustic research, tests and measurements.

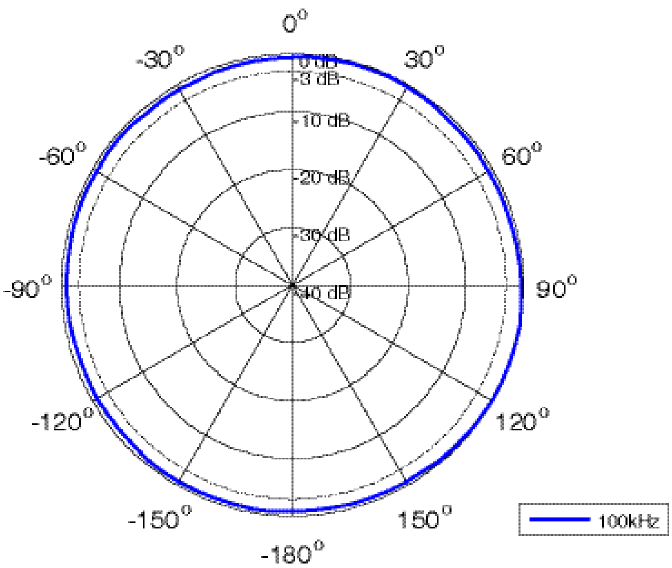
The TC4040 utilises sensor element technology that ensures a high stability with time and excellent performance.
The ceramic sensor element is encapsulated in Special formulated NBR. The metallic support made of titanium, allows for precise mounting in suspension hangers.

TECHNICAL SPECIFICATIONS	
Usable Frequency range:	1Hz to 120kHz +2 -10dB
Linear Frequency range:	1Hz to 80kHz ±2dB
Receiving voltage Sensitivity:	-206dB re 1V/μPa (±3dB) 56μV/Pa (nominal)
Charge Sensitivity:	0.42pC/Pa (nominal)
Transmitting sensitivity:	132dB re 1μPa/V at 1m (at 100kHz)
Horizontal directivity:	Omnidirectional ±2dB at 100kHz (Typical)
Vertical directivity:	270° ±2dB at 50kHz (Typical)
Capacitance:	8.3nF (nominal)
Leakage resistance:	>2Gohm
Operating depth:	400m
Survival depth:	500m
Operating temperature range:	-2°C to +80°C
Storage temperature range:	-40°C to +80°C
Weight incl. Cable, (in air):	1.6kg
Cable (length and type):	10m shielded twisted pair, DSS-2 MIL-C-915 Optional cable lengths available on request
Encapsulating material:	Special formulated NBR
Metal body:	Titanium

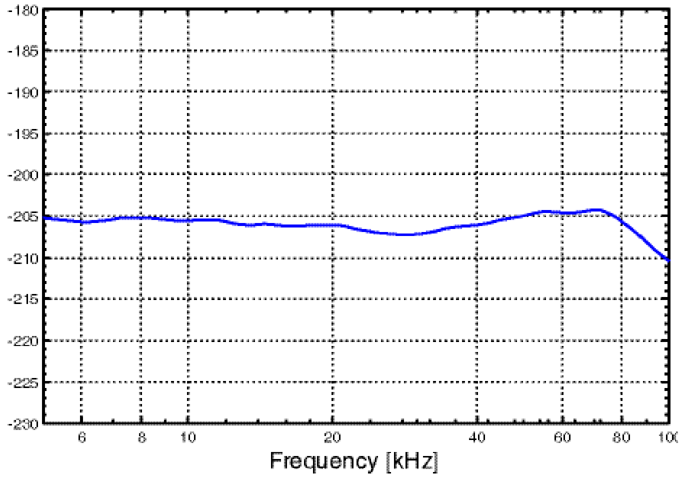
Hydrophone TC4040

Reference Hydrophone

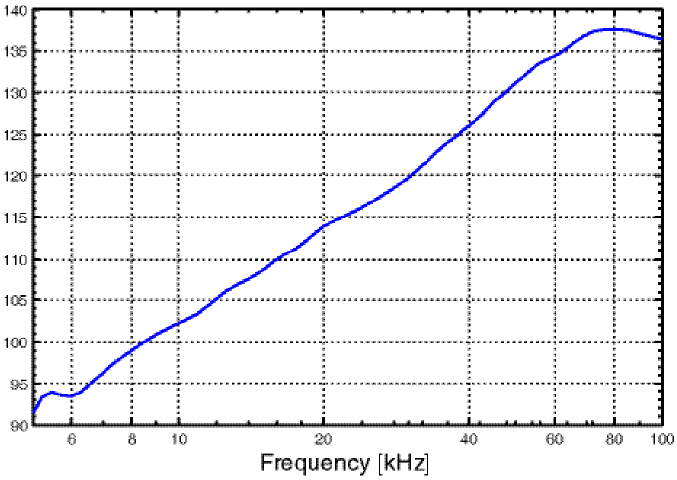
Horizontal Directivity Pattern



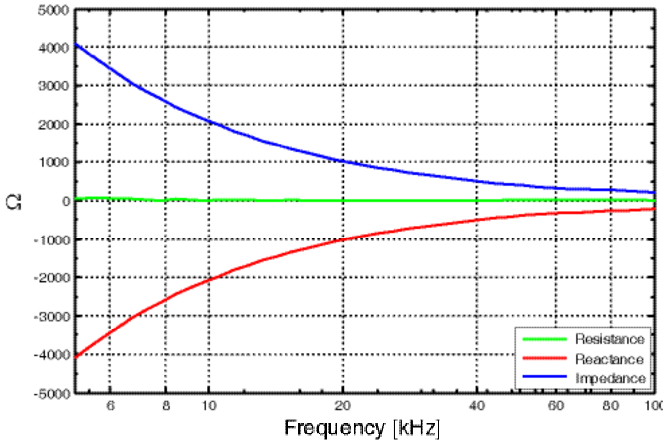
Receiving Sensitivity [dB re 1V/μPa @ 1m]



Transmitting Sensitivity [dB re 1μPa/V @ 1m]

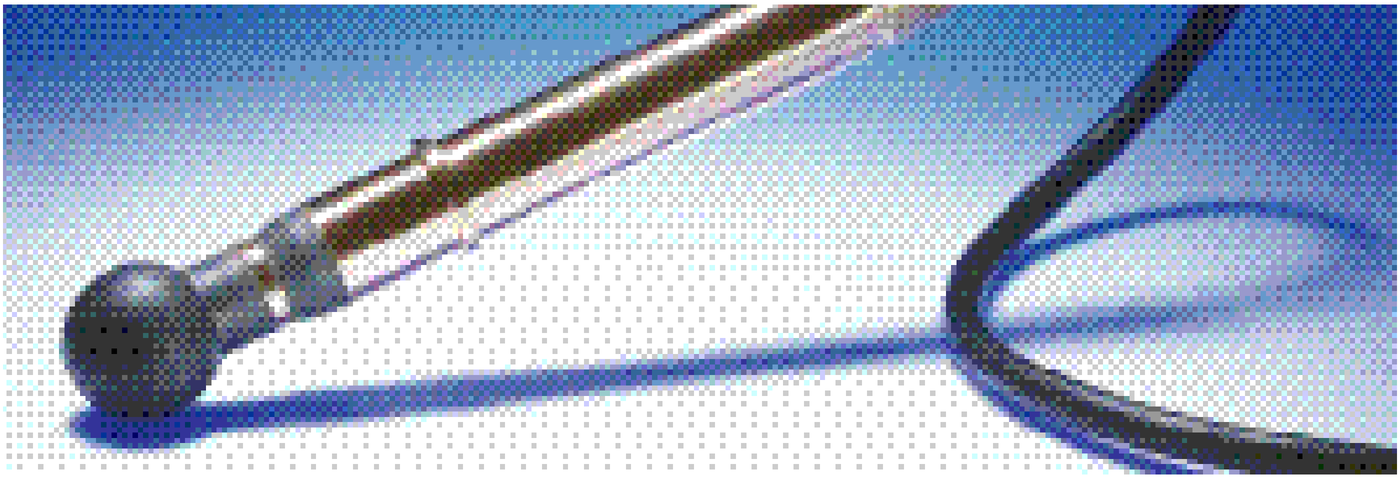


Impedance



Hydrophone TC4042

Low-Noise Spherical Hydrophone



TC4042

- **Wide frequency range**
- **Spherical differential sensor**
- **Differential in/output amplifier**
- **Single or differential output**
- **Self supporting cables to 1000m**
- **IVC calibration**

The TC4042 is a spherical, low-noise hydrophone with 20dB differential pre-amplifier. The hydrophone provides a single output mode.

The single-end output mode is established with a four conductor cable. The built-in preamplifier has the capability of driving cables of more than 1km.

The TC4042 features an insert voltage calibration facility (IVC), which enables remote testing of the hydrophone condition.

TECHNICAL SPECIFICATIONS	
Receiving Sensitivity, typical:	-173dB re 1V/uPa (2.2 mV/Pa)
Useable frequency range:	5Hz to 85kHz
Linear frequency range:	15Hz to 45kHz +1/-5dB
Horizontal directivity:	±2dB at 40kHz
Vertical directivity:	±3dB at 40kHz over 270 deg.
Max. operating depth:	1000m
Survival depth:	1200m
Operating temperature range:	-2°to +55°C
Storage temperature range:	-30°to +70°C
Preamplifier gain:	+20dB
Max. voltage output:	3Vrms (at 12V supply) 7Vrms (at 24V supply)
Current consumption:	≤9mA (at 12V supply) ≤22mA (at 24V supply)
Output impedance:	10ohms + 100μF
High pass filter:	15Hz (-3dB)
Low-pass filter:	150kHz (-3dB)
Hydrophone weight:	450g
Housing material:	Alu Bronze AICu1ONi5Fe4
Encapsulating polymer:	Special formulated NBR

Hydrophone TC4042

Low-Noise Spherical Hydrophone

RESON

Documentation:

Individually calibration curves:

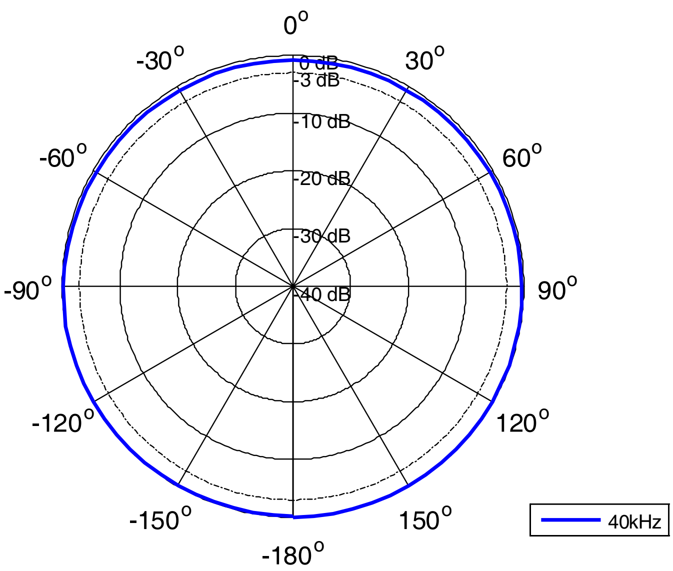
Sensitivity at ref.: frequency:
250Hz

Receiving sensitivity:
At 5kHz to 90kHz

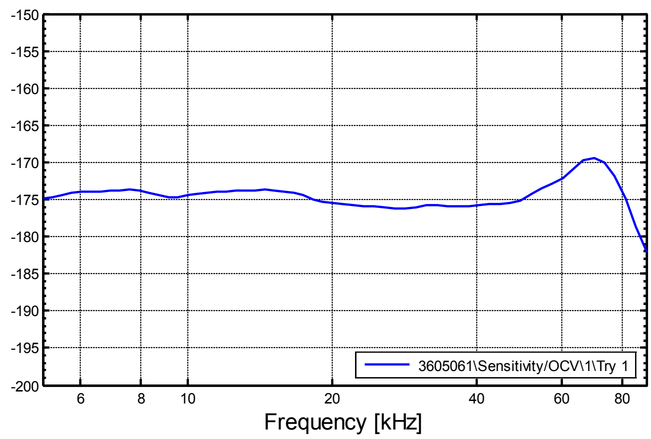
Vertical directivity:
At 40kHz

Horizontal directivity:
At 40kHz

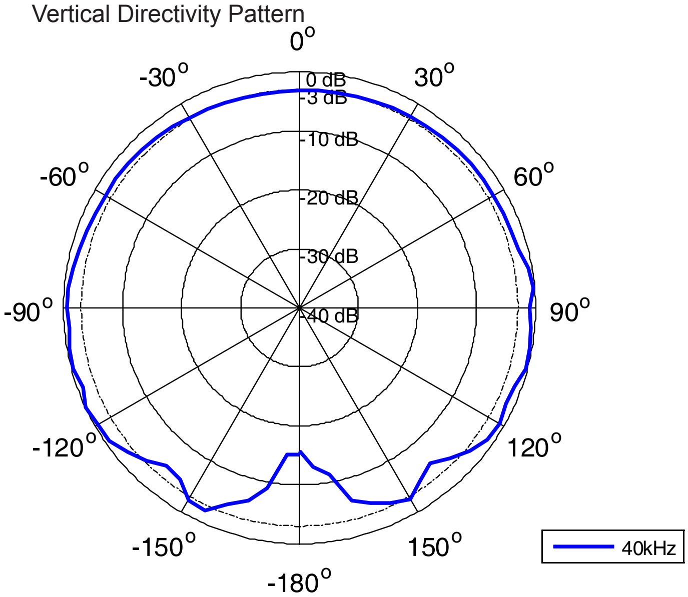
Horizontal Directivity Pattern



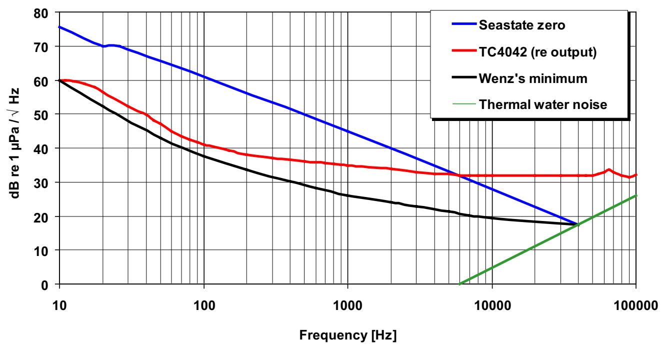
Receiving Sensitivity [dB re 1V/µPa @ 1m]



Vertical Directivity Pattern



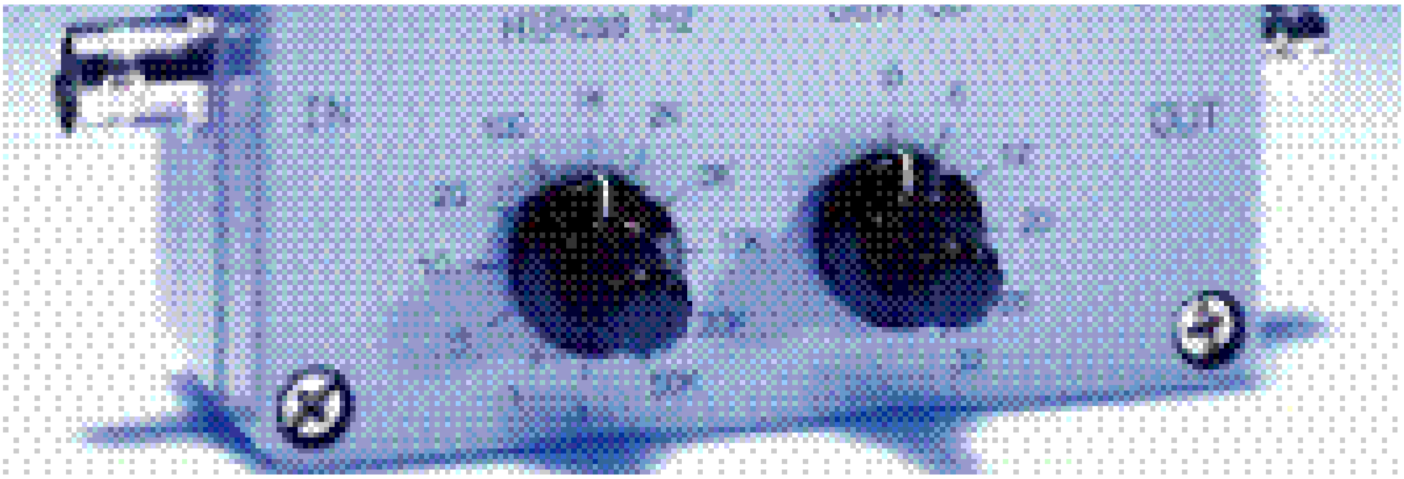
Typical Equivalent Noise Pressure Curve



RESON

EC6061

VP1000 Voltage preamplifier



EC6061

- **1Hz to 1MHz bandwidth Hi-pass filter options**
- **6 level gain selection**
- **100Mohm inputimpedance**
- **Excellent low-noise characteristic**

The VP1000 is a 1MHz bandwidth single ended voltage preamplifier, designed for use with piezoelectric hydrophone and a variety of transducers. VP1000 offers excellent low-noise performance, gain selection in 6 levels and options of 12 Hi-Pass filters.

The high input impedance of 100Mohm allow for low frequency measurements with even very small sensor element capacities.

Encapsulated in aluminum box The VP1000 is water stain resistant.

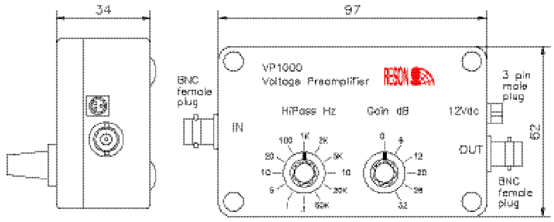
TECHNICAL SPECIFICATIONS	
Input:	
Impedance:	100MΩ//2.5pF
Max. level:	2.8Vrms at 12V supply
Output:	
Impedance:	10ohm/100µF
Max. level:	2.8Vrms at 0dB gain
Max. load:	10nF ≈100m cable
DC offset Phase @:	OmVdc (capacitive coupling) -180°
Gain:	
Gain settings:	0, 6, 12, 20, 26, 32 dB
Tolerance:	±0.5dB
Bandwidth	
Operating frequency range -3dB at 20dB gain:	0.5Hz to 1MHz
Noise:	
Power spectrumdensity noise:	20nV/√Hz (at 1kHz)
Hi-Pass Filters:	1,5,10,20,100,1k,2k,
-3dB @ Hz:	5k, 10k, 20k, 50k
-12dB @ Hz:	0.1
Power supply:	12Vdc
Voltage nominal:	min 9Vdc, max 18Vdc
Current quiescent:	12mA @ 12Vdc
Weight:	305g. (with supply cable and LEMO adaptor)
Accessories included:	Supply cable TL 8088

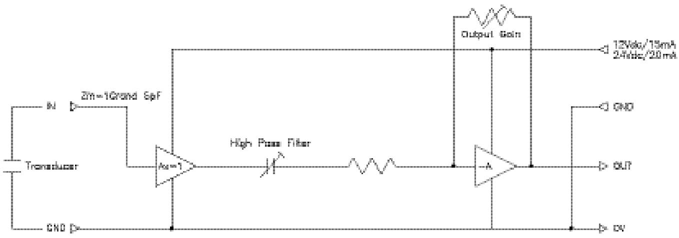
RESON

EC6061

VP1000 Voltage preamplifier

VP1000 outline dimensions and layout





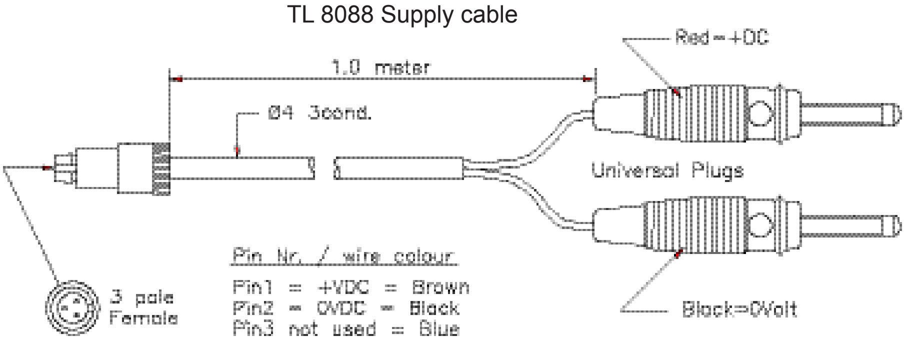
Transducer Capacitance
1nF nominell
Range: 100pF to 10nF

High Pass Filter
0.1Hz/-6dB
1Hz to 50KHz/-3dB

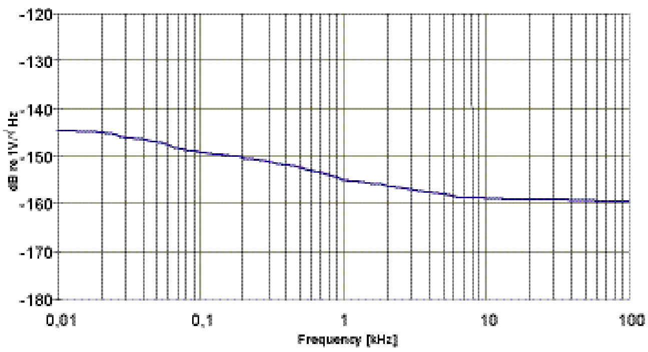
Gain:
0dB to +32dB
Output signal max:
+/-3V peak

Upper Limit Frequency / worst case=1MHz at gain +32dB
Roll-off=6dB at 1MHz at Load max. 600ohm and/or 10nF and output signal max.
-6dBm=387mVrms

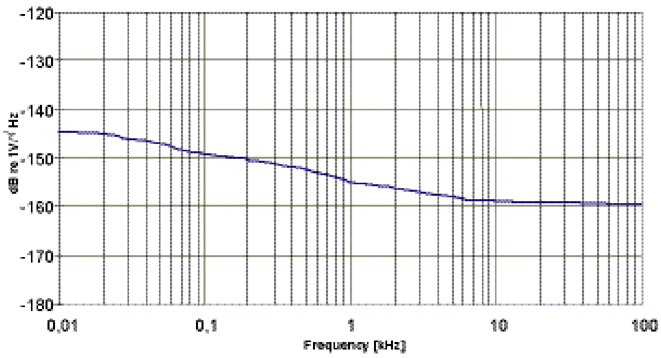
TL 8088 Supply cable



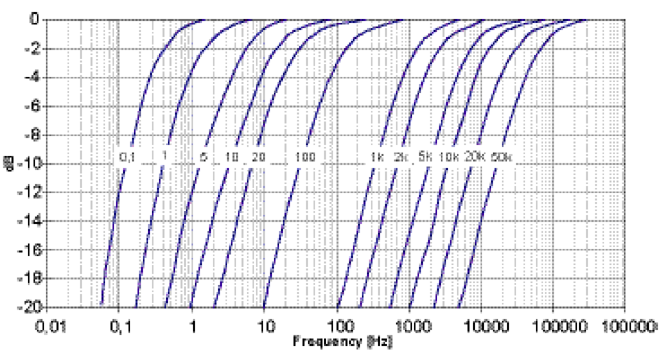
Noise power density spectrum re input
Input load 1nF, gain 20dB, 0.1Hz filter



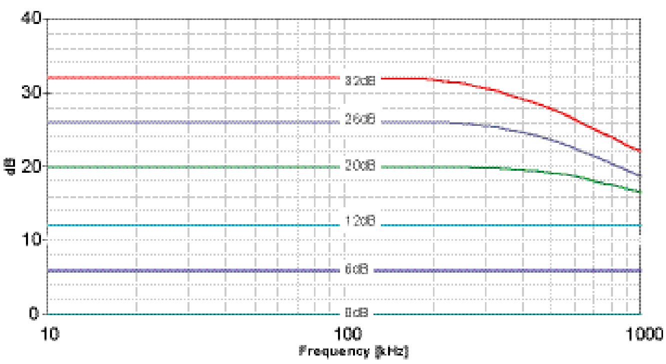
Voltage preamplifier VP1000
Phase shift with 0.1Hz filter at 0dB and 20dB gain



VP1000 filter characteristics



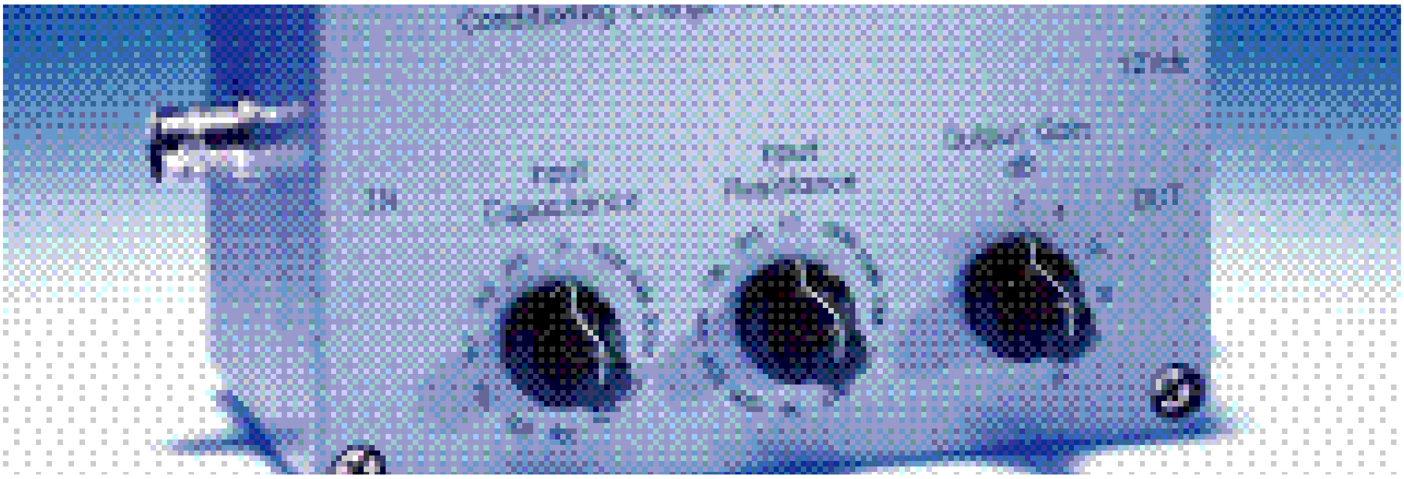
VP1000 Frequency roll-off versus gain



RESON

EC6067

CCA 1000 Conditioning Charge Amplifier



EC6067

- **1Hz to 1MHz bandwidth Input capacitance, selectable**
- **Lower frequency limit, selectable**
- **6 levels voltage gain 0 to 32dB**
- **Water stain resistant**

The CCA 1000 is a compact low-noise conditioning charge amplifier designed for use with piezoelectric hydrophones and other piezoelectric detectors. The CCA 1000 enables the uses of long cables between hydrophone and amplifier without affecting the hydrophone sensitivity.

The input capacitance can be selected to match the hydrophone capacitance for close unity gain or to achieve input gain up to 20dB.
The input resistance, control the lower frequency limit -3dB break frequency.
The output gain can be selected from 0 to 32dB.

TECHNICAL SPECIFICATIONS

Input:		
Impedance max.:	1Gohm	
Max input at (unity gain):	$2V_p$	
Estimating Input gain:	(dB) = 20 log C_{tr}/C_{in}	
Input capacitance selector:	12 steps: 22pF to 10nF	
Input resistance selector:	12 steps: 3.3kohm to 1Gohm	
Output:		
Output gain settings 6 steps:	0, 6, 12, 20, 26, 32dB	
Signal output, max:	$2V_p$	
Output impedance:	20ohm	
DC off-set:	0	
Bandwidth:		
Operating -3dB Frequency range at 20dB gain:		1Hz to 1MHz
Noise:		
Input termination:	1nF to GND	
Output noise with selector settings		
1nF/1GOhm/0dB:	2-4μV_{rms}/A	
10nF/1GOhm/20dB:	8-10μV_{rms}/A	
1nF/1GOhm/20dB:	14-20μV_{rms}/A	
100pF/1GOhm/20dB:	80-110μV_{rms}/A	
Power supply:		
Voltage:	min.:	12VDC
	max.:	24VDC
Current consumption:	40mA ±10mA at 12Vdc	

EC6067

CCA 1000 Conditioning Charge Amplifier

TECHNICAL SPECIFICATIONS

Lower frequency limit:	
Frequency limits (-3dB) versus input resistance at 1nF	
input load:	
1GOhm	0.3Hz
330Mohm	0.5Hz
100Mohm	1.5Hz
33Mohm	4.5Hz
10Mohm	15Hz
3.3Mohm	45Hz
1ohm	150Hz
330kOhm	450Hz
100kOhm	1.5kHz
33kOhm	4.5kHz
10kOhm	15kHz
3.3kOhm	45kHz
Weight:	
Including supply cable:	530g
Accessories included:	Supply cable TL 8088 at one end.

Input capacitance settings:

To obtain close unity input gain from a hydrophone, - set the input capacitance selector to a capacitance value close as possible to the hydrophone (end of cable capacitance).

The input gain is then calculated from: transducer capacitance Ctr. divided by the input capacitance Cin x 20 log = dB gain

Example:

a. 20 log (1nF/1nF) = 0dB

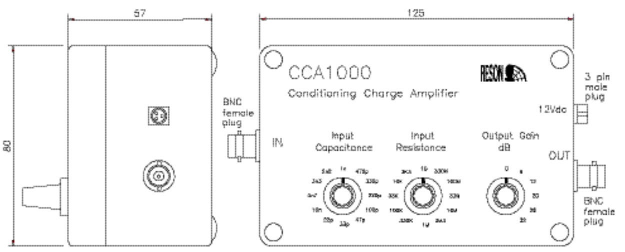
b. 20 log (8nF/4.7nF) = +4.62 dB gain

USER INSTRUCTIONS

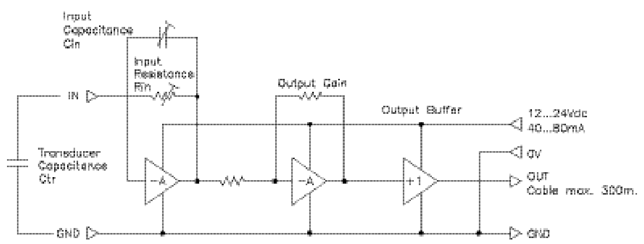
Voltage supply:

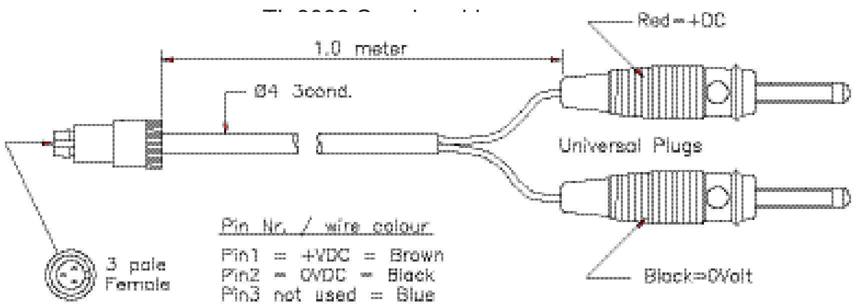
Connect the supply cable to a battery or AC powered DC supply. The required voltage is 12 to 24VDC. DC supply common/ground should be connected to water for min. noise.

CCA 1000 outline dimensions and layout



Simplified block diagram





RESON

EC6068

Battery Module Rechargeable

EC6068

- **Sealed EMI/RFI shielded aluminum box**
- **Battery charge condition indicator**
- **ON/OFF switch exposing red for ON**
- **Internal automatic 0.5A fuse**

Underwater sound measurements at sea or in the field often require hydrophones with built-in preamplifiers with a portable DC voltage supply.

The TC6068 Battery Module provides an ideal portable and compact DC source for the hydrophones and the conditioning amplifiers VP1000 and CCA 1000.

The EC6068 consists of a 12 Volt/1.2Ah Ni-Ca high quality battery enclosed in a sealed EMI/RFI shielded aluminum case.

TECHNICAL SPECIFICATIONS	
Battery voltage:	12Volt
Battery capacity:	1.2Ah
Typical recharge time:	10 hours (avoid over charging)
Operating time w. Hydrophone type:	
TC4032:	>12 hours
TC4035:	> 20 hours
Temperature range:	
Operating:	-10 to +50°C
Storage:	-30 to +50°C
Battery type:	Ni Ca
Accessories included:	TL8084 DC Supply cable
Dimensions:	L.w.h.125 x 80 x 60mm
Weight including cable:	1.4kg

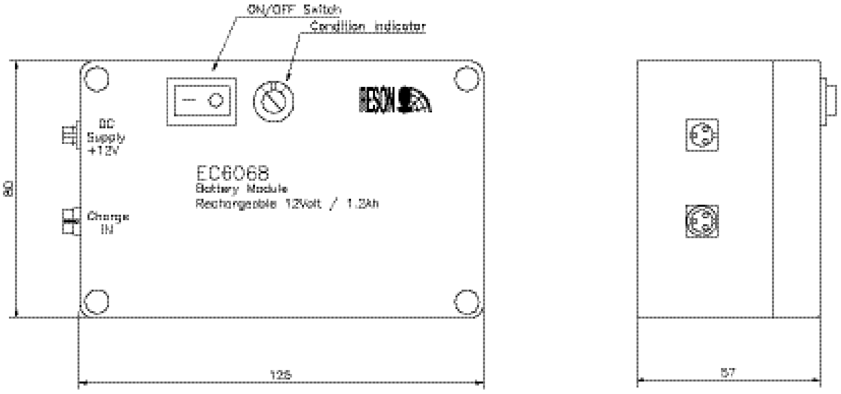
The battery condition is displayed on the indicator with a red and green field. The battery is fully charged when the pointer centered in the green field.

The ON/OFF switch is exposing a red mark in ON position to remind the user to shut off the module when not in use.

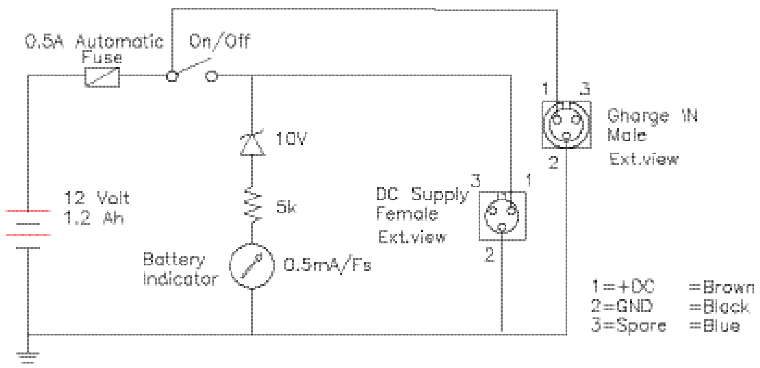
The EC 6068 battery can be recharged by use of EC 6072 battery charger connected with, a TL 8084 cable.

The EC6068 output is short circuit protected at 0.5 A. The reset time is approximately 2 sec.

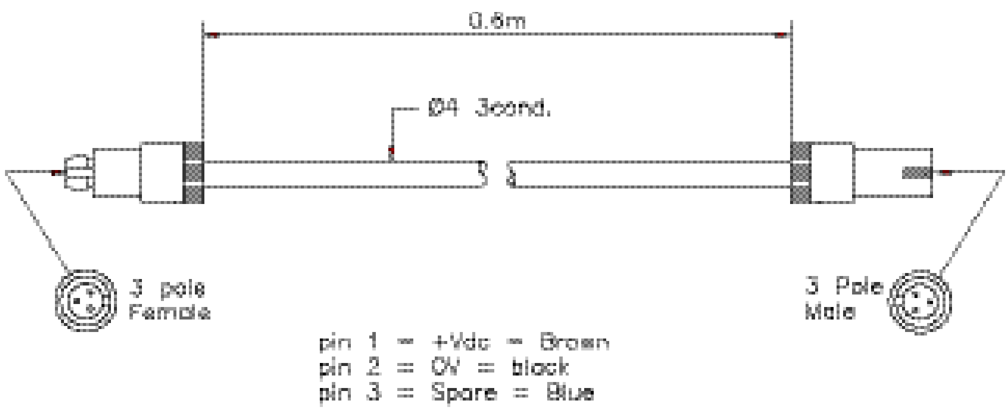
EC 6068 Outline dimensions and layout



Circuit Diagram



DC supply cable TL 8084



EC6069

Battery Module Dry Cell 2 x 9 V

EC6069

- **Sealed EMI/RFI shielded aluminum box**
- **Battery charge condition indicator**
- **ON/OFF switch exposing red for ON**
- **Easy replaceable 9V 6F22/PP3 batteries**

Underwater sound measurements in the field often require hydrophones with built-in preamplifiers or they are connected to conditioning amplifiers that requires portable DC voltage supply.

The EC6069 Battery Module supplies 18VDC from two exchangeable dry cell batteries. EC6069 is an ideal DC voltage source for hydrophones and for the preamplifiers VP1000 and CCA1000.

The EC6069 consists of a sealed EMI/RFI shielded aluminum case that encloses 2 x 9 Volt Alkaline batteries type IEC 6 LR 61 9Volt 0.55ah.

TECHNICAL SPECIFICATIONS	
Battery voltage:	18Volt (2 x 9Volt) Dry Cell
Operating time for long life batteries supplying Hydrophone type:	
TC4032:	>10 hours
TC4035:	>16 hours
Temperature range:	
Operating:	-10 to +50°C
Storage:	-30 to +50°C
Battery type:	IEC 9V 6LR 61 0.55 ah
Dimensions (L.w.h.):	125 x 80 x 60mm
Weight including cable:	0.56kg.
Accessories included:	DC supply cable TL 8084

The battery condition is displayed on the indicator with a red and green field. The battery is fully charged when the pointer is in center of the green field.

The battery condition indicator measures the actual voltage on the battery cells.

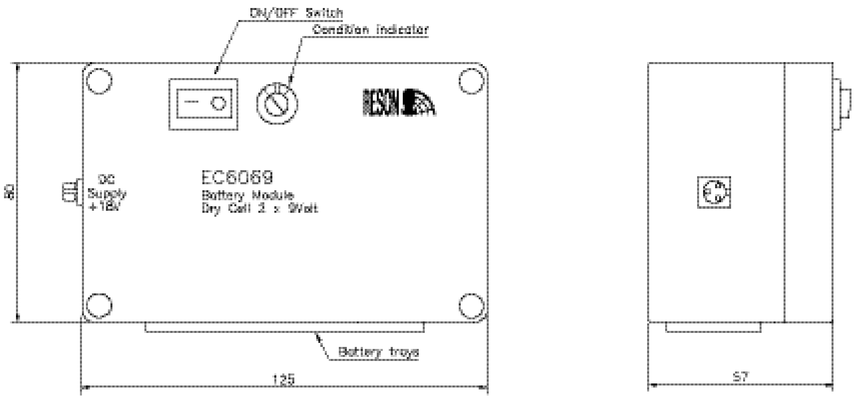
The indicator should be read with load applied.

The ON switch is exposing a red mark in ON position to remind the user to shut the battery supply off when not in use.

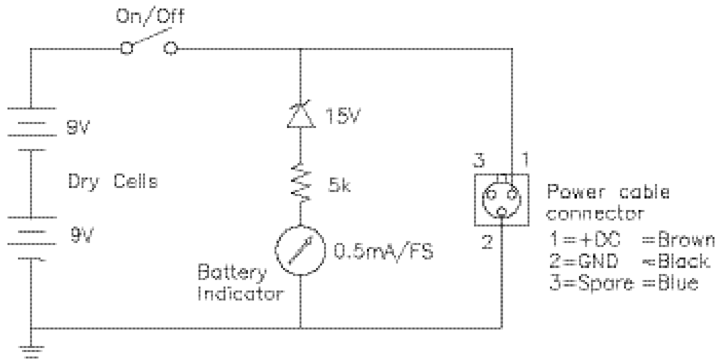
EC6069

Battery Module Dry Cell 2 x 9 V

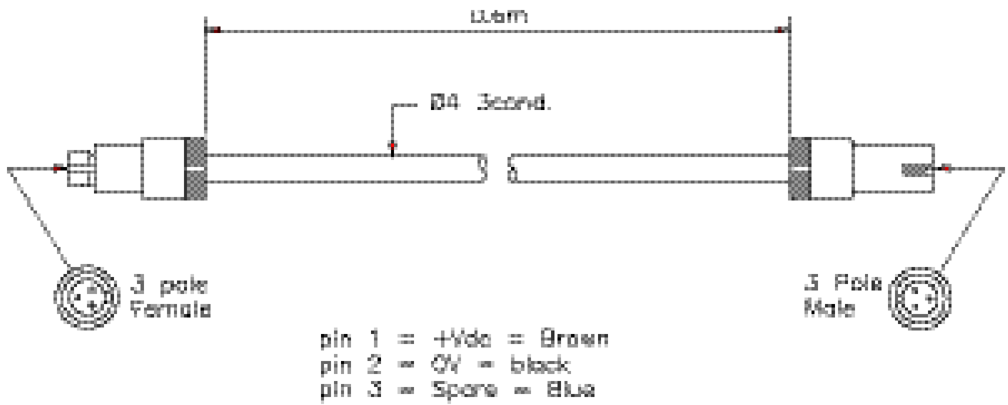
Outline dimensions and layout



Circuit Diagram



DC supply cable TL 8084



RESON

EC6070

Hydrophone Audio Amplifier

EC6070

- Bandwidth up to 700kHz
- Total signal amplification up to 90 dB
- Input selector for two types of Hydrophones
- Individual input and output gain settings
- Input low frequency sea wave cut-off filter
- Build-in envelope sonar detector
- Build-in Loudspeaker amplifiers
- Build-in Headphone amplifier
- Individual volume controls
- Recording and Playback switch
- Input and Output's both on BCN's and mini jack's
- Supplied with Loudspeakers and Headphones
- Supplied with Cables
- Battery powered 24 Volt (Battery not supplied)

RESON's EC 6070 is a sophisticated preamplifier and audio amplifier system with loudspeakers designed for monitoring underwater acoustic signals from 10Hz to 700kHz.
This system is ideal for listening and recording both low frequency whale vocalization and high-frequency echo-location sonar signals of dolphins and porpoises. A selectable envelope modulation detector converts high frequency signals to human-audible range. The versatility and user-friendly operation of the EC 6070 make it a beneficial addition to many acoustic research laboratories, aquariums, and bioacoustic programs. It operates on 24VDC, with several stages of adjustable input and output gain, built-in high-pass filter options, convenient output lines for ocsilloscopes, analyzing equipment, or recorders (tape, minidisc, etc), and input lines for playback.

TECHNICAL SPECIFICATIONS

Frequency range ±3dB:	10Hz to 700kHz	
Ultrasound detector range:	20kHz to 200kHz	
Input gain:	-20 to +30dB	
Output gain:	-20 to +30dB	
Envelope detector gain:	-20 to +30dB	
Output power:	2x10Watt/8ohm	
Line output level:	100mV to 1Vrms	
Line input level:	100mV to 1Vrms	
Voltage supply:	24Volt (2x12 Volt Batteries)	
Current consumption/standby:	0.14Amp	
Current consumption/maximum:	4Amp	
Rack case 19":	Dimensions:	19"x12"x3.5" (w.d.h.)
Weight:	4.3kg	
Loudspeaker :	Impedance: 8ohm	
Effect:	60Watt	
SPL/W:	86dB	
Dimensions w.d.h.:	160x160x230	
Weight:	3.5kg each	
Accessories delivered with EC6070:		
Loudspeakers:	Monacor type LSP-60-2 pcs	
Headphones:	1 set	
Loudspeaker Cables:	1x5 meter	
Battery Cable:	1x2 meter	

RESON

EC6070

Hydrophone Audio Amplifier

Description

The EC6070 Audio Amplifier is designed for detection of underwater acoustic sounds. It contains a low noise broadband Hydrophone preamplifier combined with a loudspeaker power amplifier in the same case. The amplifier has been designed especially for optimum operation with the RESON TC4032 and TC4033 Hydrophones.

The TC4032 has a built in low-noise preamplifier and should be used generally where long cables and/or extremely low-noise are required. The TC4033 without pre-amplifier is a spherical type and provides a broad frequency range up to very high-frequencies.

The Hydrophones are connected directly to the input connectors located at the rear panel. The BNC input connector for the TC4033 incorporates an extra 30dB amplifier in order to match the level of the TC4032.

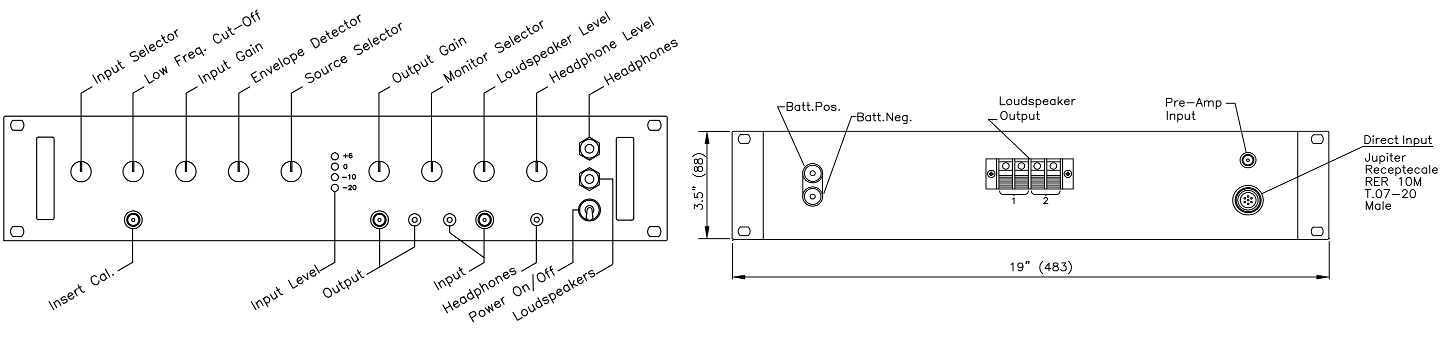
The EC6070 provides high quality real-time reproduction of sound from marine mammals such as whales dolphins and porpoises.
With the sonar detector engaged are frequencies above 20kHz envelope detected and reproduced in the audible frequency range of the human ear.
The wide frequency range of this amplifiers from 10Hz to 700kHz enables detection of sound from low audible frequencies to high ultrasound frequencies.

The EC6070 is supplied with two loudspeakers and a set of headphone for monitoring.
The loudspeakers supplied with the system are for usage in sheltered/indoor areas only.
The sound level of the speakers should be sufficient for most indoor applications.
For outdoor applications under ambient (often humid and noisy) conditions the use of water-resistant horn loudspeakers is recommended. Common horn speakers may deliver up to 10 times the sound pressure level of that of the indoor speakers.
The EC6070 is contained in a 19 inch. rack case which enables permanent mounting in laboratories / research stations or other facilities where fixed installations are required.

The input and output BNC connectors on the front panel enables direct connection to oscilloscopes, spectrum analyzers or other storage equipment.
The output signal covers the full frequency range of the Hydrophone at line level for recording and analyzing.

Line input and outputs are available on mini jack connectors enabling recording and Playback from common Tape recorders or Mini Disk recorders.
The insert Cal. BNC connector on the front panel, enables connection of an insert voltage signal for calibration of the TC4032 with the EC6070.
The EC6070 is to be powered from external 24Volt batteries.

Schematic drawing of the EC6070 front and rear panel, showing the function title and location of the selector knobs, indicator diodes and connectors.



RESON

EC6072
Battery Charger

EC6072

- **Sealed durable aluminum box**
- **EMI/RFI shielding Charging of two batteries simultaneously**
- **Useable as DC Voltage supply**

The EC6072 Battery Charger has been designed for recharging of the EC6068 Battery Module.

Two EC6068 Battery Modules can be connected to EC6072 and recharged simultaneously.

Furthermore, the EC6072 can be used as DC voltage supply for hydrophones with built-in preamplifiers and for the VP1000 Voltage Amplifier or the CCA1000 Charge Conditioning Amplifier.

TECHNICAL SPECIFICATIONS	
Mains supply:	110/220 VAC (Auto-setting)
DC output:	15 Volt/0.12 A
Temperature range:	
Operating:	-10 to +50°C
Storage:	-30 to +50°C
Dimensions:	125 x 80 x 60mm (L.w.h.)
Weight:	0.6kg
Accessory included:	IEC Mains cable 2 pcs DC supply cable TL 8084

The EC6072 is equipped with an ON/OFF switch displaying a red mark in ON position.

A red light is shown when 110/220V mains is on.

A green light is shown when the charger is active.

EC6072 accepts both 110 and 220V mains. The voltage level is internally detected and automatically switched to the right setting.

The DC charge voltage is supplied to the batteries or the preamplifiers through the DC charger cable TL8084 when connected to the 3 pole connector.

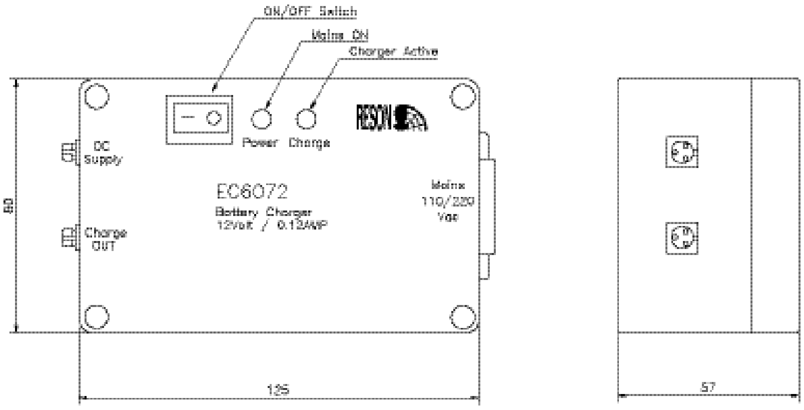
EC6072 is current limited @ 0,12A mains fuse 0.1A inside box.

RESON

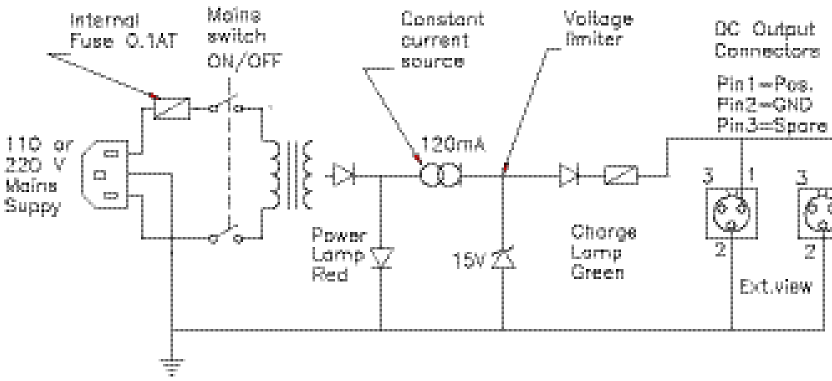
EC6072

Battery Charger

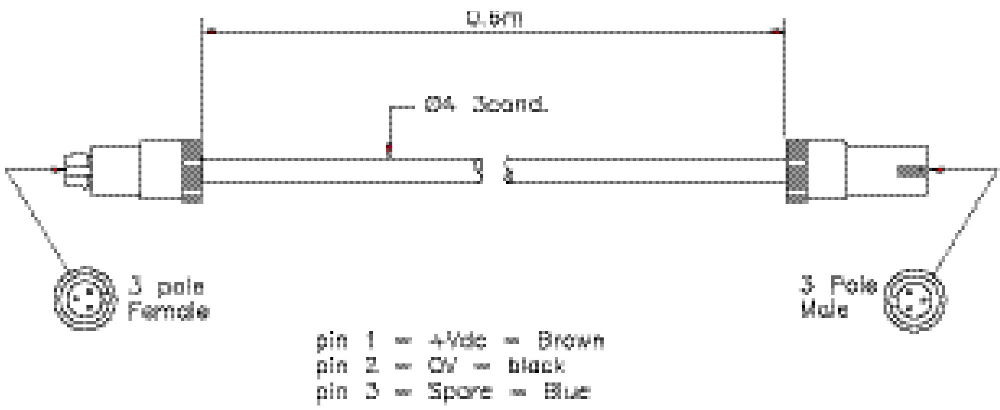
Outline dimensions and layout



Circuit Diagram



DC supply cable TL 8084 (2 pcs.)



RESON

EC6073

Input Module

EC6073

- **Sealed EMI/RFI shielded aluminum box**
- **Dual input**
- **DC supply from battery modules**
- **Insert calibration**
- **BNC OutputConnector**

The EC6073 Input Module is equipped with two input connectors that provides connection for RESON hydrophones terminated with either Jupiter or LEMO connectors.

A four-pole connector required for TC4014 connectors can be optionally supplied on request.

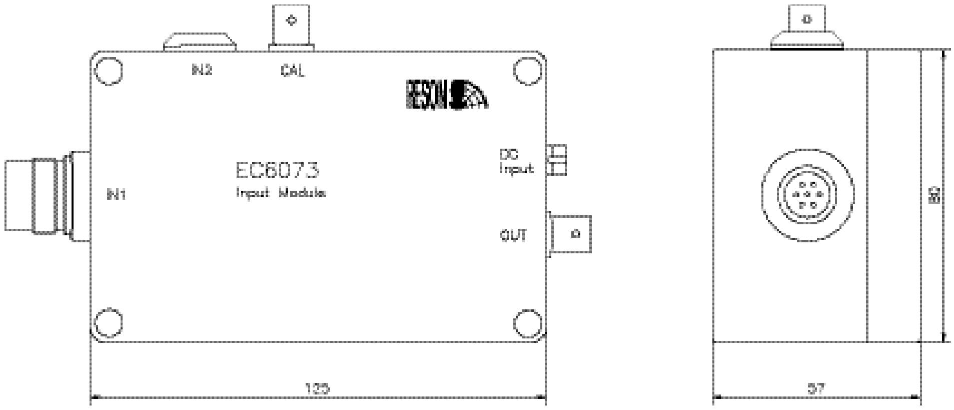
The EC6073 distributes and terminates the hydrophone cable connections to DC supply, signal output and insert calibration.

TECHNICAL SPECIFICATIONS

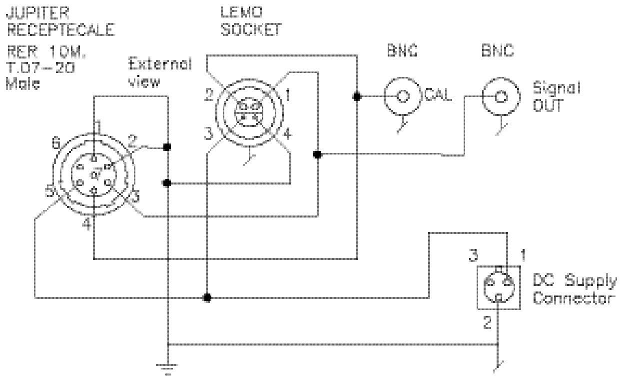
EC6073 Connections:	
TL4032 connection JUPITER M 10 7 polereceptacle	
TC4014 connection. Not standard, 4 poleinsert is available on request.	
TC4035 connection LEMO 4 polereceptacle.	
Signal output on BNC connector.	
Insert Voltage Calibration on BNC connector	
DC-supply to hydrophones on 3 pole connector	
Weight:	0.55kg
Dimensions:	L.w.h. 125 x 80 x 60mm
Accessories included:	Supply cable TL8088

Insert voltage calibration of hydrophones can be performed by connecting CAL. (BNC connector) to a Sine-generator and the hydro- phone output from OUT connector to scope or voltmeter measures the response.
DC voltage supply to the hydrophone preamplifiers can be supplied either from the portable Battery Modules EC6068 or EC6069 or from the EC6072 battery charger if mains are available. The TL8084 cable is used for DC supply connections.

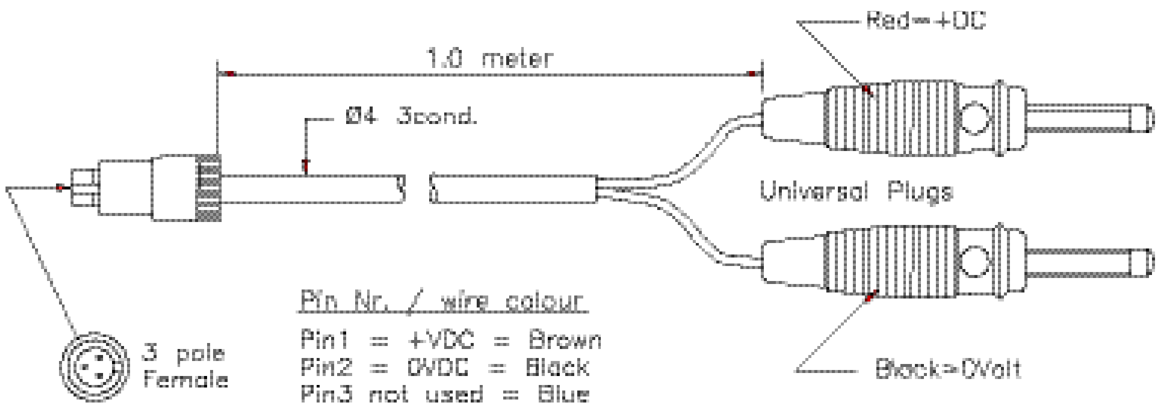
Outline dimensions and layout



Circuit Diagram



TL 8088 Supply Cable



RESON

EC6081

VP2000 Voltage preamplifier

EC6081

- **1Hz to 1MHz bandwidth**
- **Gain selection From 0 to 50dB**
- **Options of 12 high-pass filters and 12 low-pass filters**
- **Excellent low-noise characteristic**

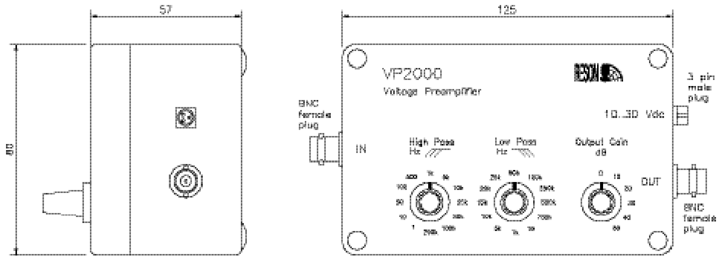
The VP2000 is a 1MHz bandwidth voltage preamplifier designed for uses in conjunction with piezoelectric hydrophones.
VP2000 offers excellent low-noise performance over the entire frequency range; gain selections in 6 levels from 0 to 50dB.
A range of 12 high-pass and 12 low-pass filters are available, - these allow ideal band pass filter settings.
The VP2000 has a high input impedance which allow the measurements at frequencies below 1Hz with even very small hydrophones sensor capacities.

TECHNICAL SPECIFICATIONS	
Input:	
Impedance:	>100M-ohm´s
Max. level:	2.4Vrms at 12V supply
Output:	
Impedance:	10ohm//100µF
Max. level:	2.4Vrms at 12Vdc 5.4Vrms at 24V supply
Max. load:	10nF (100m cable)
Gain:	
Gain settings, 6 steps dB:	0–10–20–30–40-50
Bandwidth	
Frequency range with 20dB gain:	-3dB 0.5Hz to 0.5MHz -6dB 1MHz)
Noise:	
Power spectrumdensity noise	20nV/√Hz (at 1kHz)
Hi-Pass Filters: -3dB @ Hz (6dB/oct):	1-10-50-100-500-1k-5k 10k-25k-50k-100k-250k
Lo-Pass Filters: -3dB @ Hz (6dB/oct):	1k-5k-10k-20k-25k-50k 100k-250-500k-750-1M
Power supply:	12Vdc (min. 10Vdc, max. 30Vdc)
Voltage nominal:	15mA @ 12Vdc
Current quiescent:	20mA @ 24Vdc
Enclosure case, dimensions:	125, 80, 60mm. (l w, h) (Splash proof aluminum box)
Accessory included:	Supply cable TL8088 for laboratory. Vdc supply.
Accessory available:	See page 2

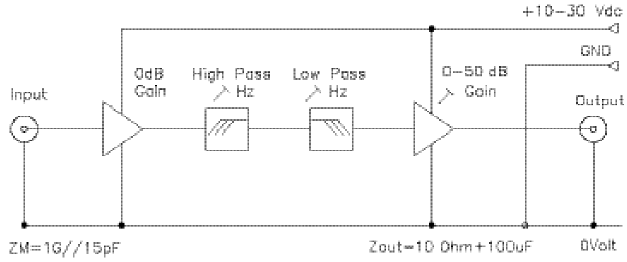
EC6081

VP2000 Voltage preamplifier

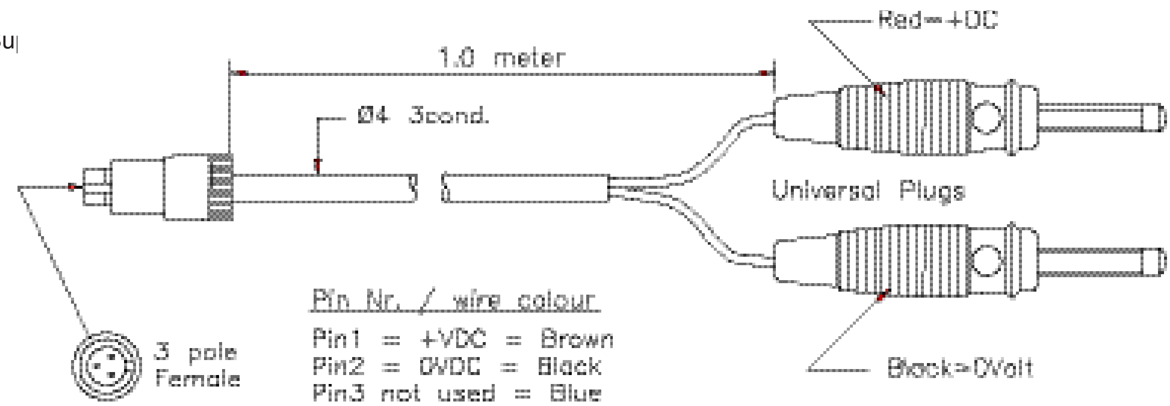
Outline dimensions and layout



Functional Block Diagram

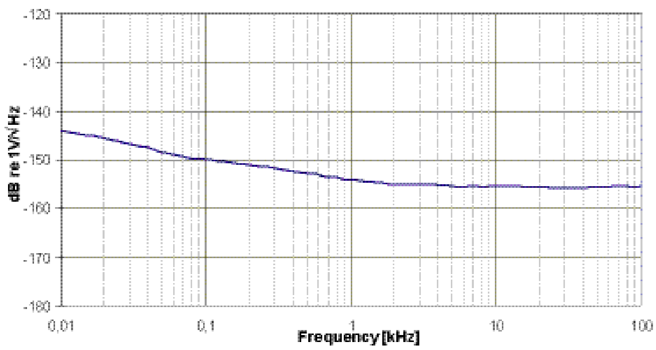


TL 8088 Su



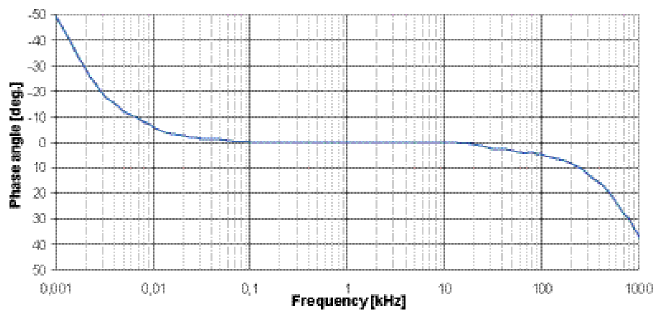
Noise power density spectrum re input

Input load 1nF, gain 0dB, 1Hz filter

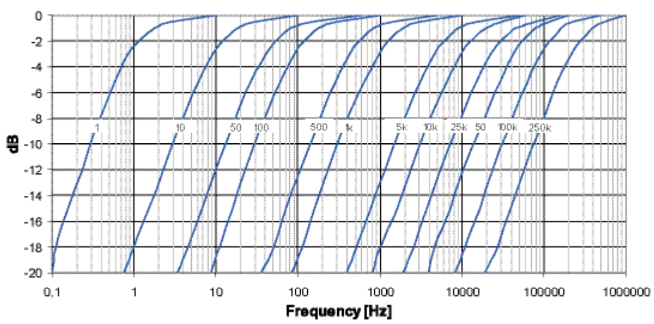


Phase shift

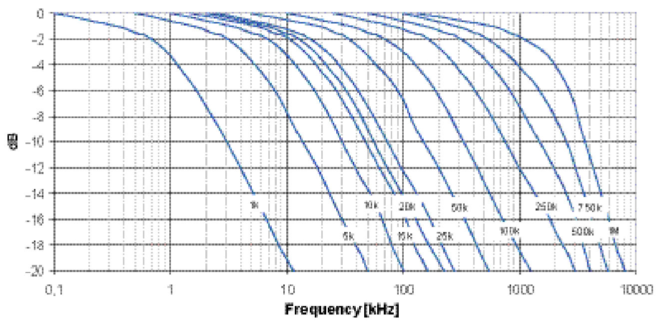
With 1 Hz filter at 0dB and 0dB gain



High Pass filter characteristics

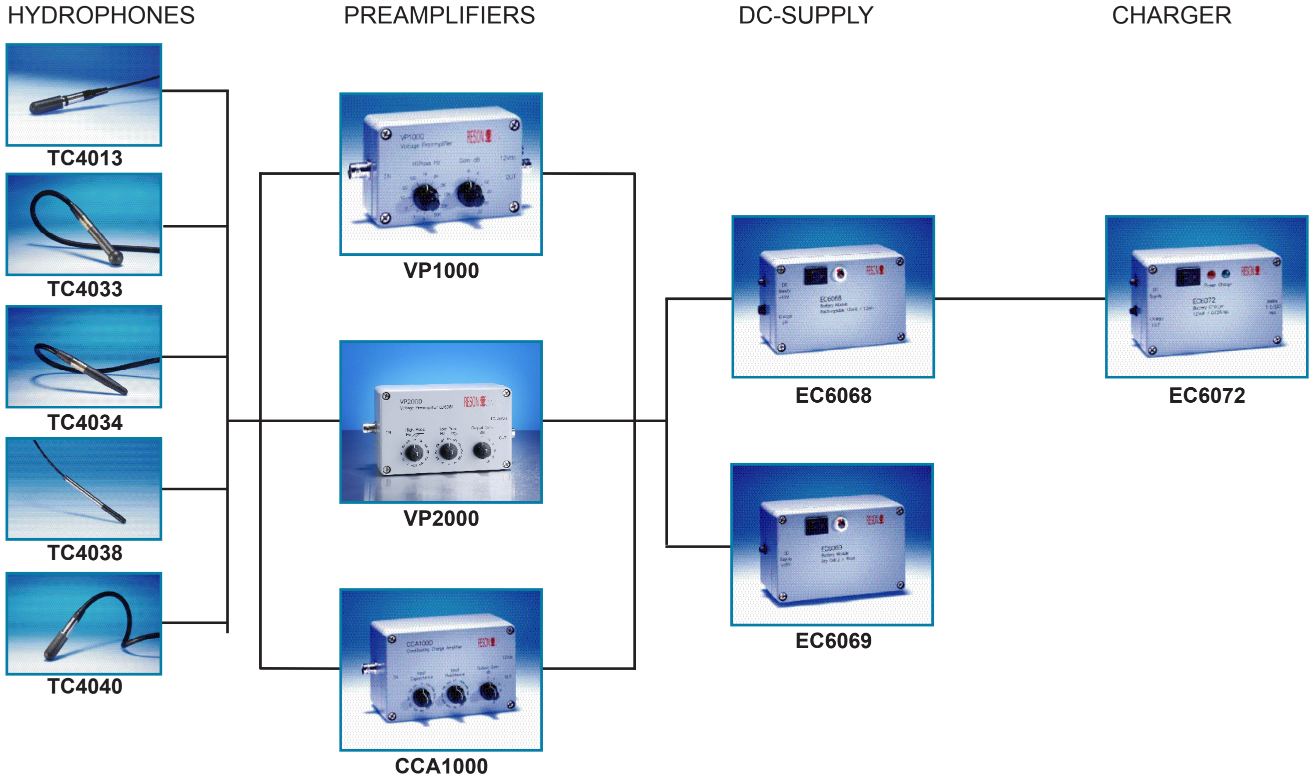


Low Pass filter characteristics

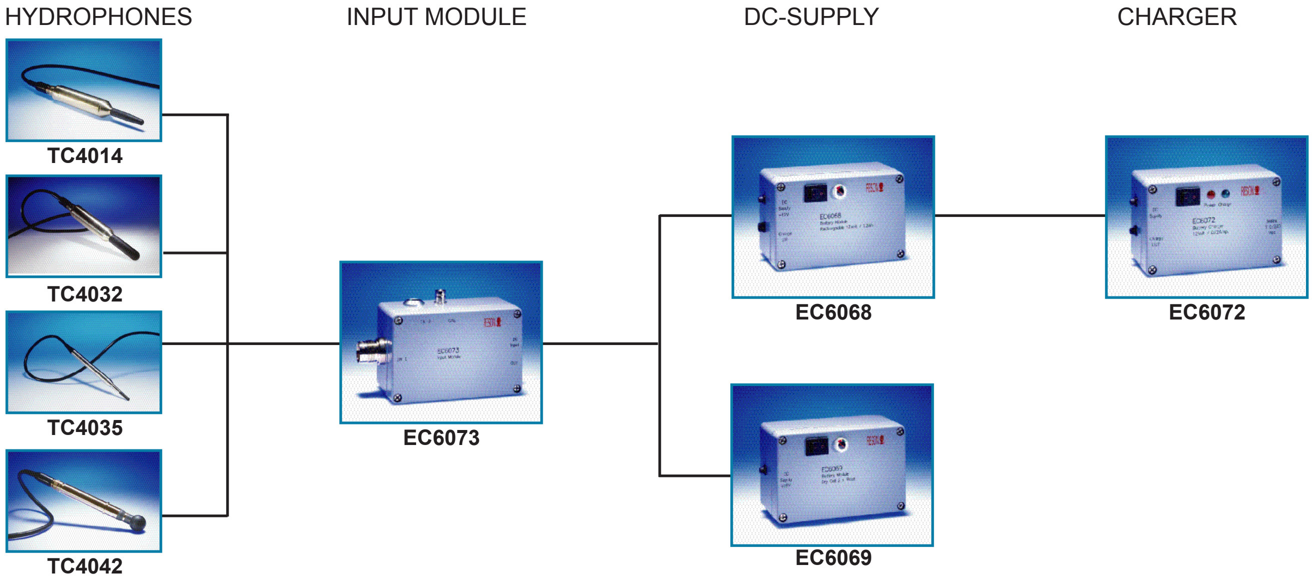


Accessories

Diagram on Accessories

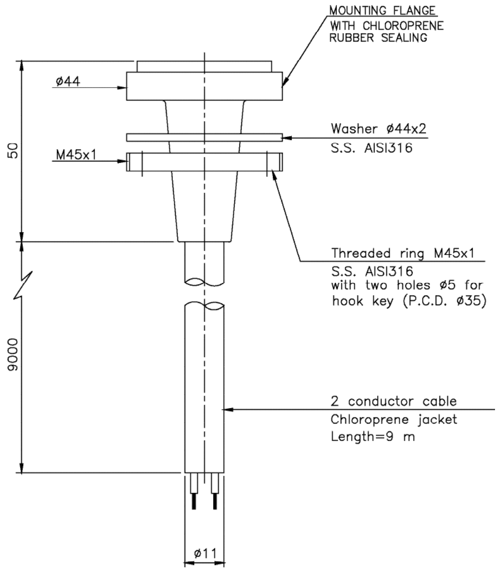


Hydrophones with integrated preamplifiers, -connections of, for portable use:



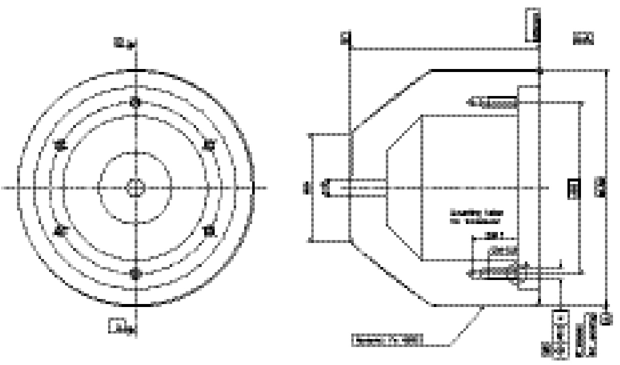
Model	TL 8038	TL 8043	TL 8069	TL 8070	TL 8084	TL 8088	TL 8116	TL 8140	TL 8142	TL 8144
TC1026	•	•								
TC1037	•									
TC2024			•							
TC2122				•						
TC4014-5								•	•	•
TC4032								•	•	•
TC4042								•	•	•
EC6061						•				
EC6067						•				
EC6068					•					
EC6069					•					
EC6081					•					

TL8038/8044

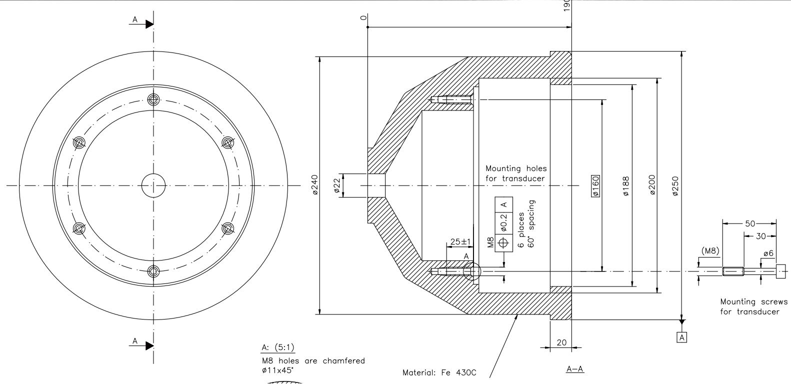


TL8069

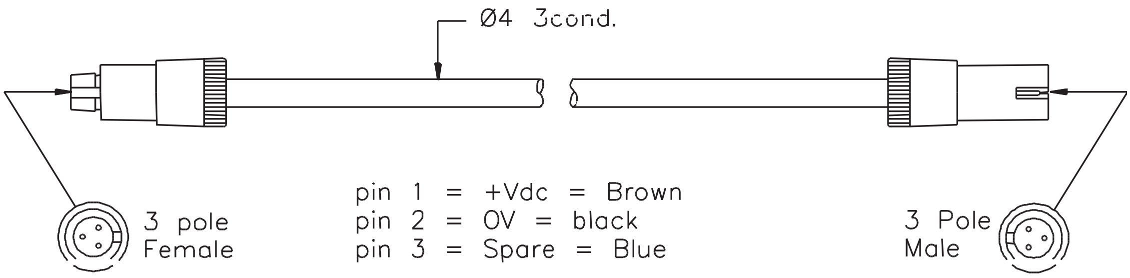
Transduser Housing, small



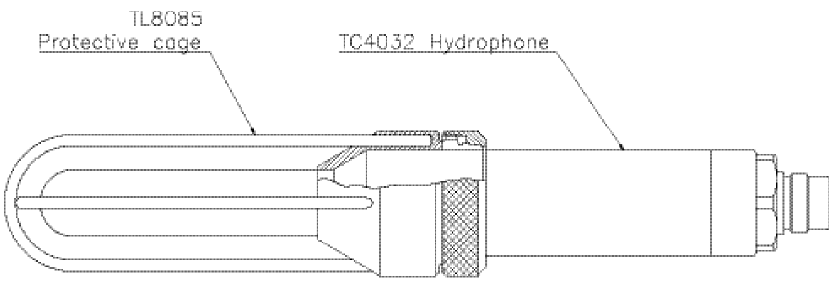
TL8070
Transduser Housing, large



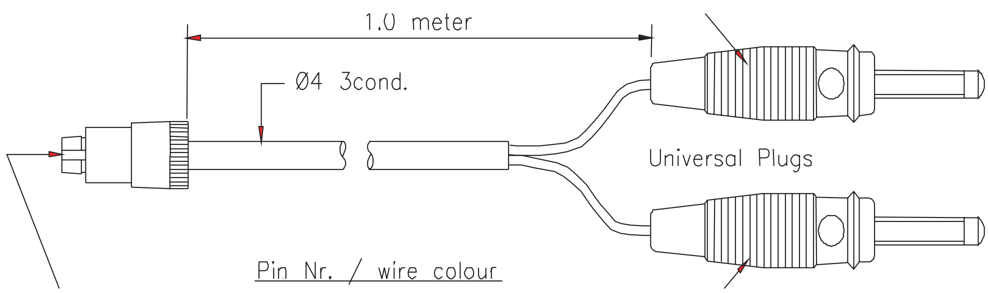
TL8084



TL8085
Protectiv Cage for TC4032

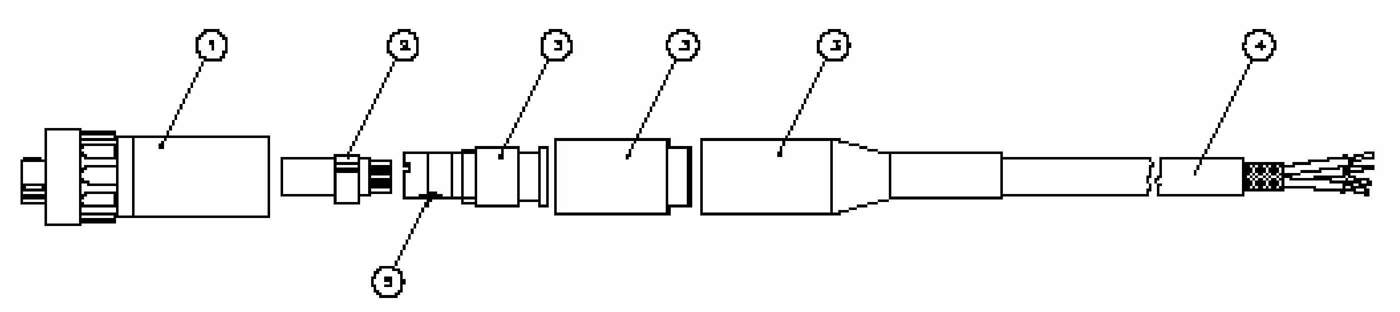


TL8088

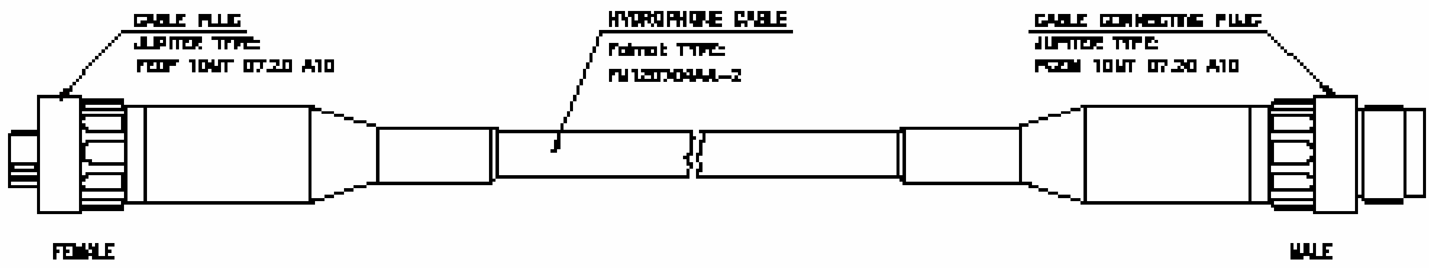


Cables and Accessories

TL8140



TL8142



TL8144

Electro-Acoustic Properties

Name	Symbol	Unit	Quick Formula	Explanation
Frequency	f_{kHz}	kHz	-	Frequency is cycles per time unit
Input Voltage	V_{in}	Volt-rms	-	Input voltage at the transducer terminals in rms-value while transmitting
Output Voltage	OCV	Volt-rms	-	OpenCircuitVoltage.Outputvoltageatthetransducerterminalsin rms-valuewhilereceivingwhennocurrentpassesitsterminals
Electric Impedance	Z	Ohm	Z=V/I=|Z|<φ $\|Z\|^2=R^2+X^2$	The transducer's impedance, which is the ratio between voltage V and current I. Z is a complex number Z=R+jX with modulus |Z| and phase ϕ
Electric Phase	ϕ	deg	tan(ϕ)=X/R	Thetransducer'sphase.Thephaseanglebetweenthecurrentand the voltage
Electric Resistance	R	Ohm	R=|Z|cos(□)	Equivalent series resistance. Real part of Z,
Electric Reactance	X	Ohm	X=|Z|sin(√°)	Equivalent series reactance. Imaginary part of Z,
Conductance	G_P	Ohm^{-1}	$R/(R^2+X^2)$	Equivalent parallel conductance. $G_P=R/\|Z\|^2 = \cos(\phi)/\|Z\|$
Electric Power	P_e	Watt	$P_{e,in}=V^2{}_{in}\phi G_P$	Electrical power at the transducer terminals
Speed of Sound	c	m/s	-	About ~1500m/s for water
Density	ρ	kg/m^3	-	About ~1000kg/m³ for water
Pressure	P	Pa	-	Therms-amplitudeofasoundwave.Forplanewavesincompress-ible medias p= ρϕc ϕu where u is the particle velocity.
Acoustic Intensity	I_a	$Watt/m^3$	$I_a=p^2/(\rho c)$	Acoustic power per area. Loudness of sound.
Acoustic Power	P_a	Watt	$P_a=I_a\phi A_a$	Acoustic power
Acoustic Area	A_a	m^2	Square: L^2 Circle: πr^2 Sphere: $4\pi r^2$ Cylinder: $2\pi rh$	Anyarea,throughwhichacousticenergyistransferred.Often usedtodescribethesizeoftheactivesound-emittingpartsofa transducer
Efficiency	η_{ea}	-	$\eta_{ea} = P_{a,out} / P_{e,in}$	Electric to acoustic efficiency
Directivity Index	DI	dB	-	Thedirectivityindexistheratio(indB)ofthemaximumintensity producedbythetransducercomparedtoapointsource,whichis putting out the same acoustic power.
Source Level	SL	dB re 1µPa@1m	$SL=TRV+20\log(V_{in})$	Thesourcelevelistheratio(indB)ofthemaximumintensitypro-ducedbythetransducerat1mdistancecomparedtotheintensity of a plane wave with rms-amplitude 1µPa ($0.667\phi10^{-18}w/m^2$).
TransmittingResponsetoVoltage	TRV	dB re 1µPa/V@1m	-	Transmitresponsewithrespecttovoltagetakenatthereference distance 1m
TransmittingResponsetoCurrent	TRC	dB re 1µPa/Amp@1m	-	Transmitresponsewithrespecttocurrenttakenatthereference distance 1m
Receiving Response	RR	dB re 1V/µPa	RR=20log(OCV)-IL	Opencircuitvoltageresponsewithrespectto1µPa.Alsocalled receiving sensitivity.
Intensity Level	IL	dB re 1µPa	IL=20log(p/1µPa)	Theintensitylevelistheratio(indB)ofanintensitycomparedto thereferenceintensityofaplanewavewithrms-amplitude1µPa ($0.667\phi10^{-18}w/m^2$).
Transmitting Loss	TL	dB	TL=20log(r)+α(r-1)	Thedropinacousticintensitycausedbysphericalspreadingand attenuation

RESON

Basic Acoustics

Electro-Acoustic Equations

Name	Equation (reciprocal transducers)	Unit
Source Level	$SL = 10\log(P_e) + 10\log(\eta_{ea}) + DI + 170.8$	[dB re 1μPa @1m]
Transmit Response to Voltage	$TRV = 10\log(G_P) + 10\log(\eta_{ea}) + DI + 170.8$	[dB re 1μPa/V @1m]
Transmit Response to Current	$TRC = 20\log(\lvert Z \rvert) + TRV$	[dB re 1μ Pa/Amp @1m]
Receiving Response	$RR = TRC - 354 - 20\log(f_{kHz})$	[dB re 1V/μPa]

Unit Conversion

Property	Conversions
Pressure	$1Pa = 10^6 \mu Pa = 10^{-5}$ bar $= 0.145 \phi 10^{-3}$ psi $\approx 10^{-5}$ atm
Length	1m = 1.094yd = 39.4inch
Weight	1kg = 2.205lb

Unit to convert from	Unit to convert to	Conversion formula
X [°C]	Y [°F]	$Y = 1.8 \phi X + 32$
X [dB re 1 μPa]	Y [W/m²]	$Y = 0.667 \phi 10^{-18} W/m^2 \phi 10^{(X/10)}$
X [W/m²]	Y [Pa] rms	$Y = (X \phi 1000 kg/m^3 \phi 1500 m/s)^{1/2}$
X [Decibel]	Y [Nepers]	$X = 8.686 \phi Y$

Word	Symbol	Factor	dB
tera	T	10^{12}	+120
giga	G	10^{9}	+90
mega	M	10^{6}	+60
kilo	k	10^{3}	+30
hekto	h	10^{2}	+20
deca	da	10^{1}	+10
-	-	10^{0}	0
deci	d	10^{-1}	-10
centi	c	10^{-2}	-20
milli	m	10^{-3}	-30
mikro	μ	10^{-6}	-60
nano	n	10^{-9}	-90
pico	p	10^{-12}	-120

Property	SI/unit	Symbols	Comment
Length	Meter	1m	-
Area	Square meter	$1m^2$	-
Volume	Cubic meter	$1m^3$	-
Weight	Kilograms	1kg	-
Time	Seconds	1s	-
Temperature	Celsius	1°C	or Kelvin
Energy	Joule	1J	-
Charge	Coulomb	1C	-
Voltage	Volts	1V	-
Impedance	Ohm	1Ω	Electrical
Impedance	Rayl	1Rayl	Acoustical
Current	Ampere	1A	1C/s
Conductance	Siemens	1S	Ω^{-1}
Power	Watt	1W	1J/s
Force	Newton	1N	$1kg \phi m/s^2$
Pressure	Pascal	1Pa	$1N/m^2$

Definitions, References and Decibels

The Decibel:

A decibel is, regardless of the sort of application, always ten times the logarithmic (base ten denoted log10 or simply log) function of a number. That is:

$$x_{dB} \phi 10\log_{10}(x)$$

The decibel is often used when the range of x is very broad – say from 0.0001 to 10000 – and the advantage is that the decibel “compresses” x. The table below shows some examples.

x	0.0001	0.001	0.01	0.1	1	10	100	1000	10000
x_{dB}	-40	-30	-20	-10	0	10	20	30	40

The logarithmic function, and therefore also the decibel, is only defined for dimensionless x, which means that x cannot have a unit like e.g. meters or Watt. Because of this, x is very often a fraction of two numbers with units; the nominator being the quantity of interest and the denominator being the reference.

$$x_{dB} = 10\log\left(\frac{a}{a_{ref}}\right)$$

The reference concept is very important for the proper understanding of decibels because it uniquely determines what the decibel number is referring to. An example should clarify this point. If for example “a” is the length of a stick, say a=1.3m, we cannot give the length of a in decibels before we choose a reference distance simply because log(a) doesn’t make sense when “a” has a unit. However, if we choose 1m as the reference we can express “a” in dB relative to 1m. That is:

$$a_{dB} = 10\log\left(\frac{1.3m}{1m}\right) = 10\log\left(\frac{1.3m}{1m}\right) = 10\log(1.3) = \underline{1.14dB\ re\ 1m}$$

Notice that the result “1.14dB re 1m” specifically points out that the chosen reference is 1m, which enable the reverse calculation back to a=1.3m from the dB. Therefore, even when the reference is left out in formulas to save time and writing, all dB numbers refer to references and any dB number only makes sense if it is clear what the reference is.

The decibel and other logarithmic functions have some nice properties whereof the most important is that multiplication becomes summation. The laws of logarithmic functions are:

$$\log_k(a \phi b) = \log_k(a) + \log_k(b)$$
$$\log_k(a/b) = \log_k(a) - \log_k(b)$$
$$\log_k(a^n) = \log_k(a)$$

The last rule is often applied when the property “a” can be expressed as e.g. the square of some pressure, voltage or distance. A missing subscript k usually refers to the logarithm with base ten k=10, but it can also mean the natural logarithm ln(x) with base k=e=2.7183.

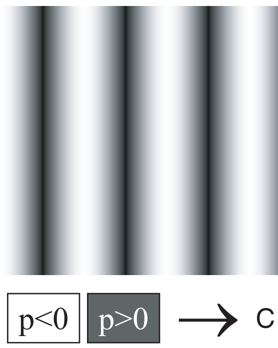
RESON

Basic Acoustics

Underwater sound:

Sound is disturbances of the medium – here water – travelling in a 3 dimensional manner as the disturbance propagate with the speed of sound. The sound is defined as a plane wave when the sound propagates in a single direction i.e. the lines for uniform phase are straight.

Plane wave propagation



f=frequency

p=sound pressure

c=speed of sound

ρ=density

u=particle velocity

Z_a=acoustic impedance

Acoustic impedance is perhaps the most basic concepts of underwater sound because its definition is a constitutive equation (one from which others are derived) for underwater sound propagation. The relation is:

$$p \phi Z_a \phi u \quad \text{,and for a plane wave} \quad Z_a = \rho \phi c$$

This definition is analogous to Ohm's law for electrical circuits i.e. V=RϕI and you can often think of particle velocity, acoustic impedance and sound pressure in the same way. Mechanical engineers may think of Newton's law F=mϕa as analogy. It shows that particle velocity and pressure are in phase in a plane sound wave.

Acoustic intensity – power (P_a) per unit area (A_a) or energy flux - is used to describe levels of underwater sound like e.g. an echo, a whale's call or a signal from a remote transducer. The intensity of a plane harmonic wave is:

$$I_a = \frac{P^2_{rms}}{\rho \phi c} = \frac{P_a}{A_a}$$

The daily term "a high sound" refers to a sound with a high intensity. A reference intensity I_{ref} has been defined in order to enable direct comparison of the loudness of sounds and the reference intensity used in underwater acoustics is that of a plane harmonic wave with an rms-pressure of 1μPa, which for ordinary seawater with c≈1500m/s and ρ≈1000kg/m³ gives

$$I_{ref} = \frac{(1\ \mu Pa)^2}{1000^{kg}/_{m^3} \phi 1500^{m}/_{s}} = \frac{10^{-12}}{1.5 \phi 10^6}\ {}^{W}/_{m^2} = 0.667 \phi 10^{-18 W}/_{m^2}$$

The intensity level (IL=how high a sound is) is the intensity of the sound wave taken in decibels relative to the reference intensity of 1μPa plane wave rms-pressure (which is shortened to "re 1μPa"):

$$IL = 10\log\left(\frac{I}{0.667 \phi 10^{-18}\ {}^{W}/_{m^2}}\right) \text{dB re } 1\mu P_a$$

The intensity level is thus the loudness of a sound at a field point, which is different from the loudness of a source of sound because the intensity level decreases as the distance to the source increases. The intensity level of a sound is for example 200dB re 1μPa, which is the same as $I = I_{ref} \phi 10^{(200dB/10)} = 66.7 W/m^2$.

RESON

Basic Acoustics

Beam patterns and Directivity:

The beam pattern of a transducer contain information about the transducer's spatial response i.e. how it transmits or receives in different directions. Transducers that are very small compared to the wavelength have omni directional beams, which means that the energy is not concentrated in any particular direction. Transducers that are large compared to the wavelength have a very directive beam pattern, which means that their energy is concentrated in a specific direction.

The beam width, which is the angle subtended by the points where the intensity has dropped 3dB below the maximum on-axis response, is often used as indicators of how concentrated the energy is for a specific transducer in a given cross section.

The directivity index of a transmitter describes how concentrated the transmitted energy is at the maximum response point and for receivers the directivity index indicates the ability to discriminate a signal from an ambient background noise, both cases relative to an omni directional transducer.

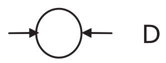
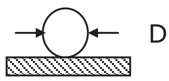
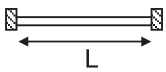
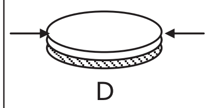
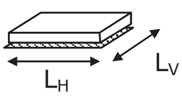
Source Type	-3dB Beam Width	Directivity Index	Sketch	Beam Shape	Validity Conditions
Point	360°	≈0dB		Spherical	D<<λ
Point (baffled)	180°	≈3dB		Half spherical	D<<λ
Line (baffled)	$ß \approx \frac{76200}{f_{kHz} \phi L_{mm}}$	$DI \approx 10\log\left(\frac{100}{ß}\right)$		Toroidal	L>λ L in [mm] f in [kHz] β in [deg] DI in [dB]
Disc (baffled)	$ß \approx \frac{91440}{f_{kHz} \phi D_{mm}}$	$DI \approx 10\log\left(\frac{36000}{ß^2}\right)$		Conical	D>λ D in [mm] f in [kHz] β in [deg] DI in [dB]
Rectangular (baffled)	$ß_H \approx \frac{76200}{f_{kHz} \phi L_H}$ $ß_V \approx \frac{76200}{f_{kHz} \phi L_V}$	$DI \approx 10\log\left(\frac{31600}{ß_H \phi ß_V}\right)$		Shell-like or conical	L_H, L_V > λ L_H, L_H in [mm] f in [kHz] $β_H$, $β_V$ in [deg] DI in [dB]
Arbitrary (baffled)	$ß_H$, $ß_V$	$DI \approx 10\log\left(\frac{2.455}{\sin(\frac{ß_H}{2}) \phi \sin(\frac{ß_V}{2})}\right)$		Shell-like or conical	$β_H$ <180° $β_V$ <180° $β_H$, $β_V$ in [deg] DI in [dB]

Table 1: Approximations to far-field beam width and directivity index for various sources. Formulas for finding beam widths assume that the speed of sound is c≈1500m/s (c=λφf). Notice that the beam width of a transducer is the same whether it is transmitting or receiving.

The nearfield (or Fresnel field) of a transducer is characterized by irregularity and changes due to refraction effects leading the fact that the interference pattern (the beam) has not yet been fully formed. The Rayleigh distance r_0 can approximate the nearfield extension:

$$r_0 \approx A_{active}/\lambda$$

A_{active} is the active area of the transducer's face. For line arrays, cylindrical arrays and the like it is often better to use $A_{active}=(L_{max})^2$ where L_{max} is the longest dimension found on the active face of the transducer. The farfield (Fraunhofer field) precedes the nearfield after a transition region and is characterized by spherical spreading and regular beam patterns.

RESON Basic Acoustics

Underwater Sound Transmission:

Sounds originating from acoustic sources are measured in intensity level, which decreases as the distance to the source is increased due to transmission loss (TL) i.e. spreading and absorption:

$$IL = SL - TL = SL - \underbrace{20\log(r)}_{\text{Spreading}} - \underbrace{a \, \phi \, (r\text{-}1m)}_{\text{Attenuation}}$$

The formula assumes spherical spreading for the transmission loss i.e. the sound is unbounded and spreads out like it was originating from a point – the acoustic center of the source.

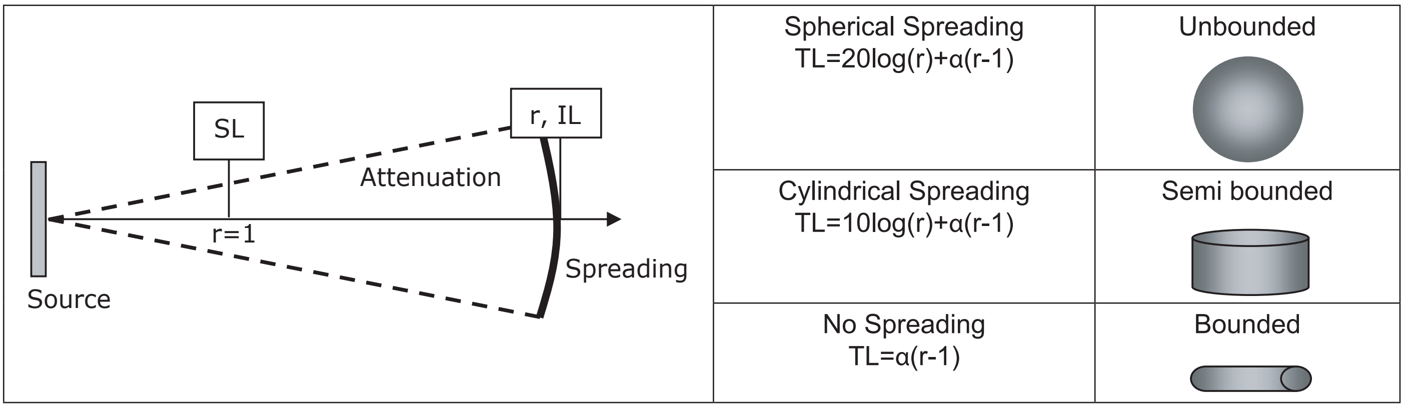


Figure 1: Schematics of sound transmission with different kind of spreading

Spherical spreading is most common and is valid in the far field required that the source is placed far enough from any large structure. Cylindrical spreading occurs for example in shallow waters when the bottom and the surface reflects the sound and forces it to spread like a cylinder. When the sound is completely bounded (e.g. inside a pipe) it cannot spread and only absorption remains in the formula for transmission loss.

The last term of the transmission loss is the attenuation, which increases very significantly with the frequency and furthermore varies with pressure, temperature, salinity and acidity. Accurate approximations are hard to come by, but the following approximation may be used:

Description	Equation	Remarks
Absorption coefficient of sound in seawater at the sea surface	$a_0 \approx A \cdot S \cdot \frac{f_T \cdot f^2}{f^2_T + f^2} + B \cdot \frac{f^2}{f_T}$	α=attenuation [dB/m] A=2.34ϕ10^{-6} Np/m (Empirical constant) B=3.38ϕ10^{-6} Np/m (Empirical constant) f=frequency [kHz] f_T=relaxation frequency [kHz] S=salinity [ppt]
Correction for Temperature	$F_T = 21.9 \, \phi \, 10^{\left(6 - \frac{1520}{T+273}\right)}$	f_T=relaxation frequency [kHz] T=temperature [°C] T=20°C: fT=142kHz
Correction for depth	$a_d = a_0 (1\text{-}6.33 \cdot 10^{-5} \cdot D)$	α_d=attenuation at depth d>0m [dB/m] α_0=attenuation at d=0m [dB/m] D=depth [m]

Table 2: Approximate formula by Schulkin & Marsh for the sound attenuation in seawater[1]

[1] Reference: Schulkin, M., and H. W. Marsh: "Absorption of sound in seawater", J. Brit. IRE, 25:493 (1963). Also, "Sound Absorption in Sea Water", J. Acoust. Soc. Am., 34:864 (1962).

Following Schulkin & Marsh's approximate expressions, the special case of freshwater (S ≈ 0ppt) at room temperature (T=20°C) and surface pressure (D=0m) gives the very simple formula for α[dB/m] as a function of the frequency f[kHz]:

$$a \approx 2.06 \cdot 10^{-7} \frac{dB}{m \phi kHz^2} \cdot f^2_{kHz}$$

It should be noted that the effect of having saltwater (North Atlantic S ≈ 35ppt) instead of freshwater (S ≈ 0ppt) is significant.

The speed of sound is a very important parameter in any echo-sounding system where a range is determined based upon the elapsed time and the speed of sound. The speed of sound can be approximated with a simple formula:

Description	Equation	Remarks	Limits
Speed of sound in seawater	$c \approx 1449.2 + 4.6T$ $-5.5 \cdot 10^{-2}T^2 + 2.9 \cdot 10^{-4}T^3$ $+ (1.34 - 10^{-2}T)(S - 35)$ $+ 1.6 \cdot 10^{-2} D$	c=speed of sound [m/s] T=temperature [°C] S=salinity [ppt] D=depth [m]	0 ≤ T ≤ 35°C 0 ≤ S ≤ 45ppt 0 ≤ d ≤ 1000m

Table 3: Approximate formula by Medwin for the speed of sound in seawater[2]

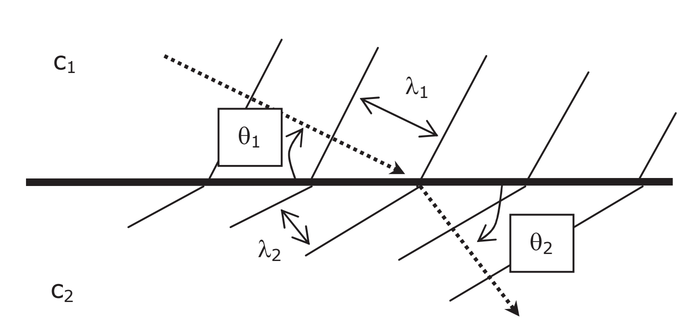
If we take the special case of freshwater (S ≈ 0ppt) at room temperature (T=20°C) and surface pressure (D=0m) again Medvin's formula yields:

$$c \approx 1482 \ ^{m}/_{s}$$

The corresponding result for North Atlantic seawater (S ≈ 35ptt, T=20°C, D=0m) would leave a higher speed of sound c ≈ 1522m/s. The speed of sound is by definition the frequency multiplied with the wavelength:

$$c \approx f \cdot \lambda$$

The frequency cannot change, which implies that when the speed of sound changes the wavelength changes accordingly and this forces the sound to refract ("bend") in order to enable the change in wavelength – see Figure 2.



Snell's Law of Refraction

$$\frac{\cos(\theta_1)}{c_1} = \frac{\cos(\theta_2)}{c_2} = ... = \text{constant for a single beam}$$

where θ is the grazing angle and c is the speed of sound.

Figure 2: Sketch of refraction (ray bending).

Snell's Law of refraction gives the bending angle of the sound "ray" i.e. that particular grazing angle indicating the chance in the ray propagation direction. Ray bending is only significant when the speed of sound changes and then usually only at large ranges. For more information on sound refraction and ray bending see Urick3.

[2] Reference: Medwin, H.: "Speed of Sound in Water For Realistic Parameters", J. Acoust. Soc. Am. 58:1318 (1975)

[3] Urick, Robert J.: "Principles of underwater sound, 3rd edition". McGraw-Hill Book Company, 1983

RESON

Basic Acoustics

<u>Sound pressure levels:</u>

The source level of an acoustic source compares the intensity emitted by the acoustic source to a reference source. This of course, also enables direct comparison of acoustic sources with each other i.e. which one is the most powerful? The reference source is an omni directional source (DI=0dB) with an acoustic output power of 1W taken at the reference distance r=1m from the acoustic center. In terms of acoustic intensity the reference source has an acoustic intensity I_0:

$$I_0 = \frac{P_{a,0}}{A_{sphere}} = \frac{1W}{4\pi(1m)^2} = 0.0796 \,{}^{W}\!/_{m^2} @1m$$

In dB relative to the reference intensity I_{ref} this is

$$I_{0,dB} = 10\log\left(\frac{I_0}{I_{ref}}\right) = 10\log\left(\frac{0.0796 \,{}^{W}\!/_{m^2}}{0.667 \cdot 10^{-18} \,{}^{W}\!/_{m^2}}\right) = 170.8 \text{ dB re } 1\mu Pa\ @1m$$

This is where the (to some well-known) reference level 170.8dB re 1µPa @ 1m derives from and it should be noted that the “dB re 1µPa @1m” should be understood as “the intensity level relative to the intensity of a plane wave with an rms-pressure of 1µPa taken at the reference distance 1m from the source”. Most acoustic sources have an acoustic power output different from 1W and they are not always omni-directional. To find the source level of such a more generic source we simply add (in dB) the directivity and the ratio of power output relative to 1W:

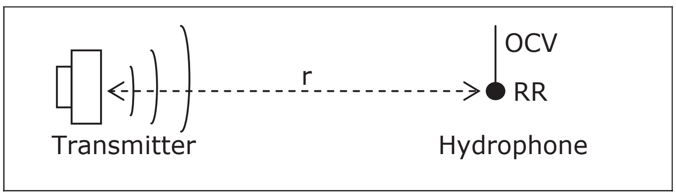
$$SL = 10\log(P_a) + DI + 170.8\text{dB re } 1\mu Pa\ @1m$$

In this formula, and in many similar, it is always understood that Pa is relative to unity with the proper unit assigned i.e. 1W. So “Pa” is really an abbreviation for “Acoustic output power relative to 1W” just like “DI” is short for directivity relative to an omni-directional source. The transmit response to voltage, TRV, is defined in such a way that the source level can be calculated from:

$$SL = TRV + 20\log(V_{in})$$

The TRV value is, however, often measured at low power and since the electric-to-acoustic efficiency can drop significantly with increased power levels it is often best to use the TRV relation with caution. It should be emphasized that the number and term source level refers to an acoustic source, not to the level of a particular sound, and that a source level is merely a practical definition.

The source level of a transmitter can be estimated (ignoring attenuation) by measuring the output voltage of a hydrophone submerged in the vicinity of the transmitting transducer, see the sketch below.



$$SL = 20\log(OCV) - RR + 20\log\left(\frac{r}{m}\right)$$

For an example, the hydrophone has a receive response RR=-190dB re 1V/µPa with an open circuit (output) voltage OCV=2.4Vrms on its terminals. This means that the intensity level at the hydrophone is IL=20log(2.4Vrms) - (-190dB re 1V/µPa) = 197.6dB re 1µPa and if the distance between the hydrophone and the transmitter is r=4m the source level is calculated from SL=IL+ 20log(4m/1m)=209.6dB re 1µPa @ 1m.