Benthowave Instrument Inc.
Underwater Sound Solutions
www.benthowave.com

BII7180 Series Miniature Probe Hydrophone and AE Sensor: Φ1.0 to Φ3.0mm Aperture

BII7180 Series Miniature Probe Hydrophone and AE Sensor

Underwater Sounds: BII7180 series are miniature hydrophones with small aperture size and usable up to 3 MHz. Conical and omnidirectional directivity patterns are available. Multiple miniature probe hydrophones can be configured as a vector hydrophone (vector sensor) or array for uses in extraction of directional information (source location), measurement of particle velocity, particle acceleration and pressure gradient.

The probe hydrophones are practical and handy tools for research and application of Helmholtz Integral Equation in underwater acoustics and for the measurement of pressure or intensity distribution of near-field and far-field radiated from vibrational and acoustical sound sources underwater.

NDT in Solids: receiving audible and ultrasonic sounds, acoustic emission (AE), structural health monitoring (SHM), metallurgical properties of metals, etc... The couplant such as water or gel is a must-have material to provide efficient acoustic coupling between the receiving face of the hydrophone and the piece under test (the subject). The hydrophones can be glued on or inside subject permanently with adhesives such as epoxy.

NDT in Fluids: uses in waterlike and airlike fluids for the analysis of their macroscopic and microscopic, physical and chemical properties.

BII7180 series should not be used with flammable and/or explosive materials, and not used in Solvents such as hydrochloric acid, isopropyl alcohol, ethyl lactate, acetone, xylene, Iso hexanes, mineral spirits, etc...

Technical Notes:

Particle Velocity in x direction ux = - 1/(jωρ)*(ap/ax); ρ: Density; ap/ax: Pressure Gradient in the x direction.

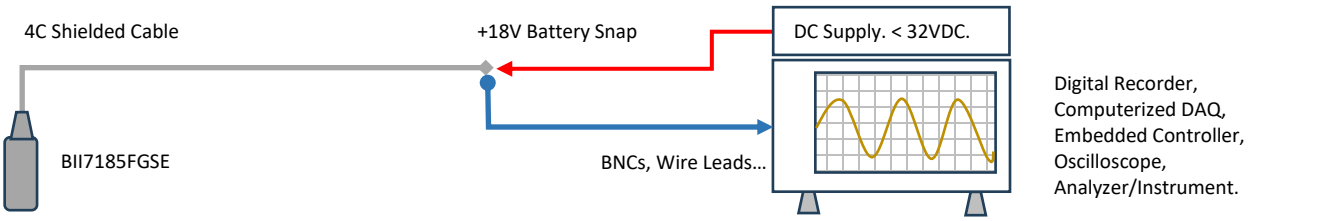
Dipole Vector Hydrophone: Voltage Response V=M*(d/λ)*cosθ; M: Amplitude Constant related to element sensitivity; d: spacing distance between two elements; θ: Arriving angle from the axis of the two elements.

$$\text{Helmholtz Integral: } p(\vec{r}) = \frac{1}{4\pi}\iint\left[\frac{e^{-jkR}}{R}j\omega\rho u(\vec{r_0}) + p(\vec{r_0})\frac{\partial}{\partial n_0}\left(\frac{e^{-jkR}}{R}\right)\right]dS_0$$

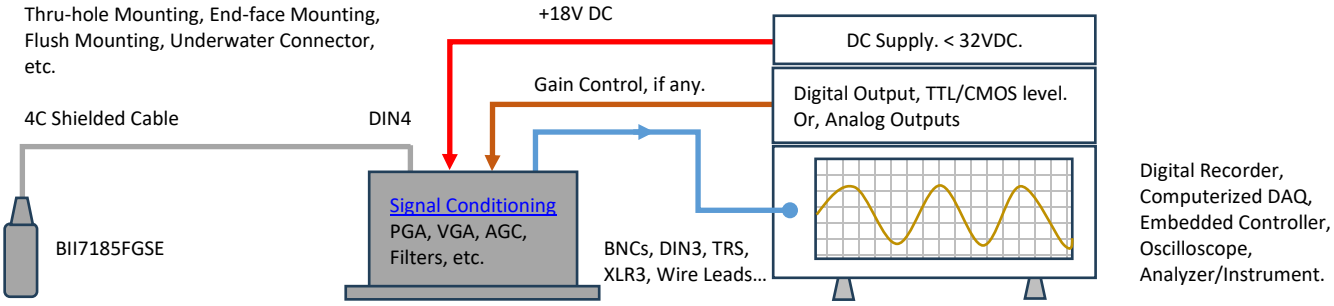
Typical Applications

Study of Acoustic Radiation Field	General Purpose Hydrophone, Reference Hydrophone
Ultrasonic Testing and Analysis	Acoustic Emission (AE), Structural Health Monitoring (SHM), Thermoacoustic Tomography
Helmholtz Integral in Acoustics	Near-field Calibration and Measurement
Elements of Vector Hydrophones/Array	High Sound Level Measurement (Warning: Cavitation will damage hydrophone)
Research in Boundary Element Acoustics	Trouble-shooting, Maintenance and Development of Transducers and Array

System Configuration of Receiving Sounds and Waves.



Installation to Underwater Submersibles:
Thru-hole Mounting, End-face Mounting, Flush Mounting, Underwater Connector, etc.



Specification

The hydrophone is tested in water unless stated otherwise.	
FG: Fixed Gain; **PG:** Programmable Gain; **DF:** Differential Output; **SE:** Single Ended Output; **BPF**: Band Pass Filter; **HPF**: High Pass Filter; **LPF**: Low Pass Filter.	
Part Number:	**BII7184FGSE**
Sensitivity @ 1 kHz:	-170.0 + Preamp Gain, ± 3 dB V/µPa.
FFVS:	Refer to Graph of FFVS vs. Frequency. Free-field Voltage Sensitivity.
Built-in Filters	Bespoke HPF. Minimum high pass filter f_{-3dB} = 600 Hz.
	1. Reduce Noise. Both ocean ambient noises and the self-noises of electronic devices decrease when frequency increases. It is recommended to choose a built-in high pass filter to reject noises in low frequency range. For example, if you are interested in the signals greater than 100 kHz, you may specify a high pass filter with -3dB cut-off frequency at 10 kHz to improve signal to noise ratio of the signals of the interest.

	2. Avoid Saturation. When there are strong low frequency noises, disturbances, and/or vibrations, resulting from rough surface waves and/or mechanical movements of the platform, it is recommended to specify a high pass filter to avoid hydrophone saturation in these low frequency ranges.
Usable Frequency Range:	in Water: 600 Hz ~ 3.5 MHz.
	in Air: 600 Hz ~ 3.5 MHz.
Preamp:	Yes, Built-in BII1040 series Preamp.
Signal Conditioning:	If your project need extra signal conditioning before data acquisition, please refer to signal conditioning, and order separately. 1. Programmable Gain Amplifier PGA, 0/20/40/60 dB, etc. 2. Variable Gain Amplifier (VGA): 60 to 70 dB Range. 3. Automatic Gain Control (AGC) Amplifier: 100 dB Gain Dynamic Range. 4. Amplifiers with Built-in, High-pass, Low-pass, and Band-pass Filters.
	Packages: **Standalone Devices** for portable uses, and **Coated PCB** with Wire Bundles for underwater submersibles.
Receiving Face:	Circular Planar Face
Directivity Pattern:	Conical Beam
Beam Width:	θ_{-3dB} = 44175°/f(kHz); θ_{-6dB} = 60961.5°/f(kHz); θ_{-10dB} = 79515°/f(kHz). f: Operating Frequency in kHz.
Side Lobes:	< -17.8 dB with $\theta_{-3dB} \leq 49°$; No side lobe with $\theta_{-3dB} > 49°$.
Signal Output Type:	Single Ended.
Maximum Output V_{omax}:	Supply Voltage V_s - 4, in Vpp.
Overload Pressure Level:	20*log(V_{omax}/2.828) - Sensitivity, in dB µPa. For example, with +24VDC supply, Overload Pressure Level = 20*log((24-4)/2.828) – (-170) = 187 dB µPa.
Acceleration Sensitivity:	**Acoustic Axis**: 130 dB µPa/(m/s²). **Non-Acoustic Axis**: ≤120 dB re µPa/(m/s²).
Operating Depth:	300 m or 3MPa, and limited by the cable length if the cable has wire leads or a non-waterproof connector.
Mounting Options:	1. Default: Free Hanging (**FH**) 2. Thru-hole Mounting with Single O-ring (**THM-M10, THM-7/16", or THM-5/8".)** 3. Thru-hole Mounting with Double O-ring (**THDO-7/16"**) 4. Bolt Fastening Mounting (Stainless Steel) (**BFM-7/16", or BFM-5/8".**) 5. Bolt Fastening Mounting (Plastics) (**BFMP-M12, or BFMP-NPT3/8".**) 6. Thread Mounting with Single O-Ring (**TMSO-M10x15, TMSO-M10x22.**) 7. Free-hanging with Male Underwater Connector (**FHUWC-4P)**
	Please refer to online document AcousticSystem.pdf for a complete list of Mounting Options and more details.
Cable Options:	Four Conductor Shielded Cable (**SC**)
Cable Orientation:	Perpendicular to end face of hydrophone.
Cable Length:	1. Default: 10m (32.8ft) for Non-Underwater Connector; 0.6m (2ft) for Underwater Connectors. 2. Custom-fit Cable Length up to 50m.
Connector:	1. Default: Wire Leads (**WL**) 2. Male BNCs (**BNC**) (Max. Diameter Φ14.3 mm). 3. DIN Receptacle with 4 Male Pins (**DIN4**), (Max. Diameter Φ17 mm). 4. Underwater Mateable Connector (4 pins) (**UMC4P**) (Max. Diameter Φ21.5 to Φ35 mm). **UMC** is from global manufacturers of underwater connectors. Its part number is listed in quote in detail.
	5. +9VDC Battery Snap (**BS**), for +9VDC or +18VDC power supply. 6. 4mm Banana Plug Pair (Red and Black Color) (**BP**), for DC power supply ONLY.
	Underwater Mateable Connectors are for underwater uses. Other connectors/wire leads are for dry uses and are not waterproofed.
1. **BNC**: "Bayonet Neill–Concelman" is a miniature quick connect/disconnect radio/audio frequency connector used for coaxial cable. **Fastening Type**: Bayonet Lock. 2. **DIN**: Electrical cylindrical connectors, 3 to 14 contacts, Φ20mm diameter, used for audio, RF, digital, and DC or AC power signals. **Fastening Type**: Threaded.	
Supply Voltage V_s:	+9 to +26 VDC. Warning: The device will be destroyed with Vs ≥ +32VDC.
Suggested DC Supply:	+9VDC Battery, Marine Battery, Automobile Battery, Fixed DC Linear Power Supply, Not Included. DO NOT use variable power supply whose maximum supply voltage is higher than the rated voltage. DO NOT use switching mode DC power supply.
Current (Quiescent):	8.0 mA with +9 VDC. 8.8 mA with +12 VDC. 10.5 mA with +18 VDC. 12 mA with +24 VDC.
Size:	Sensing Element: ΦD = Φ3.0 mm; Solid Support: ΦDxL = Φ7.5x30 mm; Preamp Housing: ΦDxL = Φ21x95 mm.
	Varies with options. Other Mounting Types: actual length depends on Mounting Parts.
Weight:	0.386 kg with 10m cable. Actual weight depends on Mounting Parts, Cable Types and Length.
Operation Temperature:	-10 °C to +60 °C or 14 °F to 140 °F.
Storage Temperature:	-20 °C to +60 °C or -4 °F to 140 °F.
Sound Measurement in Air: The hydrophones can be used to detect sounds in air. The sensitivity in air is same to the one in water in low frequency range.	

How to Order Standard Hydrophones. BII Keeps Standard Products in Stock**.**

FG: Fixed Gain; **SE:** Single-ended Output; **BPF**: Band Pass Filter; **HPF**: High Pass Filter; **LPF**: Low Pass Filter.				
Part Number	**-High Pass Filter**	**-Mounting**	**-Cable Length**	**-Connectors for Signal/DC Supply**
BII7184FGSE	Default: 600 Hz. Bespoke: > 600 Hz.	FH: Free Hanging.	10 m (32.8 ft)	WL, BNC, DIN, BS.
Example of Part Number:	**Description**			
BII7184FGSE-FH-10m-WL	BII7184FGSE Hydrophone, Free Hanging, 10m Shielded Cable, Connector: None, Wire leads.			
BII7184FGSE-FH-10m-BNC/BS	BII7184FGSE Hydrophone, Free Hanging, 10m Shielded Cable, Connector: BNC for Signal, 9V Battery Snaps for DC Supply.			
BII7184FGSE-FH-10m-DIN4	BII7184FGSE Hydrophone, Free Hanging, 10m Shielded Cable, Connector for Signal and DC Supply: DIN4.			

BII7184FGSE-100kHz-FH-10m-BNC/BS	BII7184FGSE Hydrophone, High Pass Filter: 100kHz. Free Hanging, 10m Shielded Cable, Connector: BNC for Signal, 9V Battery Snaps for DC Supply.

Wiring Information of Hydrophones with Fixed-gain Preamps:

Single-ended Output:	Wire Leads	UMC4P	BNC + Two 9V Battery Snaps	DIN4
+VDC	Red	Pin 3	Battery Female Snap	Pin 4
Common	Black	Pin 1	Battery Male Snap	Pin 1
Signal	White	Pin 2	BNC Center	Pin 3
Signal Common	Blue, Green, or Yellow	Pin 4	BNC Metal Shell	Pin 2
Shielding	Cable Shield	N/A	BNC Metal Shell	Metal Shell

Question:

What if the mating connector of my DAQ module or recording device is NOT available from BII? A bespoke connector adaptor might be assembled by BII and BII ships the adaptor to buyer as accessory of the device. Please contact BII for customizations. Many adaptors for standard connectors are available in worldwide electronic suppliers such as BNC to SMA, BNC to SMC, XLR to TRS, etc. Check out your local suppliers.

Is impedance matching necessary between hydrophones/sensors and preamplifiers/Recorders/Analyzers? it is NOT necessary to do impedance matching in low frequency range applications in which electromagnetic wave lengths are much greater than the cable length. High frequency transducers such as NDT pulsing transducers need 50Ω impedance matching among transducers, cables, and analyzers/digitizers.

Can BII explain why the capacitance of my hydrophone/transducer affect high pass filtering? (1). Hydrophone/transducer is high impedance devices in low frequency range. Its simplified complex impedance = $j/(2\pi fC_h)$, C_h is the capacitance of hydrophone/transducer, f is frequency in Hz. This impedance is in series with preamp R_i and can reach several MΩ to hundreds MΩ depending on C_h and f. (2). Most high-performance operational amplifiers (IC chips) can use input resistors R_i up to 1 to 200 MΩ to avoid bumping into saturation issue.

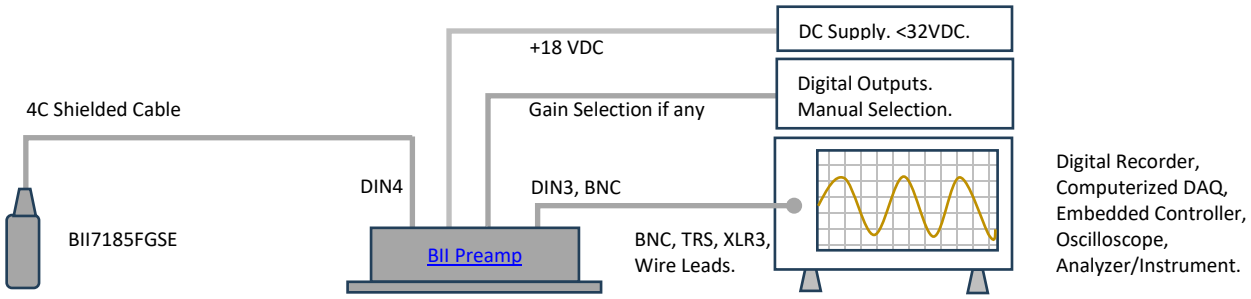
How to increase hydrophone sensitivity for extremely weak sounds?

BII low noise hydrophone with built-in preamp (Differential Output) -> Long Cable -> Standalone Preamp -> Analyzing Instrument or Recorder.

What components are necessary to compensate the propagation and spreading loss?

A low noise hydrophone + PGA amplifier with gain of 0/20/40/60 dB.
A low noise hydrophone + VGA amplifier with gain of 0 ~ 70 dB.
A low noise hydrophone + AGC amplifier with gain of -20 ~ 80dB.

Acoustic Receiving System of Programmable Sensitivity.

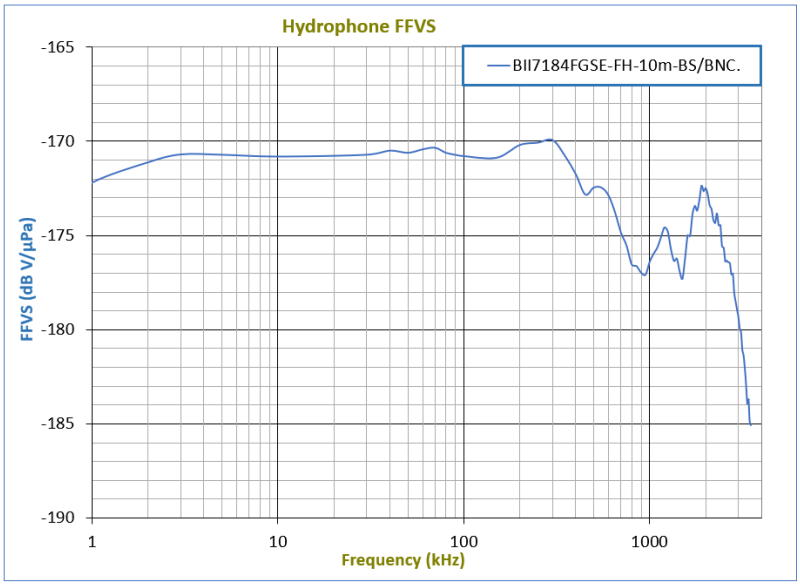


How do I use Gain Selection wires of a standalone PGA in field?

(1). **Manual Gain Selection.**
When a **Gain Selection wire** is floating or open, its digital logic is High or "1". When a **Gain Selection wire** is short to **Digital Common**, its digital logic is Low or "0". Sensitivity of a Hydrophone is fixed when its Gain Selection wires are fixed to **Digital Common** or open (floating) during operation.

(2). **Gain Selection with Digital Outputs.** Digital Outputs of a DAQ (data acquisition device) select gains with TTL/CMOS logic levels.

Free-field Voltage Response (FFVS):



Physical Size (Dimension Unit: mm): Varies with mounting options.