SE=SL-TL+AG-NL

Benthowave Instrument Inc.

Underwater Sound Solutions www.benthowave.com

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

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.

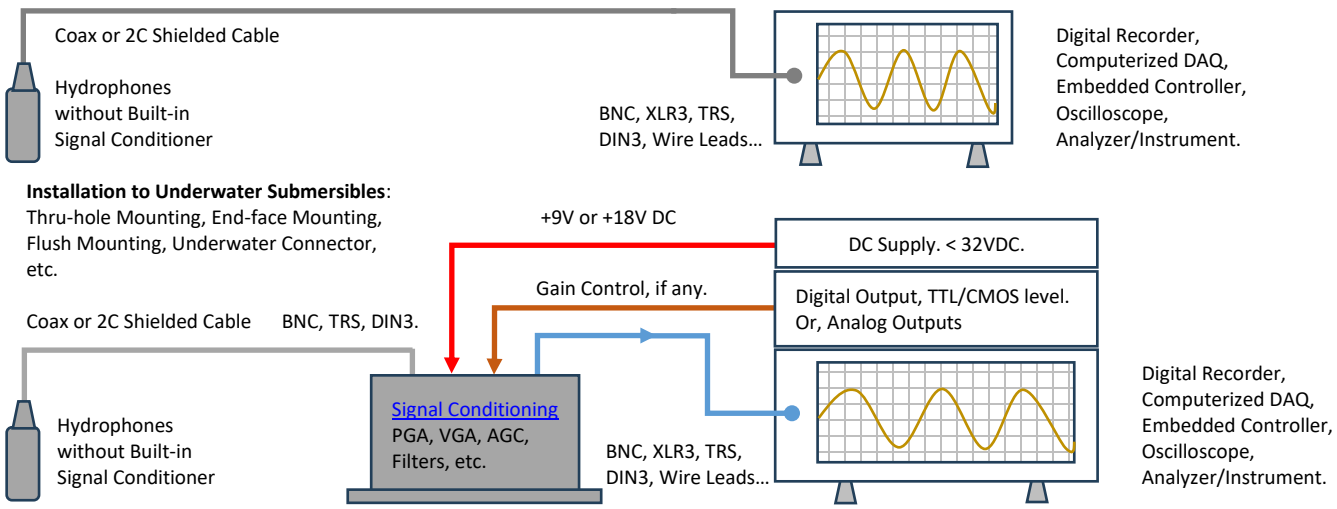
Dipole Vector Hydrophone: Voltage Response V=M*(d/λ)*cosθ; M: Amplitude Constant related to element sensitivity; d: spacing distance between two elements; θ: Arriving angle from the axis of the two elements.

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

System Configuration of Receiving Sounds and Waves.



SPECIFICATIONS

Part Number:	BII7184EF	BII7184SW
Aperture Size:	Sensing Element: ΦD = Φ3 mm	
Sensitivity @ 1kHz:	1. with 2m Coax/BNC: -217.0 dB V/μPa Variation: ±3 dB. 2. with 1m Coax/BNC: -213.0 dB V/μPa Variation: ±3 dB.	
	Sensitivity Loss over Extension Cable (dB) = 20*log[C_h/(C_h+C_c)]. Valid for hydrophone without preamplifier. C_h: Hydrophone Capacitance; C_c: Capacitance of Extension Cable. Cable is of 100 pF/meter roughly.	
Free-field Voltage Sensitivity:	Refer to Graph of FFVS vs. Frequency.	
Usable Frequency in Water:	26 Hz ~ 3.5 MHz	
	Minimum Usable Frequency depends on -3dB high pass filter f_{-3dB} = 1/(2π$R_i$$C_h$). R_i: Input Resistance or Impedance of Preamp. C_h: Capacitance of hydrophone at 1 kHz. For example: A BII7184EF (2m Coax/BNC) and a BII1041 preamp of Ri = 22MΩ are used to detect sounds, -3dB high pass frequency of detection = 25.8 Hz.	
Usable Frequency in Air:	26 Hz ~ 3 MHz at -10 dB V/μPa.	
Capacitance @1kHz:	1. 0.28 nF ± 10% with 2m Coax/BNC.	

	2. 0.18 nF ± 10% with 1m Coax/BNC.
	Generally, cable capacitance ≈ 100 pF/meter.
Dissipation @1kHz:	0.02
Noise Density at f << fs: dB µPa/√Hz	64.5 – 10*log f
	1. f in kHz; fs: Resonance Frequency which is close to the frequency of maximum FFVS. 2. Noise densities in this datasheet are calculated values with transducer parameters being measured in water. 3. As hydrophones works with preamps or data acquisition modules, total noise density is determined by all noise sources. Generally, the total noise density is much higher than the ones stated in this datasheet.
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.
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.
Acceleration Sensitivity:	130.0 dB µPa/(m/s²) at Acoustic Axis. 112.6 dBµPa/(m/s²) at other directions.
Acoustic Source:	Yes.
Resonance fs:	2.8 MHz ± 10%
TVR at fs:	146 dB µPa/V at 1m.
Maximum Drive Voltage:	100 Vpp
Maximum Pulse Length:	1 mS at Maximum Drive Voltage
Duty Cycle in Water:	1% at Maximum Drive Voltage. 100% at ≤ 30 Vpp or 10.6 Vrms.
Maximum Operating Depth:	300 m 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".)** 3. Thru-hole Mounting with Double O-ring (**THDO-7/16".**) 4. Bolt Fastening Mounting (Stainless Steel) (**BFM-M6, BFM-7/16".)** 5. Thread Mounting with Single O-Ring (**TMSO-M10x15, TMSO-M10x22.**) 6. Bolt Fastening Mounting (Plastics) (**BFMP-M12.)** 7. Flush Mounting (**FSM-M10**.)
	Please refer to online document AcousticSystem.pdf for a complete list of Mounting Options and more details.
Cable Options:	1. Default: Coax RG174/U (RG174) 2. Coax RG178/U (RG178) up to 200°C. 3. Shielded Cable with Polyurethane Jacket, ΦD=2.6 mm (SC26) 4. Shielded Cable with Twisted Pair and Teflon (PTFE) Jacket, ΦD=3.2 mm (SC32), up to 200°C. Not water-proof. 6. Shielded Cable with Twisted Pair and PVC Jacket, ΦD=3.6 mm (SC36) 7. Shielded Cable with Twisted Pair and Polyurethane Jacket, ΦD=4.7 mm (SC47)
Cable Orientation:	Perpendicular to end face of hydrophone / Perpendicular to side wall of hydrophone.
Cable Length:	1. Default: 2 m. 2. Custom-fit Cable Length.
Connector:	1. Default: Wire Leads (WL) 2. Male BNC (BNC) (Max. Diameter Φ14.3 mm). 3. SMA (Plug, Male Pin) (SMA), Voltage Rating: 335 V_{RMS} Continuous. (Max. Diameter Φ9.24 mm). 4. SMC (Plug, Female Socket) (SMC), Voltage Rating: 335 V_{RMS} Continuous. (SMC) (Max. Diameter Φ6.4 mm). 5. Underwater Mateable Connector (pin) (UMC) (Max. Diameter Φ21.5 to Φ35 mm).
	Note: Underwater Mateable Connector is for uses underwater. Other connectors and wire leads are for dry uses and are not waterproofed.
Size:	ΦDxH = Φ7.5x17 mm / ΦDxH = Φ7.5x10 mm
Weight:	33 grams with 2m RG174 Coax/BNC. Actual weight depends on Mounting Parts, Cable Types and Length.
Operation Temperature:	-10°C to +70°C or 14°F to 158°F.
Storage Temperature:	-20°C to +70°C or -4°F to 158°F.

Wirings

Single Ended Output:	**Wire Leads**	**Underwater Connector**	**BNC/SMA/SMC**
Signal	White or Red	Pin 2	Center Contact
Signal Common	Black	Pin 1	Shield
Shielding	Shield	Pin 3	Shield

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

Hydrophone Part Number	**-Mounting Part**	**-Cable Length**	**-Cable Type**	**-Connector Type**
BII7184EF, BII7184SW.	**FH**: Free Hanging.	2 m (6.56ft) 1 m (3.28ft)	**RG174** Coax	BNC
Example:	**Description**			
BII7184EF-FH-2m-RG174-BNC	BII7184EF Hydrophone, Free Hanging, 2m RG174 Coax, BNC Male.			
BII7184EF-FH-1m-RG174-BNC	BII7184EF Hydrophone, Free Hanging, 1m RG174 Coax, BNC Male.			

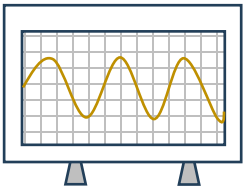
How to Order Bespoke Hydrophones. Non-stock.

Benthowave Instrument Inc.

Underwater Sound Solutions www.benthowave.com

Hydrophone Part Number	-Mounting Part	-Cable Length	-Cable Type	-Connector Type
BII7184EF, BII7184SW.	Mounting Options.	in meter.	Cable Options.	Connector Options.
Example:	**Description**			
BII7184EF-TMSO-M10x15-0.6m-RG178-WL	BII7184EF Hydrophone, Thread Mounting with Single O-Ring (TMSO-M10x15), 0.6m RG178 Coax, Wire Leads.			
BII7184EF-FSM-M10-0.15m-RG174-WL	BII7184EF Hydrophone, Flush Mounting (FSM-M10), 0.15m RG174 Coax, Wire Leads.			

Typical Components of an Acoustic Receiving System. **Depending on the system requirements, the signal conditioner is optional.**



Digital Recorder, Computerized DAQ, Embedded Controller, Oscilloscope, Analyzer/Instrument.

Question:

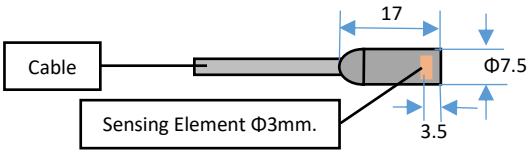
What if the mating connector of my DAQ module or recording device is NOT available from BII? A bespoke connector adaptor might be assembled by BII and BII ships the adaptor to buyer as accessory of the device. Please contact BII for customizations. Many adaptors for standard connectors are available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

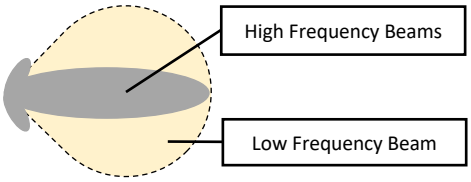
What if the connector of my analyzer (instrument) is SMA or SMC Connector? Buyer may order a SMA (or SMC) to BNC (Male) adaptor from local electronic distributors in buyer's country. BII may ship the adaptor as accessory of the device if buyer requests when ordering. **By default, BII does NOT supply the adaptor as accessories.**

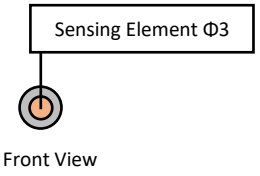
Is impedance matching necessary between hydrophones/sensors and preamplifiers/Recorders/Analyzers? it is NOT necessary to do impedance matching in low frequency range applications in which electromagnetic wave lengths are much greater than the cable length. High frequency transducers such as NDT pulsing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

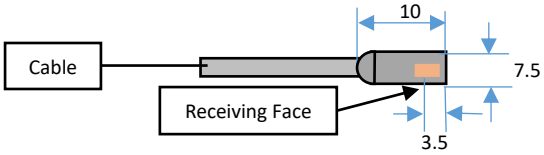
Physical Size (unit: mm, Illustration ONLY, Scale is not 1:1) (BII7184EF):

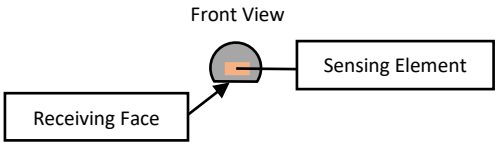




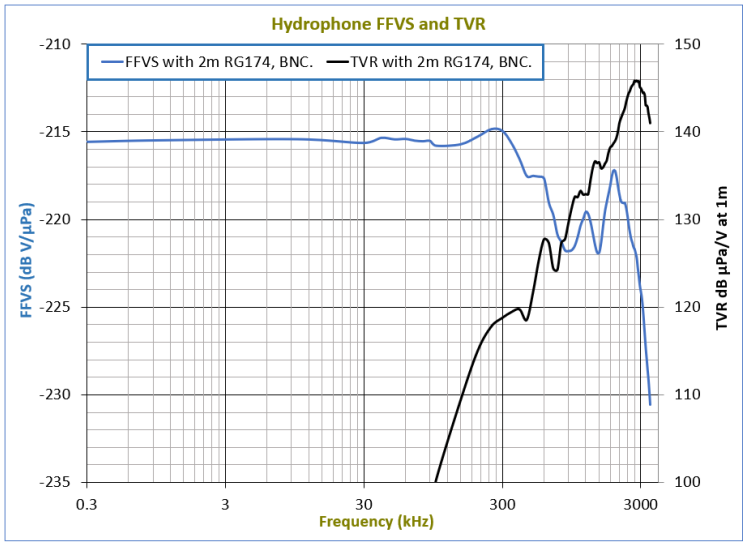


Physical Size (unit: mm, Illustration ONLY, Scale is not 1:1) (BII7184SW):





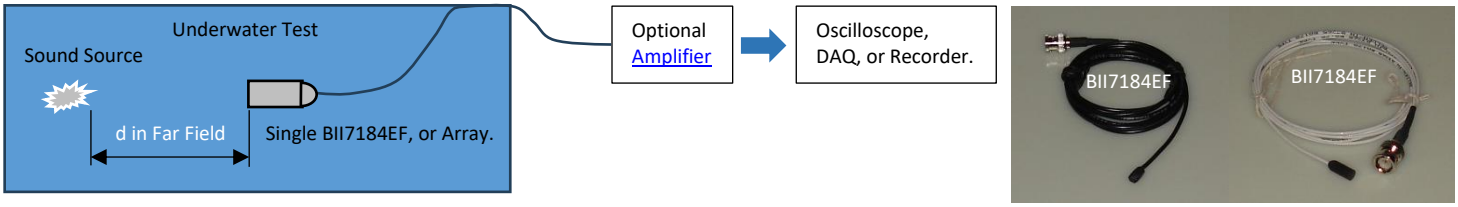
Free-field Voltage Sensitivity FFVS and Transmitting Voltage Response TVR in Water:



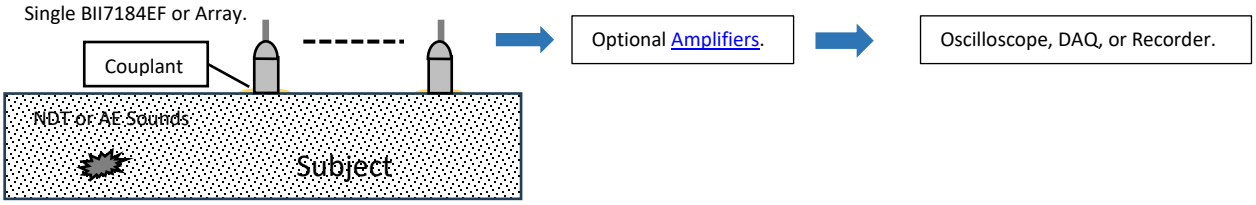
Application Notes.

1. Underwater Hydrophones: Measure HIFU (High Intensity Focused Ultrasound) and NDT Diagnostic Sounds.

Distance d of Acoustic Far Field of a Transducer:	**Planar Transducer**: d ≥ Radiation Area/λ. **Line (linear) or Thin Cylinder:** d ≥ (Length*Length)/λ and d ≥ Length.



2. Acoustic Contact Sensor: NDT and AE Applications, and Structural Health Monitoring (SHM).



3. Test BII7184EF as Acoustic Contact Sensor at BII Laboratory: BII7184EF contacts with radiation face of a transducer (projector), water as couplant.

BII Projector	f	Signal Type	Driving Voltage	Receiver	Extra Preamp	Output Voltage
BII7562/200	190 kHz	SINE and Sine Pulse	0.5Vpp	BII7184EF	None	80 mVpp
BII7562/200	200 kHz	SINE and Sine Pulse	2.0Vpp	BII7184EF	None	61 mVpp
BII7562/200	478 kHz	SINE and Sine Pulse	20 Vpp	BII7184EF	None	60 mVpp
BII7562/200	626 kHz	SINE and Sine Pulse	1.5Vpp	BII7184EF	None	50 mVpp
BII7560Q/1000	962 kHz	SINE and Sine Pulse	0.3Vpp	BII7184EF	None	42 m Vpp
BII7560Q/1000	3.3 MHz	SINE and Sine Pulse	0.3Vpp	BII7184EF	None	1.0 mVpp