Benthowave Instrument Inc.

SE=SL-TL+AG-NL Acoustical Solutions: SONAR, NDT/AE, HIFU. benthowave.com Revised on 2025/4/15

BII7010 Series Broadband Hydrophone: Low Noise, Low Power, and Low Frequency

The directional response patterns are omnidirectional in low frequency range and toroidal in high frequency range. Typical quality factor Q are 2 in useful frequency range. Pulsed sounds reach stable state quickly with short ringing. Custom-fit hydrophones with low power preamplifiers consume 1 to 2mA which is a great merit for battery-powered portable acoustic system.

These hydrophones provide low cost solutions for field recording, field listening, and acoustic research in laboratory from 0.2Hz to 500 kHz. They come with coax/shielded cables and underwater mateable/BNC/TRS/XLR/DIN/MIL-5015 style connectors, and are ready to be integrated into underwater acoustic systems. They support digital recorders and DAQs (A/D Converter). the output signal can be used for speaker system and headphones.

Small size and broadband of bespoke BII7015 offers benefit for uses in parabolic receivers underwater to achieve the highest pressure gain and the narrowest beam width which are the merits in weak signal detection and searching, directional high speed communication, etc.

Hydrophones with integrated low power preamplifiers and filters are ideal gears to amplify weak underwater sounds and reject ambient noises. Some preamplifiers can drive cable up to 1000m without significant signal loss. These features allows them to be used in long line arrays (streamers) and large planar arrays.

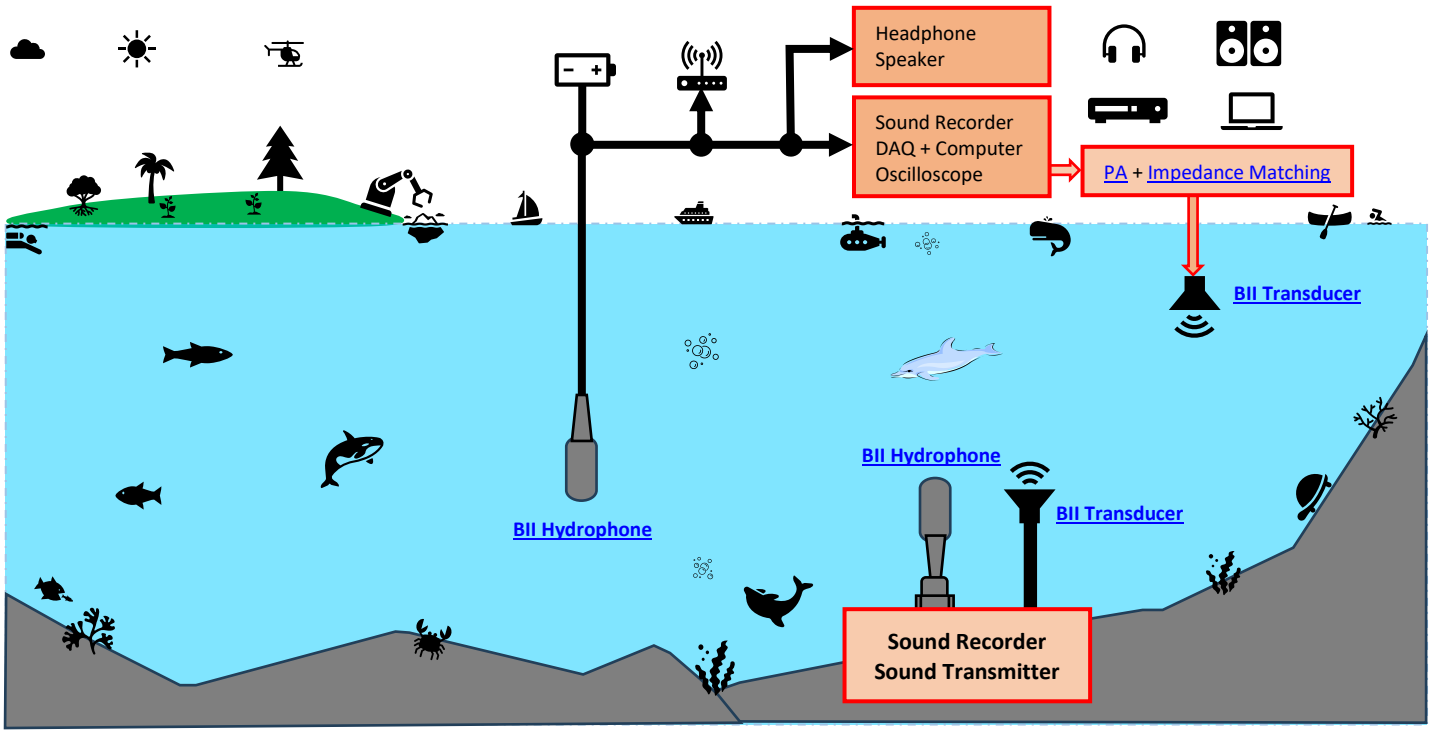
The smooth dome and small size reduce interferences to acoustic field under test. Hydrophone body possesses streamlined hemispherical domes which minimize the drag force and the hydrodynamic noise caused by the hydrophone in motion or the flow past the hydrophone. They can measure the sound radiations and pressure changes in turbulent processes and flows: surface waves (Wave-height Sensor), turbulences, seismic, ocean traffics, industrial noises, precipitations, biologics, ...

Sound Excitation by Turbulence: $\frac{1}{c^2}\frac{\partial^2 p}{\partial t^2} - \Delta p = \rho \frac{\partial^2 v_i v_k}{\partial x_i \partial x_k}$ v-Velocity of Turbulence Flow; c-Sound Speed in Fluid; p-Pressure; ρ-Fluid Density; x-Position.

Typical Applications

Towed/Dipping Hydrophone, Sonobuoy, LBL/SBL/USBL Positioning. Reference Hydrophone, Noise Measurement. Signal Detection in Strong Currents. Underwater Parabolic Antennas. Passive Acoustic Monitoring (PAM System).	Detection of Ultrasonic Cavitation Noise, Thermoacoustics in Gas. Linear and Planar Array Element, Vector Hydrophone Element. Marine Bioacoustics, Phantom-power Hydrophone, Sound Recording. Studies of Ocean Turbulence and Flow, Marine Hydrodynamics.

Underwater Sound Listening, Recording, and Communication



Typical Applications

Underwater Sounds Recording, Listening, and Communication, Noise Measurement, Marine Bioacoustics, Passive Acoustic Monitoring (PAM System).
Coastal/Offshore Processes, Engineering & Management, Wave-Structure Interaction, Wave-height Sensor, Wave and Tide Recorder/Logger.
Surface Waves, Ocean Turbulences, Hydrodynamics, Marine Geophysics, Battery-Powered Instruments: Sonobuoy, Recorder, Transponder, Acoustic Release...

Questions

How do I set up my professional sound recorders to work with BII Hydrophones?

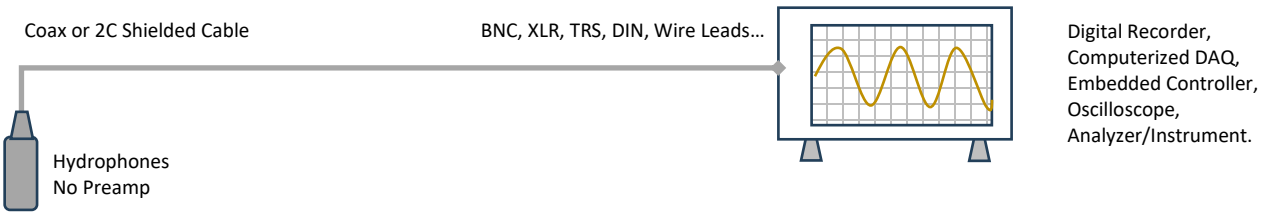
1. BII hydrophones have their own DC power supply to support **Line Input** of recorders, and **Do NOT** use phantom power 48V which may destroy the hydrophones.
2. **Maximum Input Level (Line Input)** of recorders should be large enough to avoid saturation or clipping during recording.
   Equivalent Input Noise of recorders should be low enough for the recorders to be sensitive to weak signal of the interest.
3. **Sampling Rate** of the recorder should be fast enough to avoid missing high frequency sound of the interest. Generally, the **Sampling Rate** should be at least two times greater than the maximum frequency of sound.
4. Calculate the **memory size of data storage** according to sampling rate, resolution, sampling channels, and recording time, and use suitable recording media.

5. Calculate **battery service life** according to battery power and consuming current.
6. When the cable is greater than 5m, **balanced signal or differential signal** is recommended to be in use over the cable.

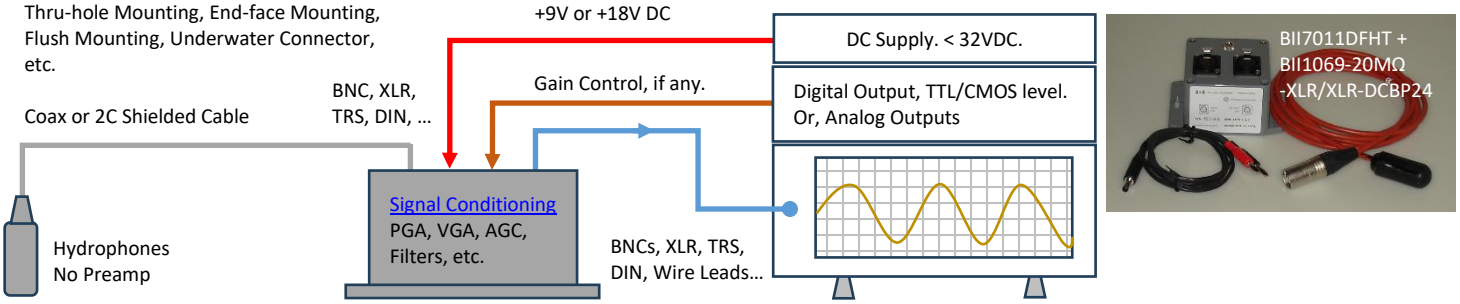
How do I playback the recorded sounds in water?

System Setup: Recorder (Recorded Sounds) with **Line or Phone Output** -> Audio Power Amplifiers -> Impedance Matching Device -> Transducers (Projectors).

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. **SE**: Single ended Output, **DF**: Differential Output, **DW**: Deep Water, **UMC**: Underwater Mateable Connector, **FFVS**: Free-field Voltage Sensitivity, **TVR**: Transmitting Voltage Response.			
Part Number:	**BII7011**	**BII7011DF**	**BII7011DW**
Sensitivity @ 1kHz: (No Cable)	-200.0 dB V/µPa ± 2 dB	-194.0 dB V/µPa ± 2 dB	-196.5 dB V/µPa ± 2 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.		
Sensitivity Matching: (at 1 kHz)	When hydrophones are used as array elements, it is necessary for array elements to possess uniform sensitivities. **Available Options of Sensitivity Tolerance**: a. ±2.0 (Default); b. ±1.0; c. ±0.5; d. ±0.3; e. ±0.1; in dB V/µPa. 1. **Sensitivity is tested at 1 kHz in water**. 2. Hydrophones whose sensitivity variations are out of specified tolerance are rejected.		
FFVS:	Refer to Graph of FFVS vs. Frequency.		
Usable Frequency: in Water, at ±3 dB V/µPa.	0.2 Hz ~ 70 kHz	0.5 Hz ~ 70 kHz	1 Hz ~ 80 kHz
	C_h and R_i constitute a high pass filter. -3dB high pass filter $f_{-3dB} = 1/(2\pi R_i C_h)$. R_i: Input Resistance or Impedance of Preamp. C_h: Capacitance of hydrophone at 1 kHz. For example: A BII7011 and a BII preamp of R_i = 100 MΩ are used to detect sounds, -3dB high pass frequency of detection = 0.16 Hz. A BII7011DF and a BII preamp of R_i = 200 MΩ are used to detect sounds, -3dB high pass frequency of detection = 0.19 Hz.		
Usable Frequency in Air:	1 Hz ~ 5 kHz at -3dB V/µPa.		
Capacitance C_h @ 1kHz:	12.7 nF ± 10%, No Cable.	2.85 nF ± 10%, No Cable.	1.25 nF ± 10%, No Cable.
Dissipation @ 1kHz:	0.015	0.015	0.005
Noise Density at f << fs: dB µPa/√Hz	24.7 – 10*log f	28.0 – 10*log f	26.0 – 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.		
Directivity Pattern:	Omnidirectional and Toroidal. Refer to Graph of Directivity Pattern.		
-3dB Beam Width:	Refer to Graph of Directivity Pattern.		
Side Lobe Level:	No side lobes.		
Signal Output Type:	Single Ended	Differential Output	Differential Output
	Differential signal has better capability to reduce and reject EMI noise, especially over long cable.		
Acceleration Sensitivity: µPa/(m/s²)	Axial or XZ Direction: 118.8 dB Horizontal or XY Direction: ≤ 114.0 dB	Axial or XZ Direction: 113.1 dB Horizontal or XY Direction: ≤ 80.0 dB	Axial or XZ Direction: 125.6 dB Horizontal or XY Direction: ≤ 90.0 dB
	Bespoke Vibration Compensation, available upon request: When suspended from a ship or boat, buoy, or used in towed array, the hydrophone experiences a large movement and induced vibration resulting from surface waves, currents, hydrodynamic flow turbulence, cable movement, etc... The translational acceleration in axial direction can be cancelled with special design and construction, and acceleration sensitivity in other directions are also lower (partially cancelled). Spurious signals caused by induced vibration can be reduced. Acceleration Sensitivity with Compensation: 1. ≤ 40 to 90 dB in axial direction of the hydrophone. 2. ≤ 90 to 100 dB in other directions of the hydrophone.		
Underwater Projector:	Yes.	No	No
Resonance fs:	52 kHz	N/A	N/A
TVR at fs:	133 dB µPa/V at 1m.	N/A	N/A

	Approximately, TVR drops 12dB/octave below fs and drops 6dB/octave above fs.		
Maximum Drive Voltage:	400 Vpp	N/A	N/A
Maximum Pulse Length:	100 mS at Maximum Drive Voltage	N/A	N/A
Duty Cycle:	10% at Maximum Drive Voltage. 100% at ≤ 30 Vpp or 10.6 Vrms.	N/A	N/A
Operating Depth:	300 m, Maximum.	300 m, Maximum.	950 m, Maximum.
	Limited by the cable length if the cable has wire leads or a non-waterproof connector.		
Mounting Options:	1. Default: Free Hanging (**FH**). 2. Free-hanging with Male Underwater Connector (**FHUWC-2P, FHUWC-3P**). 3. Thru-hole Inch Mounting with Single O-ring Sealing (**THM-7/16”**). 4. Thru-hole Inch Mounting with Double O-ring Sealing (**THDO-7/16”**). 5. Bolt Fastening Mounting (Plastics) (**BFMP-NPT3/8”**). 6. Bolt Fastening Mounting (Stainless Steel) (**BFM-7/16”, or BFM-5/8”**).		
	Please refer to online document AcousticSystem.pdf for a complete list of Mounting Options and more details.		
Cable Options:	1. **Default**: Coax RG174/U, ΦD=2.8 mm (**RG174**), (**SE**). 2. Coax RG58/U, ΦD=4.9 mm (**RG58**), (**SE**). 3. Shielded Cable with Polyurethane Jacket, ΦD=2.6 mm (**SC26**), (**SE**).		
	4. Shielded Cable with Rubber Jacket, ΦD=6.5 mm (**SC65**), (**SE or DF**). Use with Underwater Connector 3 pins UMC3P = MCOM3M + OMBMC + MCDLS-F, Depth Rating: 300 m.		
	5. Default: Shielded Cable with Twisted Pair and PVC Jacket, ΦD=3.6 mm (**SC36**), (**DF**). 6. Shielded Cable with Twisted Pair and PVC Jacket, ΦD=6.0 mm (**SC60**), (**DF**). 7. Shielded Cable with Twisted Pair and Polyurethane Jacket, ΦD=4.7 mm (**SC47**), (**DF**).		
	8. Coax RG316/U, ΦD=2.5 mm (**RG316**) up to 200°C, (**SE**). 9. Coax RG178/U, ΦD=1.8 mm (**RG178**) up to 200°C, (**SE**). 10. Shielded Cable with Twisted Pair and Teflon (PTFE) Jacket, ΦD=3.2 mm (**SC32**), up to 200°C. Non-waterproof, for dry use ONLY, (**DF**). 11. Two-conductor High Temperature Shielded Cable: -94 to 302°F (-70° to 150° C), ΦD=5.1 mm (**HTSC150**), (**DF or SE**).		
	12. Original Two Conductor Unshielded Cable (**USC**) for Underwater Connector 2 pins MCIL2M + MCDLS-F. Depth Rating: 950 m.		
	13. Original Three Conductor Unshielded Cable (**USC**) for Underwater Connector 3 pins MCIL3M + MCDLS-F. Depth Rating: 950 m.		
	Differential/balanced signals over shielded twisted pair cable is recommended to reject Electromagnetic Interference (EMI).		
Cable Length:	1. Default: 30 m.	1. Default: 10 m.	1. Default: 0.6 m.
	2. Custom-fit Cable Length.		
Connector:	1. Default: Wire Leads (**WL**). 2. Male BNC (**BNC**), Max. Diameter Φ14.3 mm, for SE ONLY. **BNC with RG178 Coax**: Service Temperature up to 165°C or 329°F. 3. XLR Receptacle with 3 Male Pins (**XLR3**), Max. Diameter Φ20.2 mm, for SE or DF. 4. 1/8" (3.5mm) TRS Plug (**TRS**), Max. Diameter Φ10.5 mm, for SE or DF. 5. DIN Receptacle with 3 Male Pins (**DIN3**), (Max. Diameter Φ17 mm). for SE or DF. 6. Underwater Mateable Connector **UMC2P** and **UMC3P** are made by global manufacturers, buyer may search online to get detailed specs of these connectors from their manufacturers. Available in-stock options (the customized is available upon request): 2 pin (**UMC2P = MCIL2M + MCDLS-F.**), Max. Diameter Φ21.5 to Φ35 mm, for SE. Depth Rating: 950 m. 3 pin (**UMC3P = MCIL3M + MCDLS-F.**), Max. Diameter Φ21.5 to Φ35 mm, for SE or DF. Depth Rating: 950 m. 3 pin (**UMC3P = MCOM3M + OMBMC + MCDLS-F.**), Max. Diameter Φ21.5 to Φ35 mm, for SE or DF. Depth Rating: 300 m.		
	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. **XLR**: Employed for balanced audio and DC or AC power signal interconnections, 3 to 7 contacts. Fastening Type: Latch Lock. 3. 3.5mm **TRS** stand for Tip, Ring, and Sleeve, miniature, quick connect/disconnect, audio frequency connector used for shielded cable. Fastening Type: None. 4. **DIN**: Electrical cylindrical connectors, 3 to 14 contacts, Φ20mm diameter, used for audio, RF, digital, and DC or AC power signals. Fastening Type: Threaded. 5. **UMC**: Underwater Mateable Connectors, interconnection solution for high power or weak signals. Fastening Type: Threaded. Underwater Uses.			
Size:	Free Hanging: ΦD = Φ22.0 mm, Length = 49.5 mm.		
	Other Mounting Types: Actual length depends on Mounting Parts.		
Weight:	0.41 kg, 30m RG174 Coax, BNC Male. 1.22 kg, 30m RG58 Coax, BNC Male.	0.47kg, 10 m SC60, Wire Leads.	90g, 0.6m Cable, UMC3P or UMC3S.
	Actual weight depends on Mounting Parts, Cable Types and Length.		
Operation Temperature:	1. Default: -10°C to +60°C or 14°F to 140°F. 2. Bespoke: -10°C to 120°C, or 14°F to 248°F. Append -HT to part number. Maximum Operating Depth at 120°C or 248°F: 100 m.		
Storage Temperature:	-20°C to +60°C or -4°F to 140°F.		
Underwater Projector Application: for 50Ω BNC/SMA/SMC connector, it is buyer's sole responsibility to make sure that the BNC/SMA/SMC shield of the signal source is firmly grounded for operating safety before hooking up transducer/hydrophone to the signal source. Coax with BNC/SMA/SMC is not intended for hand-held use at voltages above 30Vac/60Vdc.			
Do NOT use the hydrophone as a sound projector in the air otherwise the hydrophone will be damaged.			
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 (**Green Color**), Non-stock Products are in **Black Color**.

Hydrophone	-Mounting Part	-Cable Length	-Cable Type	-Connector Type
BII7011DF	FH, BFMP-NPT3/8”.	10 m (32.8 ft)	SC36 or SC60	WL, TRS, XLR3, DIN3.
	FH, BFM-7/16”, BFM-5/8”.	0.6 m (2 ft)	SC65	UMC3P.
	THM-7/16”.	0.3 m (1 ft)	SC36	WL.
BII7011	FH	30 m (98.4 ft)	RG174	BNC
	BFMP-NPT3/8”	30 m (98.4 ft)	RG58	BNC
BII7011DW	FHUWC-3P	N/A	N/A	N/A

	THM-7/16”	0.3 m (1 ft)	SC36	WL

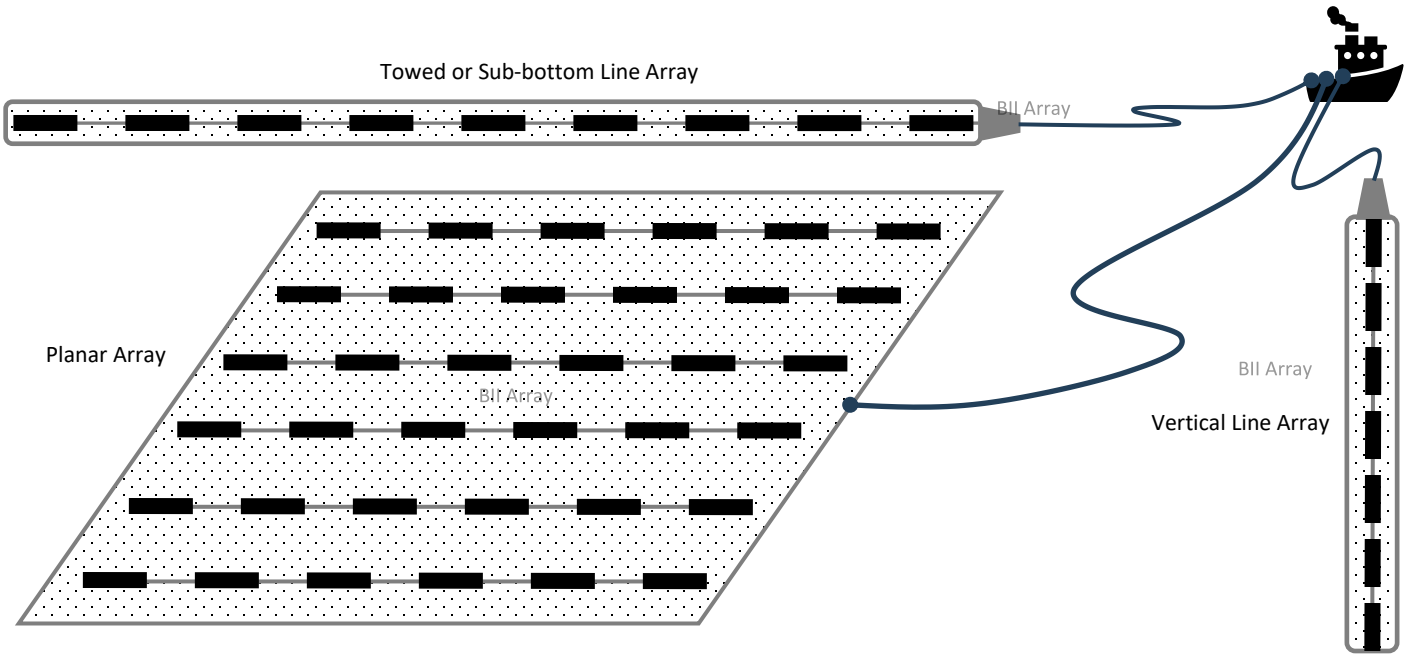
In-Stock Examples:	**Description**
BII7011DF-FH-10m-SC60-WL	BII7011DF Hydrophone, Free Hanging, 10m Shielded Cable with Twisted Pair **SC60**, Wire Leads.
BII7011DF-BFMP-NPT3/8”-10m-SC60-XLR3	BII7011DF Hydrophone, Bolt-fastening Mounting: BFMP-NPT3/8”, 10m Twisted-Pair Shielded Cable **SC60**, XLR3.
BII7011DF-FH-0.6m-SC65-UMC3P	BII7011DF Hydrophone, Free Hanging, 0.6m Shielded Cable **SC65**, 3-pin Underwater Mateable Connector UMC3P.
BII7011DF-BFM-5/8”-0.6m-SC65-UMC3P	BII7011DF Hydrophone, Bolt-fastening Mounting BFM-5/8”, 0.6m Shielded Cable **SC65**, 3-pin Underwater Mateable Connector UMC3P.
BII7011DF-THM-7/16”-0.6m-SC36-WL	BII7011DF Hydrophone, Thru-Hole Mounting THM-7/16”, 0.6m Shielded Cable **SC36**, Wire Leads.
BII7011DW-THM-7/16”-0.3m-SC36-WL	BII7011DW Hydrophone, Thru-Hole Mounting THM-7/16”, 0.3m Shielded Cable **SC36**, Wire Leads.
BII7011DW-FHUWC-3P	BII7011DW Hydrophone, Free-hanging with Male Underwater Connector FHUWC-3P.
Non-stock Examples:	**Description**
BII7011DF-FH-30m-SC60-XLR3	BII7011DF Hydrophone, Free Hanging, 30m Shielded Cable with Twisted Pair **SC60**, XLR Receptacle with 3 Male Pins.
BII7011-HT-FH-6m-RG178-BNC	BII7011 Hydrophone, Service Temperature: -10°C to 120°C (14°F to 248°F). Free Hanging, 6m RG178 Coax, BNC Male.
BII7011DF-HT-FH-10m- HTSC150-XLR3	BII7011DF Hydrophone, Service Temperature: -10°C to 120°C (14°F to 248°F). Free Hanging, 10m HTSC150 Shielded Cable, XLR3 Pins (Note: XLR3 can ONLY withstand 75°C (167°F)).

Wirings

Differential Output:	**Wire Leads**	**UMC3P, UMC3S, FHUWC-3P.**	**DIN3**	**TRS**		**XLR3**
Signal +	White or Red	Pin 2 or Socket 2	Pin 3	Tip, Positive/Hot		Pin 2, Positive/Hot.
Signal -	Black	Pin 1 or Socket 1	Pin 1	Ring, Negative/Cold		Pin 3, Negative/Cold.
Common & Shielding	Shield	Pin 3 or Socket 3	Pin 2	Sleeve, Ground/Common		Pin 1, Shield/Ground.
Single Ended Output:	**Wire Leads**	**UMC3P, UMC3S, FHUWC-3P.**	**UMC2P, FHUWC-2P.**	**DIN3**	**BNC/SMA/SMC**	**Coax with Wire Leads**
Signal	White or Red	Pin 2 or Socket 2	Pin 2	Pin 3	Center Contact	Coax Center Contact
Signal Common	Black	Pin 1 or Socket 1	Pin 1	Pin 1	Shield	Coax Shield
Shielding	Shield	Pin 3 or Socket 3	N/A	Pin 2	Shield	Coax Shield

Components of an Acoustic Receiving System.

Array Elements for Underwater Linear and Planar Arrays

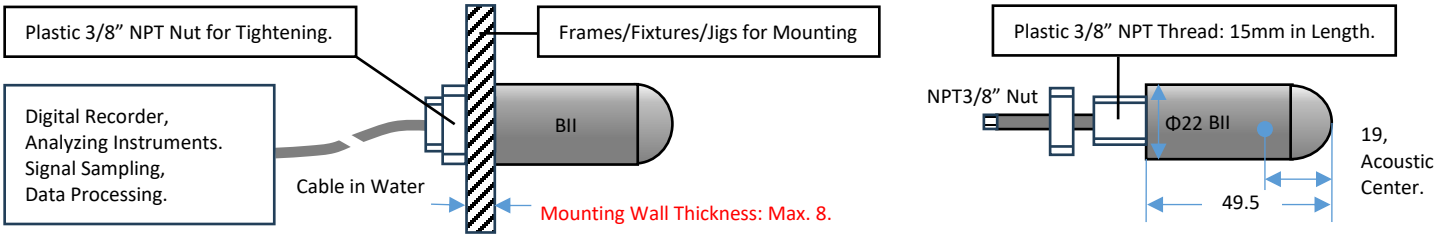


Physical Size (Dimensional Unit: mm): The overall length varies with the length of the mounting part.

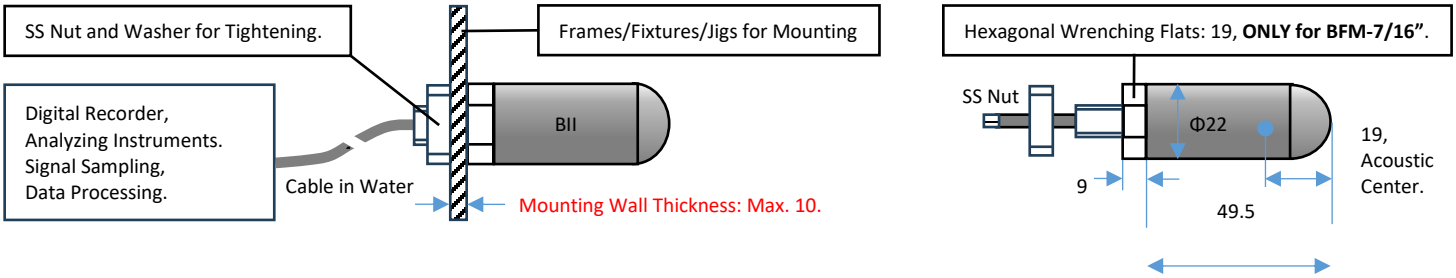
1. Free Hanging with Smooth Domes.

The streamlined hemispherical domes minimize drag forces and hydrodynamic noises caused by the hydrophone in motion or the flow past the hydrophone.

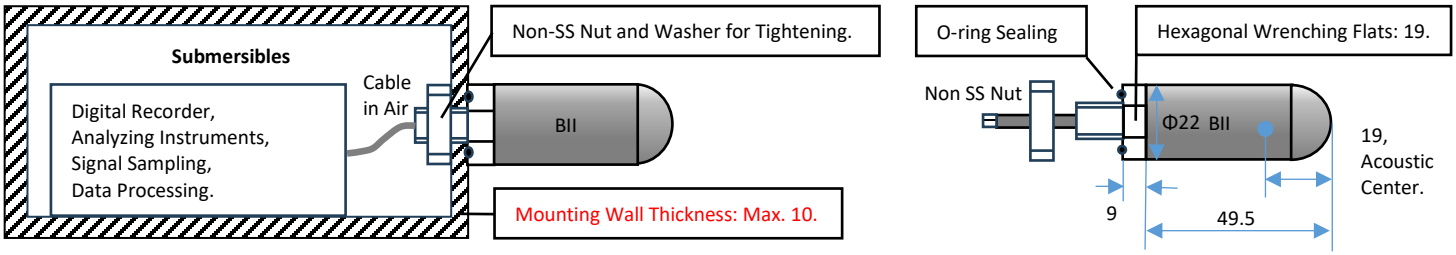
2. Bolt-Fastening Mounting BFMP-NPT3/8", 3/8" NPT Thread Length: 15mm. Nut Height: 5mm. Tips: Plastic material has less sound reflection.



3. Bolt-Fastening Mounting BFM-7/16" (7/16"-20x22 UNF-2A), and BFM-5/8" (5/8"-18x22 UNF-2A, BFM-5/8" does NOT possess Hexagonal Wrenching Flats.).



4. Thru-hole Mounting (Inch Thread) with Single O-ring Sealing THM-7/16" (7/16"-20x22 UNF-2A).

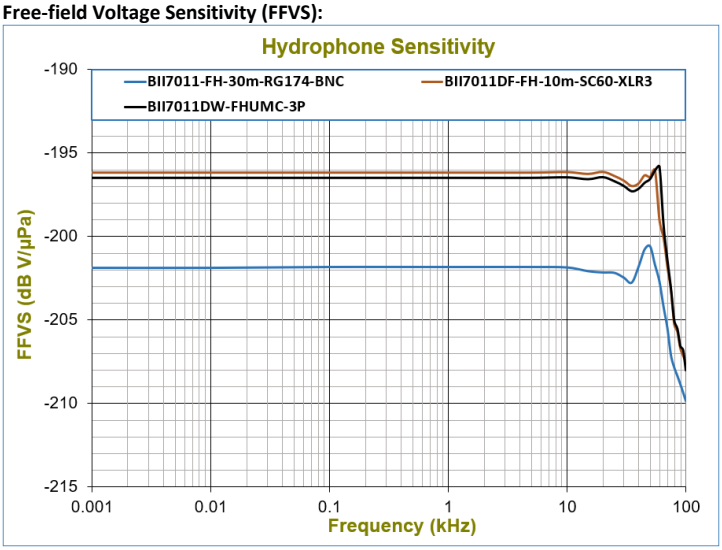


5. Free-hanging with Underwater Connector (FHUWC-3P), 3 Pins.

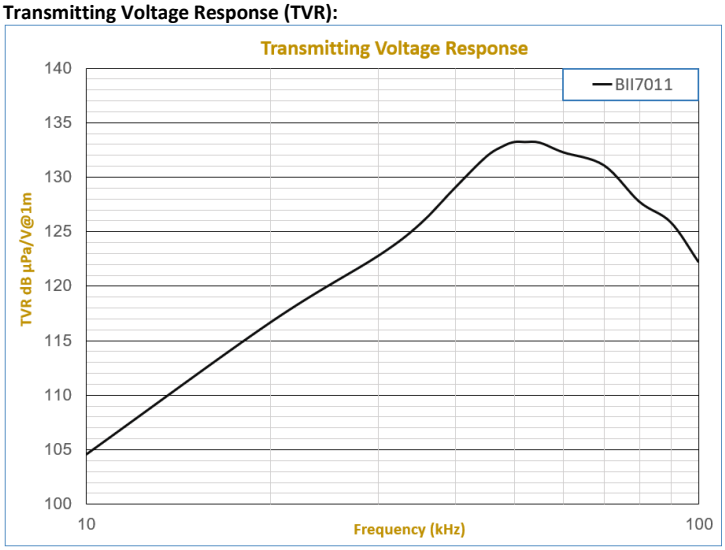
Mating Connector and Cable	**UWC-Cable Length-Connector:** Underwater Connector with Socket insert and Internal-Thread Mating Parts + customized-length shielded cable + a Connector (WL, XLR, TRS, DIN, MIL, UMC, etc.) to DAQ devices or Digital Recorders.
	How to order cable with mating underwater connector? for example: **UMC3S-20m-WL:** 20 m cable with Underwater Mateable Connector 3 Sockets (**UMC3S**) on one end and wire leads (**WL**) on other end. **UMC3S-20m-XLR3**: 20 m cable with Underwater Mateable Connector 3 Sockets (**UMC3S**) and XLR Receptacle with 3 Male Pins (**XLR3**).

6. More Mounting/Installation Options: Please refer to online document AcousticSystem.pdf for a complete list of Mounting Options and details.

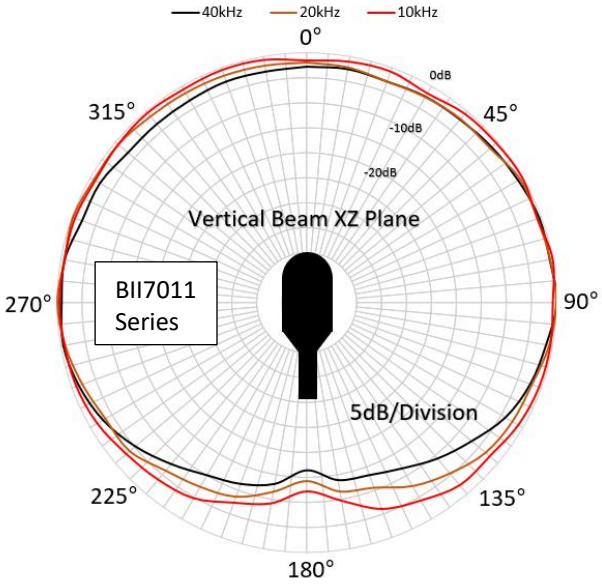
Free-field Voltage Sensitivity (FFVS):

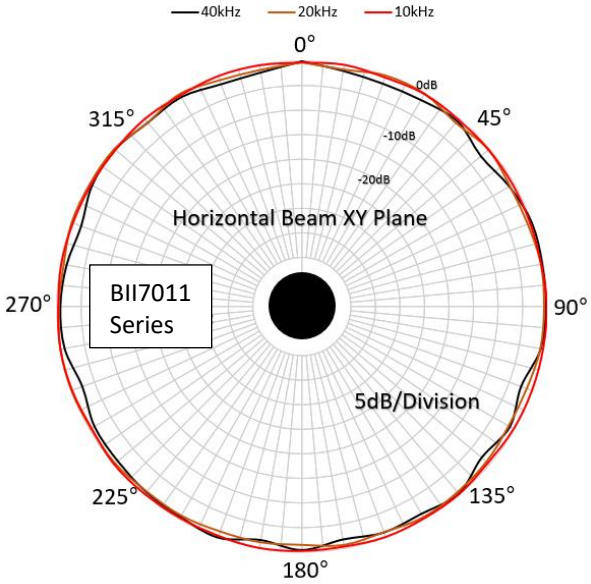


Transmitting Voltage Response (TVR):

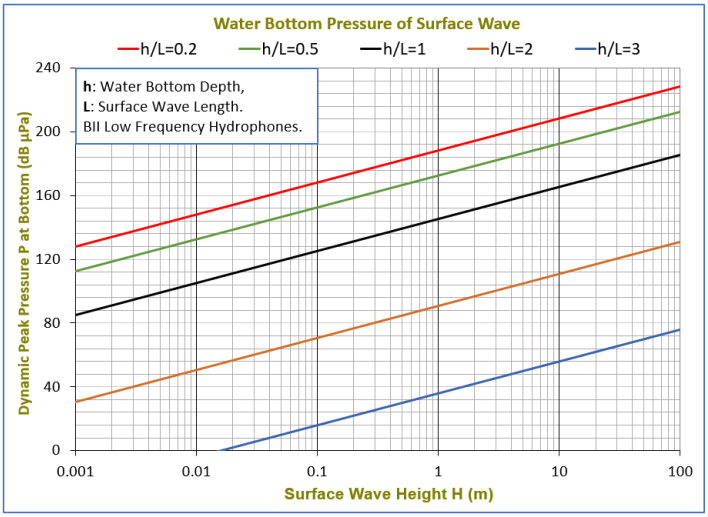


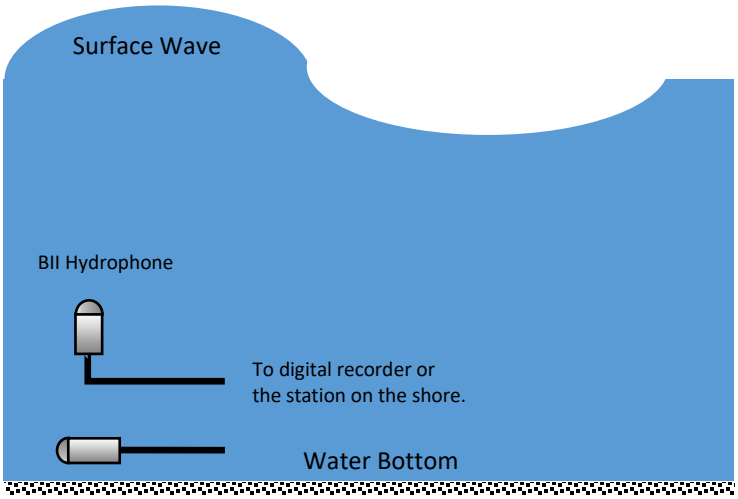
Directivity Pattern





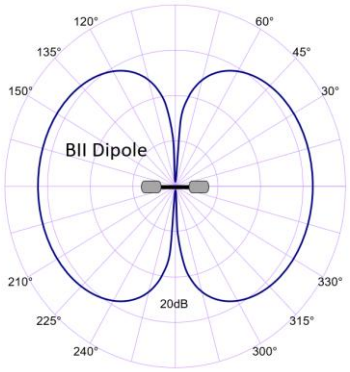
Wave-height sensors: Water-Bottom Dynamic Pressure of Surface Wave. Linear and nonlinear wave theories show that wave and tide parameters (height, period, energy, steepness, spectrum) can be deduced from the pressure time series measured over a time period under the progressive surface waves. BII low frequency hydrophone measures the dynamic pressures associated with progressive surface waves in field or laboratory and have no response to hydrostatic pressure.

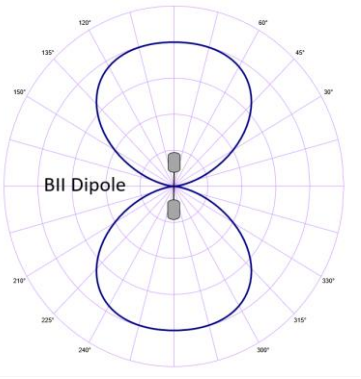




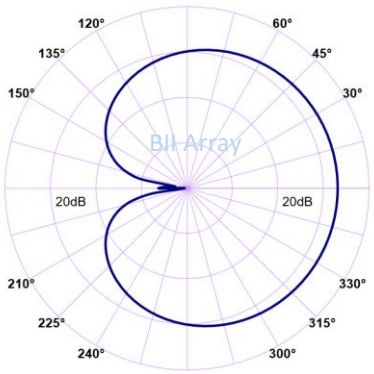
Simple Array

"Figure 8" Pattern of a Dipole (Pressure-Gradient).





Cardioid Pattern= Omnidirectional + Dipole.



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.

My acoustic sensors generate differential signals in MHz range, are TRS connectors suitable for my applications? BII's test shows TRS connectors (Plug and Jack) of BII preamps can be used up to 20 MHz. Test Conditions: TRS Jack with 0.2m cable and TRS plug with 1m cable. Oscilloscope: 1MΩ||20pF, Signal Source: DDS Signal Generator.

Can 3.5mm (1/8") TRS be configured for single-ended signal of a hydrophone/transducer which does not have built-in preamplifier? Yes, the preamp with differential-input TRS can accept single-ended signals from hydrophones/transducers whose TRS wiring should be like followings: **TRS Tip**: Signal. **TRS Ring and Sleeve:** Both terminals are soldered together for Signal Common and Shielding. Common and shielding should be "one-point" contact.

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 = $j/(2\pi f C_h)$, 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.

Can BII explain more on Single-ended (SE) and Differential (DF) measurement? (1). **SE hydrophone + coax + BNC/SMA/SMC** is compatible to most instruments such as oscilloscope, signal generators, and DAQ modules, etc.. Quick setup of SE measuring system and low cost with coax/BNC are the significant merits besides 50Ω matching in MHZ range measurement. The shortcomings are weak rejection on common-mode noise and inductive coupling of EMI. (2). **DF hydrophone + Twisted-Pair Shielded Cable + WL/TRS/XLR/DIN** is compatible to most audio recording and analyzing instruments, etc.. Efficient rejection of common mode noises and inductive coupling noise of EMI are the significant merits, especially over the long cable. The shortcomings are higher costs on hydrophones, cables, and differential signal processing circuits such as differential preamp and differential DAQ modules.