

SE=SL-TL+AG-NL

Acoustical Solutions: SONAR, NDT/AE, HIFU.

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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 and its ringing is short. Custom-fit hydrophones with [low power preamplifiers](#) consume 40μA to 0.6mA which is a great merit for battery-powered portable acoustic system.

These hydrophones provide low-cost solutions for underwater recording, listening, and laboratory acoustics from 0.2Hz to 500kHz. They come with coax/shielded cables and underwater mateable/BNC/TRS/XLR/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 headphone.

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

BII7010 Hydrophones with integrated low power preamplifiers and filters are ideal gears to amplify the weak signals underwater and reject ambient noises. Its compact and small size avoid interferences to acoustic field under test. The [preamplifier](#) integrated in the hydrophone can drive cable up to 1000m without signal loss. These features allow them to be used in long line arrays (streamers) and large planar arrays.

The hydrophone body has streamlined hemispherical domes which minimize the drag forces 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.

BII7016 hydrophones is specialized to measures low frequency underwater sounds and pressure fluctuations down to 0.02 Hz: 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. Parabolic Antennas Underwater. 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.
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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:	BII7013	BII7013DF
Sensitivity @ 1 kHz: (No Cable)	-207.5 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.	-200.0 dB V/μPa ±2 dB
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 . Free-field Voltage Sensitivity.	
Usable Frequency:	in Water: 0.3Hz ~ 160kHz at ±3dB V/μPa.	0.5Hz ~ 140kHz at ±3dB V/μPa.
	in Air: 1Hz ~ 9kHz at -3dB V/μPa.	
	Minimum Usable Frequency depends on -3dB high pass filter f _{-3dB} = 1/(2πR _i C _H). R _i : Input Resistance or Impedance of Preamp. C _H : Capacitance of hydrophone at 1 kHz. when a BII7013 and a BII preamp of R _i = 100 MΩ are used to detect sounds, -3dB high pass frequency of detection = 0.24 Hz. when a BII7013DF and a BII preamp of R _i = 200 MΩ are used to detect sounds, -3dB high pass frequency of detection = 0.44 Hz.	
Capacitance C _H @1 kHz:	6.6 nF ± 10%, No Cable.	1.8 nF ± 10%, No Cable.
Dissipation @1 kHz:	0.005	0.015
Noise Density at f << fs: dB μPa/√Hz	35.2 – 10*log f	33.0 – 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 Beam. 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
	To reject Electromagnetic Interference (EMI) over long cable, the differential (balanced) output is recommended.	
Acceleration Sensitivity:	112.5 dB μPa/(m/s ²) at Acoustic Axis or XZ Direction.	106.4 dB μPa/(m/s ²) at Acoustic Axis or XZ Direction.
	≤ 110.0 dB μPa/(m/s ²) at Horizontal or XY Direction.	≤ 75.0 dB μPa/(m/s ²) at Horizontal or XY Direction.
Underwater Projector :	Yes.	No
Resonance fs :	110 kHz	N/A
TVR at fs:	144 dB μPa/V at 1m.	N/A
	Approximately, TVR drops 12dB/octave below fs and drops 6dB/octave above fs.	
Maximum Drive Voltage:	250 Vpp	N/A
Maximum Pulse Length:	100 mS at Maximum Drive Voltage	N/A
Duty Cycle:	10% at Maximum Drive Voltage; 100% at ≤ 30 Vpp or 10.6 Vrms.	N/A

Operating Depth:	500 m, Maximum.	300 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).		
	1. Default: 15 m.		
	1. Default: 10 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. 1/8" (3.5mm) TRS Plug (TRS), Max. Diameter Φ10.5 mm, for SE or DF. 4. DIN Receptacle with 3 Male Pins (DIN3), (Max. Diameter Φ17 mm). for SE or DF. 5. XLR Receptacle with 3 Male Pins (XLR3), Max. Diameter Φ20.2 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.	
Size:	Free Hanging: ΦD = Φ12.6 mm, Length = 30 mm.		
	Other Mounting Types: Actual length depends on Mounting Parts.		
Weight:	85 grams with 6m Coax/BNC Male. 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 -HT120 to part number. Maximum Pressure at 120°C or 248°F: 1 MPa. 3. Bespoke: -10°C to 200°C, or 14°F to 392°F. Append -HT200 to part number. Maximum Pressure at 200°C or 392°F: 0.5 MPa.		
Storage Temperature:	-20°C to +60°C or -4°F to 140°F.		
Array Design Service:	Line (Linear) Array, Rectangular Planar Array, and Circular Planar Array design: Side Lobe Level SLL, -3dB Beam Angle θ _{-3dB} , Array Element Spacing d; Array Element Number N; Beam Steering, FFVS loss, and mutual effects among these parameters.		
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**.

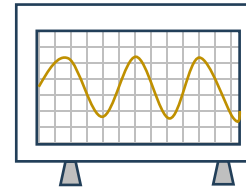
Hydrophone	-Mounting Part	-Cable Length	-Cable Type	-Connector Type
BII7013	FH, BFMP-3/8"NPT.	15 m (49.2 ft)	RG174	BNC
BII7013DF	FH, BFMP-3/8"NPT.	10 m (19.7 ft)	SC36	WL, TRS, XLR3, DIN3.
	FH.	0.6 m (2 ft)	SC36	UMC3P = MCOM3M + OMBMC + MCDLS-F.
	BFM-5/8".	0.6 m (2 ft)	USC	UMC3P = MCIL3M + MCDLS-F.
In-Stock Examples:		Description		
BII7013-FH-15m-RG174-BNC		BII7013 Hydrophone, Free Hanging, 15m RG174 Coax, BNC Male.		
BII7013-BFMP-NPT3/8"-15m-RG174-BNC		BII7013 Hydrophone, Bolt-fastening Mounting: BFMP-NPT3/8", 15m RG174 Coax, BNC Male.		
BII7013DF-FH-10m-SC36-XLR3		BII7013DF Hydrophone, Free Hanging, 10m Shielded Cable with Twisted Pair SC36, Connector: XLR3 Pins.		
BII7013DF-BFMP-NPT3/8"-10m-SC36-TRS		BII7013DF Hydrophone, Bolt-fastening Mounting: BFMP-NPT3/8", 10m Twisted-Pair Shielded Cable SC36, TRS Plug.		
BII7013DF-FH-0.6m-SC36-UMC3P		BII7013DF Hydrophone, Free Hanging, 0.6m Shielded Cable SC36, 3-pin Underwater Mateable Connector UMC3P.		
BII7013DF-BFM-5/8"-0.6m-USC-UMC3P		BII7013DF Hydrophone, Bolt-fastening Mounting: BFM-5/8", 0.6m Unshielded Cable, 3-pin Underwater Mateable Connector UMC3P (MCIL3M + MCDLS-F).		
Non-stock Examples:		Description		
BII7013DF-FH-30m-SC60-TRS		BII7013DF Hydrophone, Free Hanging, 30m Shielded Cable with Twisted Pair SC60, TRS Plug.		
BII7013DF-FH-30m-SC60-XLR3		BII7013DF Hydrophone, Free Hanging, 30m Shielded Cable with Twisted Pair SC60, XLR Receptacle with 3 Male Pins.		

BII7013DF-FH-30m-SC60-WL	BII7013DF Hydrophone, Free Hanging, 30m Shielded Cable with Twisted Pair SC60 , Wire Leads.
BII7013-HT200-FH-6m-RG178-BNC	BII7013 Hydrophone, Service Temperature: -10°C to 200°C (14°F to 392°F). Free Hanging, 6m RG178 Coax, BNC Male.
BII7013DF-BFM-5/8"-15m-SC60-WL	BII7013DF Hydrophone, Bolt-fastening Mounting BFM-5/8", 15m Shielded Cable SC60 , Wire Leads.

Wirings

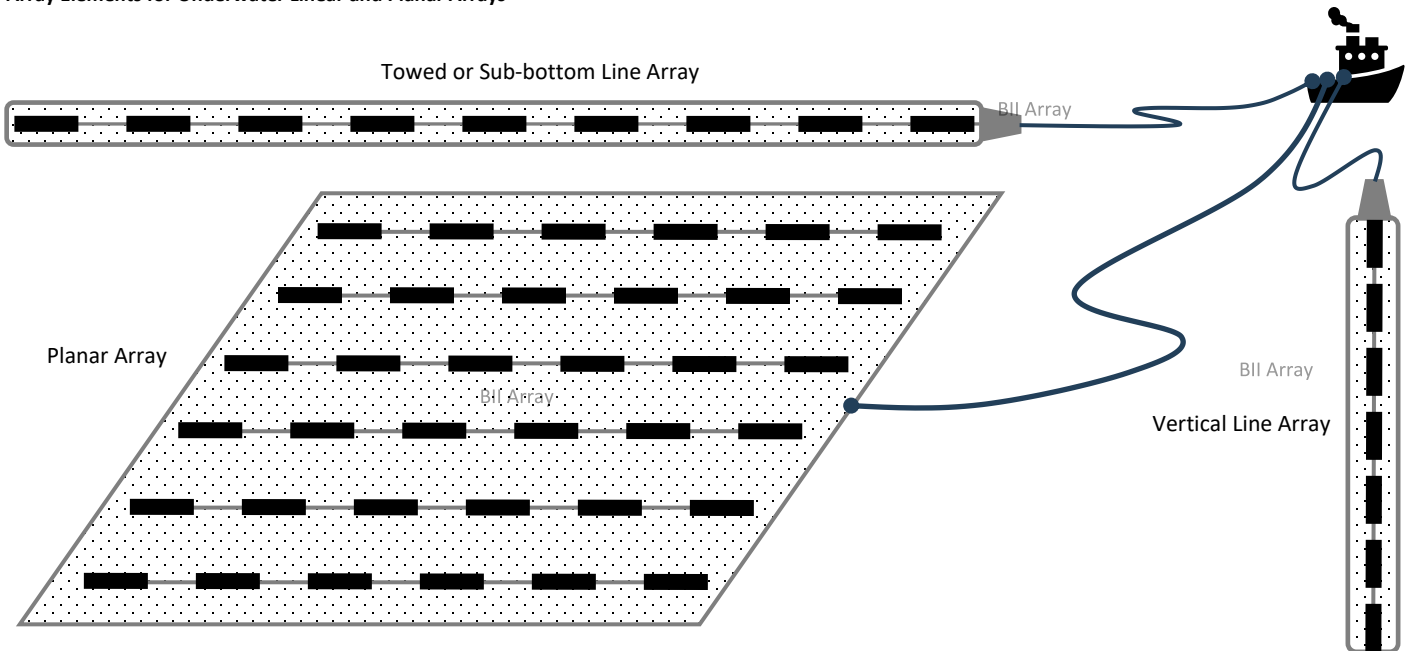
Differential Output:	Wire Leads	UMC3P, UMC3S, FHUWC-3P.	DIN3	TRS		XLR3
Signal +	White or Red	Pin 2 or Socket 2	Pin 3	Tip, Positive/Hot		Pin 2, Positive/Hot.
Signal -	Black	Pin 1 or Socket 1	Pin 1	Ring, Negative/Cold		Pin 3, Negative/Cold.
Common & Shielding	Shield	Pin 3 or Socket 3	Pin 2	Sleeve, Ground/Common		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.



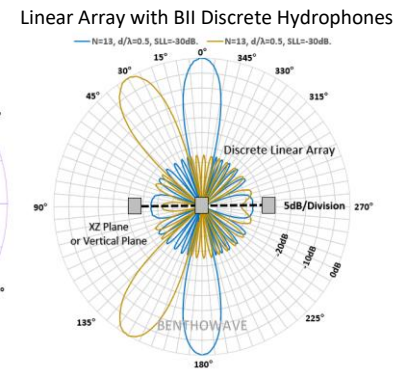
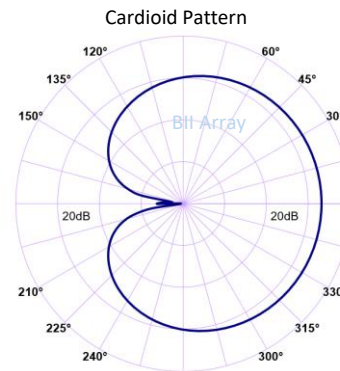
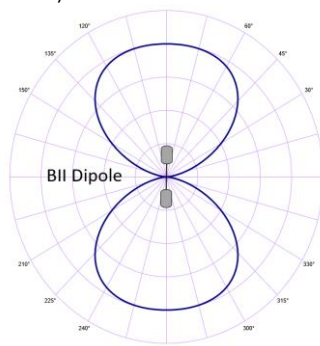
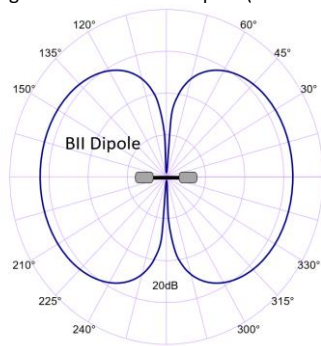
Digital Recorder,
Computerized DAQ,
Embedded Controller,
Oscilloscope,
Analyzer/Instrument.

Array Elements for Underwater Linear and Planar Arrays



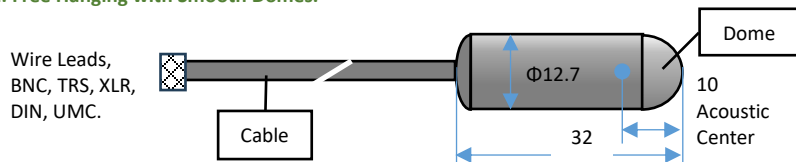
Simple Array Consisting of Hydrophones.

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



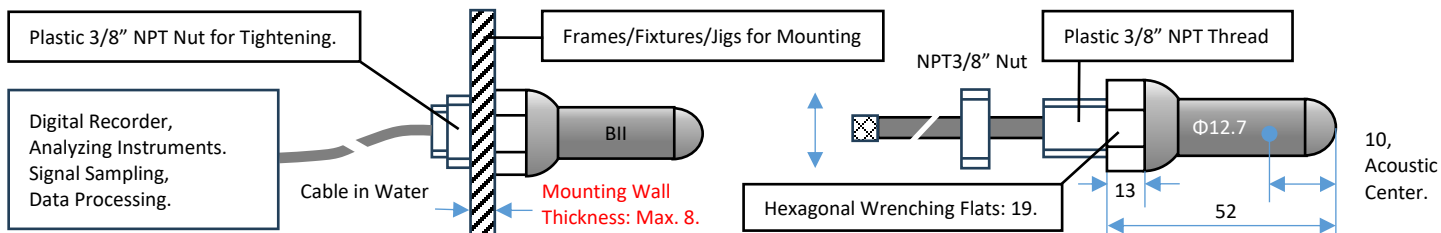
Physical Size (Dimensional Unit: mm): The overall length varies with the length of the mounting part.

1. Free Hanging with Smooth Domes.

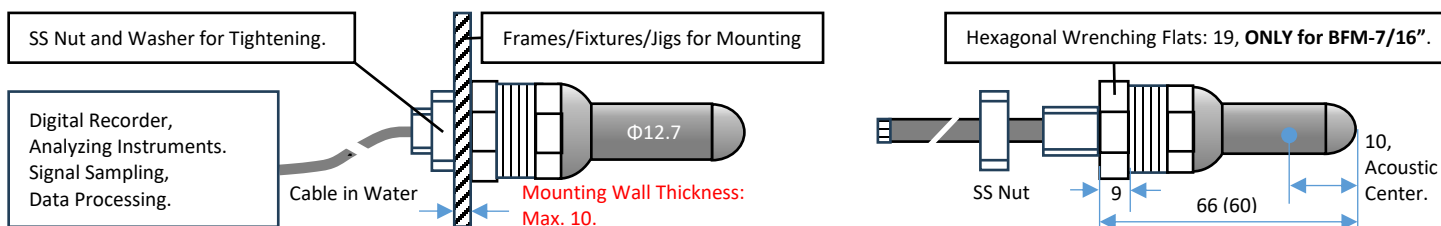


The streamlined hemispherical domes minimize drag forces and hydrodynamic noises caused by the hydrophone in motion or the flow past the hydrophone.

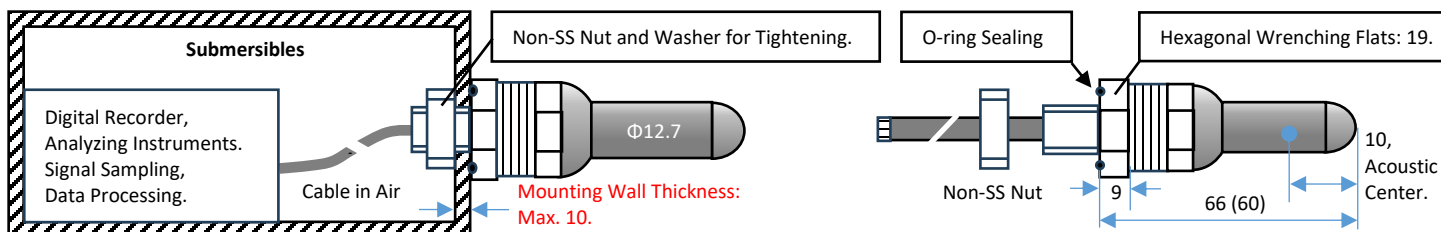
2. Bolt-Fastening Mounting BFMP-NPT3/8", 3/8" NPT Thread Length: 15mm. Nut Height: 5mm. **Tips: Plastic material has less sound reflection.**



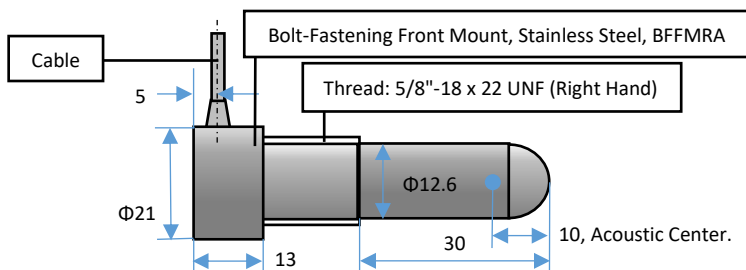
3. Bolt-Fastening Mounting BFM-7/16" (7/16"-20x22 UNF-2A), and BFM-5/8" (5/8"-18x22 UNF-2A, BFM-5/8" does NOT possess Hexagonal Wrenching Flats.).



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

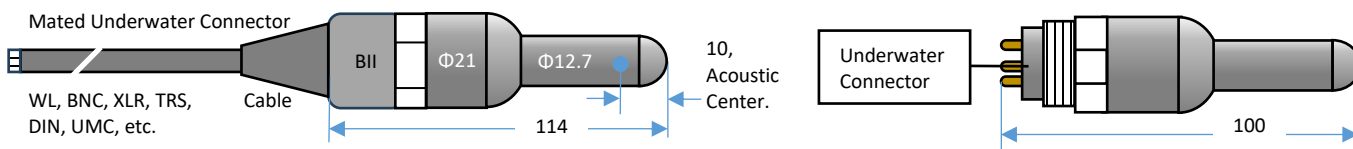


5. BFFMRA: Bolt-Fastening Front Mount with 90° Right Angle.



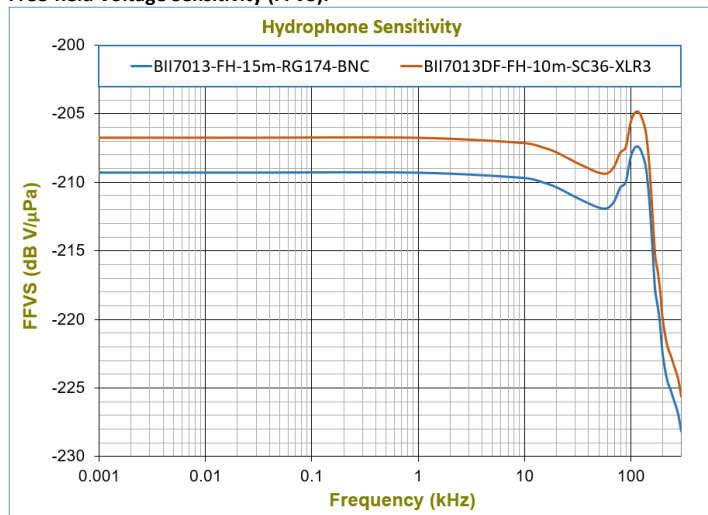
6. Free-hanging with Underwater Connector (FHUWC-3P), 3 Pins.

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).
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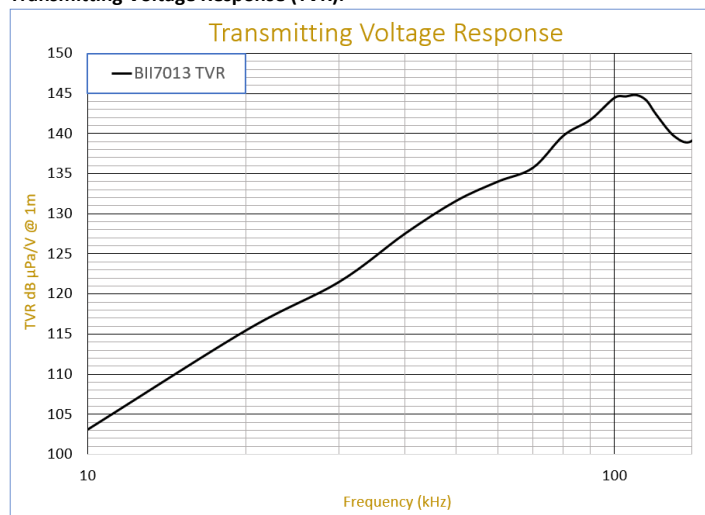


7. More Mounting/Installation Options: Please refer to online document [AcousticSystem.pdf](#) for a complete list of Mounting Options and details.

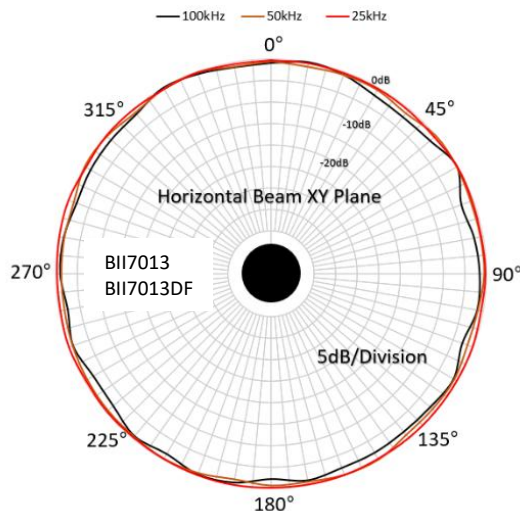
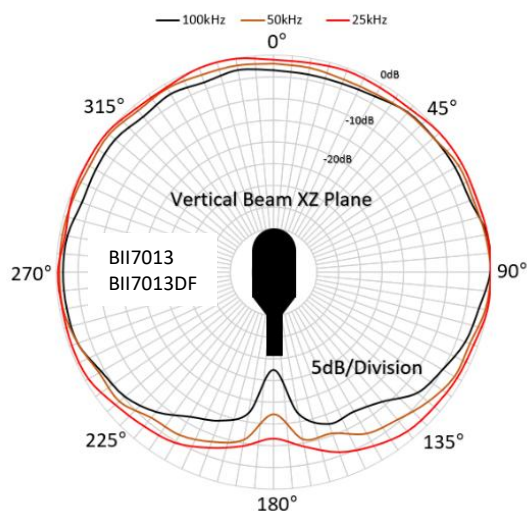
Free-field Voltage Sensitivity (FFVS):



Transmitting Voltage Response (TVR):



Directivity Pattern:



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.