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. Parabolic Antennas Underwater. Reference Hydrophone, Noise Measurement. Signal detection in strong currents.	Detection of Ultrasonic Cavitation Noise, Thermoacoustics in Gas. Passive Acoustic Monitoring (PAM System). Array Element, Vector Hydrophone Element. Marine Bioacoustics, Phantom-power Hydrophone, Sound Recording. Studies of Ocean Turbulence and Flow, Marine Hydrodynamics.

Specification

The hydrophone is tested in water unless stated otherwise.			
Part Number:	**BII7011**	**BII7011DF**	**BII7011DW**
Sensitivity @ 1kHz:	-198.8 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.		
FFVS:	Free-field Voltage Sensitivity, 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:	10.0 nF ± 10%	4.16 nF ± 10%	1.6 nF ± 10%
Dissipation @ 1kHz:	0.011	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:	118.8 dB μPa/(m/s²)	113.1 dB μPa/(m/s²)	125.6 dB μPa/(m/s²)
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-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-M12**). 6. Bolt Fastening Mounting (Plastics) (**BFMP-NPT3/8”**). 7. Bolt Fastening Mounting (Stainless Steel) (**BFM-7/16”**).
	Please refer to online document AcousticSystem.pdf for a complete list of Mounting Options and more details.
Cable Options:	**SE**: Single Ended Output Hydrophones. **DF**: Differential Output Hydrophones.
	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**).
	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 RG178/U, ΦD=1.8 mm (**RG178**) up to 200°C. (**SE**). 9. 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**).
	Differential/balanced signals over shielded twisted pair cable is recommended to reject Electromagnetic Interference (EMI).
Cable Length:	1. Default: 6 m. 2. Custom-fit Cable Length.
Connector:	**SE**: Single ended Output, **DF**: Differential Output. 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. XLR Receptacle with 3 Male Pins (**XLR3**), Max. Diameter Φ20.2 mm, for SE or DF. 5. Underwater Mateable Connector (3 pin) (**UMC3P**), Max. Diameter Φ21.5 to Φ35 mm, for SE or DF. **UMC3P** is from global manufacturers of underwater connectors. Its part number is listed in quote in detail.
	Underwater Mateable Connectors are for underwater uses. Other connectors/wire leads are for dry uses and are not waterproofed.
Size:	Free Hanging: ΦD = Φ22.0 mm, Length = 49.5 mm. Other Mounting Types: Actual length depends on Mounting Parts.
Weight:	0.12 kg 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 -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**.**

Hydrophone Part Number	**-Mounting Part**	**-Cable Length**	**-Cable Type**	**-Connector Type**
BII7011	**FH**: Free Hanging.	6 m (19.7ft)	RG174 Coax	BNC
BII7011DF	**BFMP-3/8”NPT**: Bolt-fastening Mounting.	10 m (32.8ft)	Shielded Cable with Twisted Pair SC60	WL, TRS, or XLR.
Example:	**Description**			
BII7011-FH-6m-RG174-BNC	BII7011 Hydrophone, Free Hanging, 6m RG174 Coax, BNC Male.			
BII7011-BFMP-NPT3/8”-6m-RG174-BNC	BII7011 Hydrophone, Bolt-fastening Mounting: BFMP-NPT3/8”, 6m RG174 Coax, BNC Male.			
BII7011DF-BFMP-NPT3/8”-10m-SC60-TRS	BII7011DF Hydrophone, Bolt-fastening Mounting: BFMP-NPT3/8”, 10m Shielded Cable with Twisted Pair **SC60**, TRS Plug.			
BII7011DF-FH-10m-SC60-TRS	BII7011DF Hydrophone, Free Hanging, 10m Shielded Cable with Twisted Pair **SC60**, TRS Plug.			
BII7011DF-FH-10m-SC60-XLR3	BII7011DF Hydrophone, Free Hanging, 10m Shielded Cable with Twisted Pair **SC60**, XLR Receptacle with 3 Male Pins.			
BII7011DF-FH-10m-SC60-WL	BII7011DF Hydrophone, Free Hanging, 10m Shielded Cable with Twisted Pair **SC60**, Wire Leads.			

How to Order Bespoke Hydrophones. Non-stock.

Hydrophone Part Number	**-Mounting Part**	**-Cable Length**	**-Cable Type**	**-Connector Type**
BII7011, BII7011DF, BII7011DW	Mounting Options.	In meter.	Cable Options.	Connector.
Example:	**Description**			
BII7011DW-THM-7/16”-0.6m-SC36-WL	BII7011DW Hydrophone, Thru-hole Mounting THM-7/16”, 0.6m Shielded Cable SC36, Wire Leads.			
BII7011-HT-FH-6m-RG178-BNC	BII7011 Hydrophone, Service Temperature: -10 °C to 120 °C, or 14 °F to 248 °F. Free Hanging, 6m RG178 Coax, BNC Male.			
BII7011DF-BFMP-NPT3/8”-15m-SC60-WL	BII7011DF Hydrophone, Bolt-fastening Mounting BFMP-NPT3/8”, 15m Shielded Cable **SC60**, Wire Leads.			
BII7011DF-FH-0.6m-SC65-UMC3P	BII7011DF Hydrophone, Free Hanging, 0.6m Shielded Cable **SC65**, 3-pin Underwater Mateable Connector.			

Wirings

Differential Output:	**Wire Leads**	**Underwater Connector UMC3P**	**TRS Plug (Balanced Mono)**	**XLR Receptacle with 3 Male Pins**	
Signal +	White or Red	Pin 2	Tip, Positive/Hot	Pin 2, Positive/Hot.	
Signal -	Black	Pin 1	Ring, Negative/Cold	Pin 3, Negative/Cold.	
Common & Shielding	Shield	Pin 3	Sleeve, Ground/Common	Pin 1, Shield/Ground.	
Single Ended Output:	**Wire Leads**	**Underwater Connector UMC3P**	**BNC/SMA/SMC**	**Coax with Wire Leads**	**TRS**
Signal	White or Red	Pin 2	Center Contact	Coax Center Contact	Tip
Signal Common	Black	Pin 1	Shield	Coax Shield	Ring & Sleeve
Shielding	Shield	Pin 3	Shield	Coax Shield	Ring & Sleeve

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.**

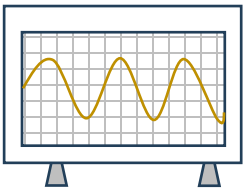
Is impedance matching necessary between hydrophones/sensors and preamplifiers/Recorders/Analyzers? it is NOT necessary to do impedance matching in low frequency range applications in which electromagnetic wave lengths are much greater than the cable length. High frequency transducers such as NDT pulsing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

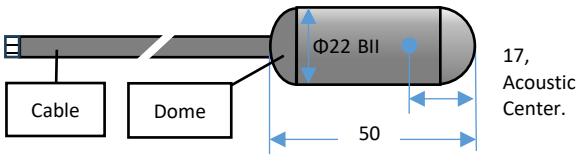
Components of an Acoustic Receiving System.



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

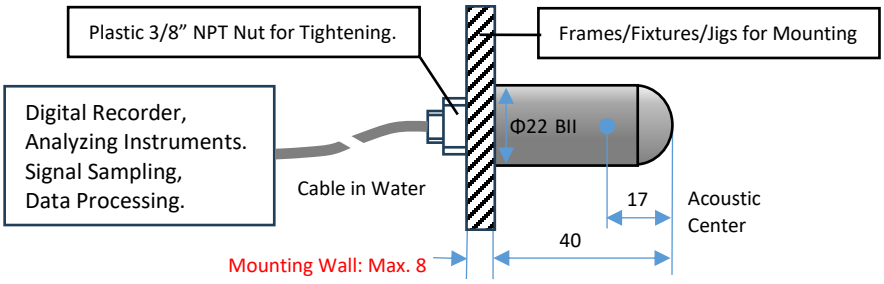
Physical Size (Dimensional Unit: mm): The overall length varies with the length of the mounting part.

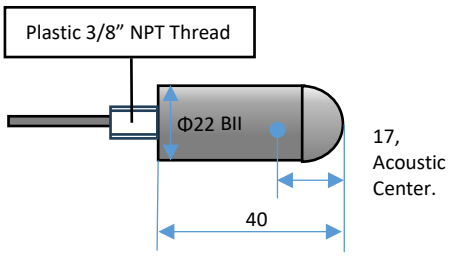
1. Free Hanging with Smooth Domes.



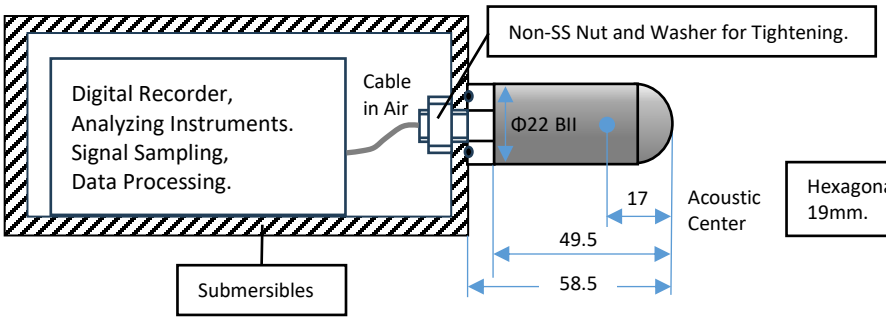
The hydrophone body has streamlined hemispherical domes which minimize the drag forces and the hydrodynamic noise caused by the hydrophone in motion or the flow past the hydrophone.

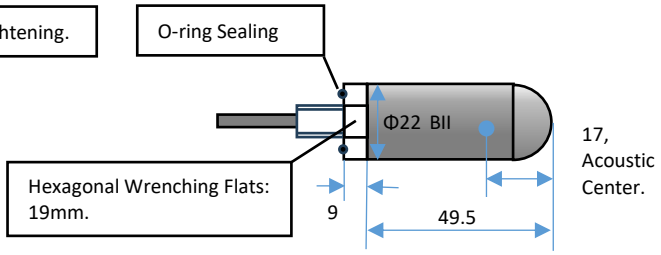
2. Bolt-Fastening Mounting BFM-NPT3/8", 3/8" NPT Thread Length: 15mm. Nut Height: 5mm.



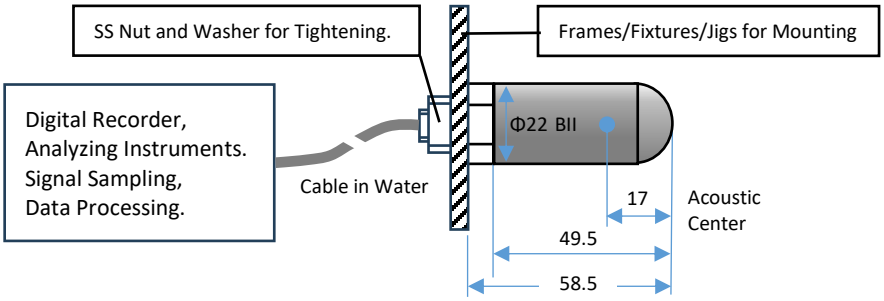


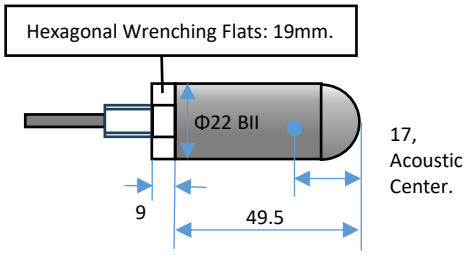
3. Thru-hole Mounting (Inch Thread) with Single O-ring Sealing THM-7/16" (7/16"-20x22 UNF-2A).



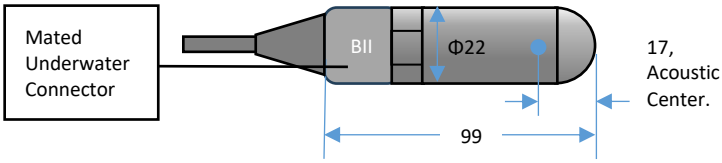


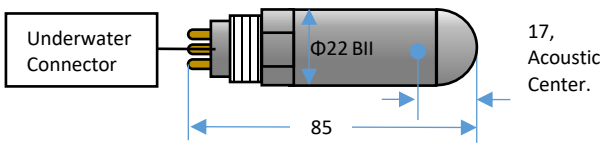
4. Bolt-Fastening Mounting BFM-7/16" (7/16"-20x22 UNF-2A).





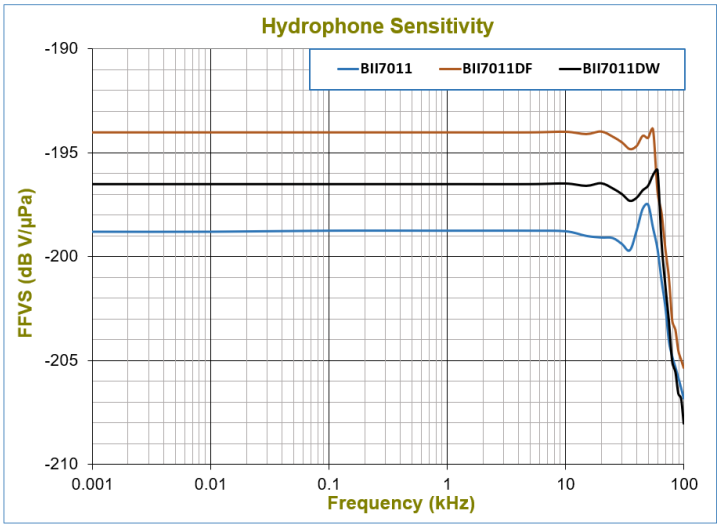
5. Free-hanging with Underwater Connector (FHUWC-3P), 3 Pins.



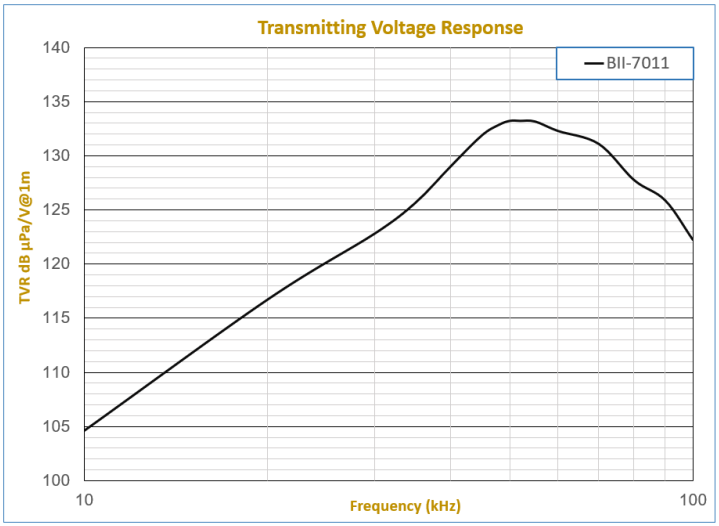


5. More Mounting/Installation Options: Please refer to online document AcousticSystem.pdf for a complete list of Mounting Options and details.

Free-field Voltage Sensitivity (FFVS):



Transmitting Voltage Response (TVR):



Directivity Pattern