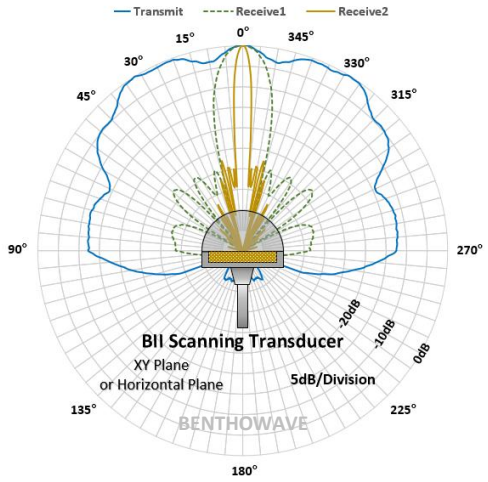
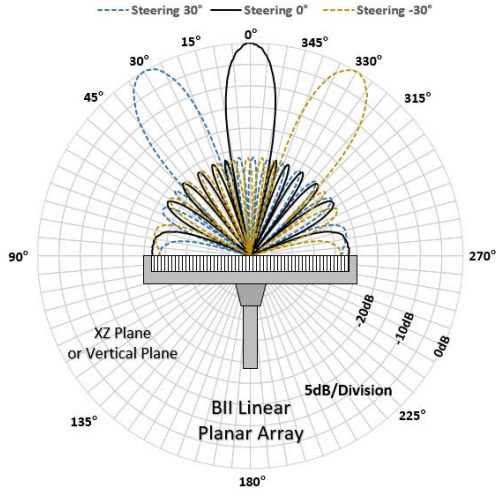
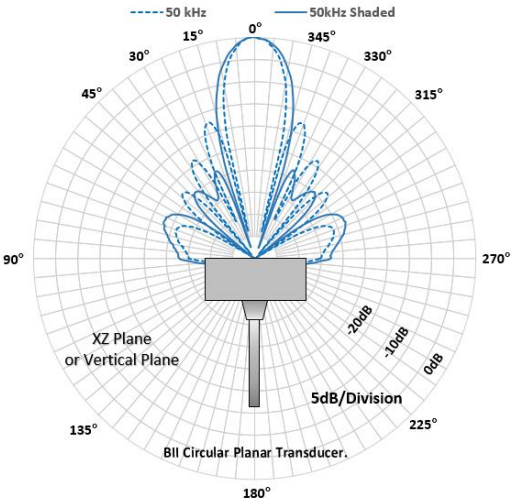
# BENTHOWAVE

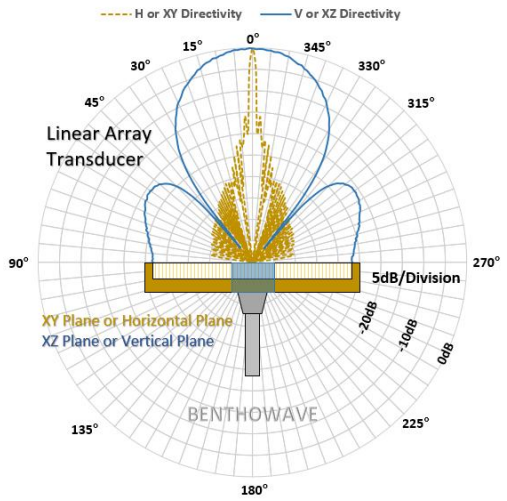
# Acoustic Transducers and Measurement Handbook

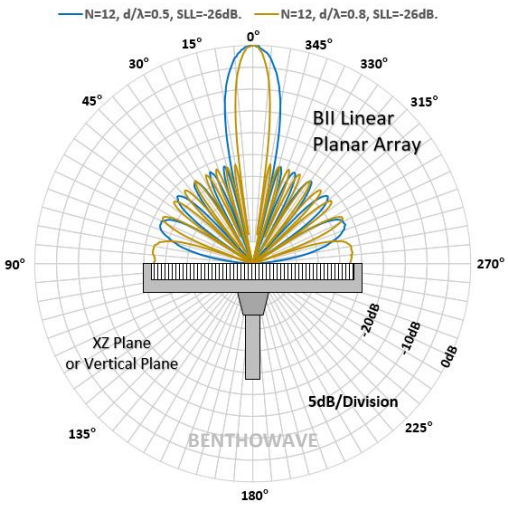
A Guide to Measurement Technology and Techniques on SONAR, NDT, AE, HIFU.

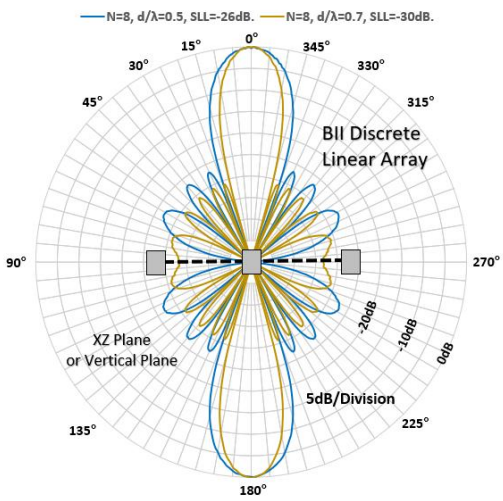



**Benthowave Instrument Inc.**

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## Acoustic Transducers and Measurement

BII manufactures acoustic and electronic components for underwater sound (oceanography and hydrography), sonic and ultrasonic engineering, electroacoustics, communication, bioacoustics, exploration seismology and seismic wave, physical acoustics, acoustical imaging, material study, Measurement, Control, and Processing.



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# Introduction to BII Electroacoustic Components

## Features of BII Electroacoustic Components:

**Available Apertures of BII Transducers:**

| Rectangular, Line | Square | Sphere, Hemisphere | Round Planar, Cylinder, Cylindrical Sector, Spherical Sector (Concave, Convex) |
|---|---|---|---|
| Length ≤ 1.8 m<br>Width ≤ 0.15 m<br>Height ≤ 0.11 m | Length ≤ 0.6 m<br>Width ≤ 0.6 m<br>Height ≤ 0.4 mm | Diameter ≤ 105 mm<br>(Resonance fs ≥ 12 kHz) | Diameter ≤ 168 mm<br>Height ≤ 400 mm |

**Broadband**: Broadband transducers with $Q_m$ = 1.56 and efficiency η =0.24. -3dB bandwidth = $f_s/Q_m$.
**High Power Projector**: Greater than 5000 W pulse power.
**High Intensity HIFU**: High Intensity Focused Ultrasound, greater than 5000 W/cm² at focal zone.
**Miniature Aperture:** Acoustic aperture size of Φ1.0 mm is available.
**Directivity Pattern:** Omnidirectional, Toroidal, Hemispherical, Conical, Cylindrical Sector (Fan-shaped), Spherical Sector, Focusing.
**Acoustic Aperture**: Spherical, Hemispherical, Rectangular, Circular, Annular, Cylindrical, Linear, Cylindrical (Curved) Segment, Spherical Segment.
**Low Noise Detection**: Low noise hydrophones with self-noise levels much below sea-state zero.
**Dynamic Range**: The Dynamic Range of signal (sound) detection is greater than 100 dB.
**Signal Conditioning with Low Power Consumption**: +2.7 to +24 VDC supply with 0.2 to 1.3 mA quiescent current. 40 μA quiescent current with +5.2 to +15 VDC supply.
**Low Frequency Detection**: Down to 0.1 Hz infrasonic sounds can be detected.
**Frequency Range**: 0.1 Hz to 10 MHz, usable up to 30 MHz at 3rd harmonics.
**Calibration**: Reciprocal and comparison indoor calibration system in air and water measures TVR, FFVS, and Directivity Pattern from 20 Hz to 10 MHz.
**Ocean Depth**: up to 1000 m.
**Service Temperature**: -10 °C to +60 °C or 14 °F to 140 °F by default. Customized on request, available from -15 to 200°C, or 5 to 392°F.

## Typical Applications:

**Marine (Underwater) Acoustics**: SONAR, Communication, Control, Marking, Navigation, Fishery, Oceanography, Seismology, Seafloor-mapping, Sub-bottom Profiling, Marine Animals, Artificial Sound Sources, Underwater Imaging (Microscopy such as surface inspection of underwater structures; Holography such as investigation of noise and vibration of submersibles; ocean acoustic tomography such as remote sensing of the ocean, lakes, rivers, and estuaries; and thermoacoustic tomography for biomedical applications).
**Acoustical Testing and Analysis (NDT, AE, Physical Acoustics, Diagnostic Ultrasound, and Acoustic Imaging)**: Flaw Detection, Thickness Gaging, Process Control, Ultrasonic Systems of A-scan, B-scan (B-mode Imaging, 2D Imaging), C-scan (3D Imaging), Materials Study, Ultrasound Spectroscopy, Shear Wave Impedometry, Examination of Structures, Control and Monitoring of Manufacturing Process, Health Monitoring of Structure, Acoustic Microscopy, Holography, and Tomography.
**Ultrasonic Processing (High Intensity Focused Ultrasound or HIFU)**: Physical, Chemical, Biological, Thermal and High-stress Effects of Ultrasonic Energy, Sonic Radiation in Sonochemistry, Material Processing, and Sonoluminescence, Cavitation, Acoustic Streaming, Acoustic Wave Interaction, Dispersion, Emulsification, Coagulation, Anti-algae and Anti-bacteria, Fluid Dynamics, Nonlinear Acoustics.
**Air Acoustics**: Air-coupled Ultrasonic Testing and Analysis; Material Study, Thermo-acoustics, Measurands influence reflection, refraction, scattering and transmission; Robotics, Proximity Detection, Sound Ranging, Counting, Monitoring, Remote Control, Alarming, Motion Detection, Level Measurement, Speed Measurement, Automatic Sizing, Sorting & Positioning of Parts, Edge Detection, Web Guiding System, Surface/Profile Characterization and Quick Scanning for Quality Control.

## Acoustical Technologies:

**Vibration Compensation:** 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 100 dB in axial direction of the hydrophone. 2. ≤ 80 to 110 dB in other directions of the hydrophone.
**High-Resolution Acoustic System**: BII's broadband transducers provide high axial resolution. BII's focusing transducers provide high Lateral Resolution.
**Beamforming**: Sidelobe suppression (weighting, amplitude shading) and beam steering (phase shift, or Time Delay). BII manufactures amplitude-shaded transducers whose side lobes is of -21dB (Linear or Line Transducers), -28dB (Disk Planar Transducer), -20dB to non-sidelobe (Multi-element Linear Array Transducer).
**Array Focusing:** By phase-shifting or time-delaying the elements to compensate the phase differences of a spherical wave, an acoustic focal zone in near field will be formed to receive or transmit sounds.
**Wide Beams**: Insonify and listen a wide field of interest (up to 120°) underwater which is valuable in such fields as signaling, communication, positioning, etc.…
**Interferometric SONAR (Phase-measuring, Interferometry)**: The phase differences of received signals are detected by multiple linear receive arrays paralleling to the linear transmit array. After ambiguity is removed with proper techniques, the direction of arrival (DOA) and location of the scatterer can be accurately determined.
**Goniometric and High-Resolution Methods** for Direction of Arrival (DOA): The amplitudes and phases of outputs of a sensor array are used to estimate the spatial location of a sound source and the number of sound sources.
**Parametric Transducers**: When two underwater sound waves of different primary frequencies $f_{p1}$ and $f_{p2}$ ($f_{p1}>f_{p2}$) propagate in the same direction, they interact with each other to create low frequency sound wave of secondary frequency $f_{sec.}$ ($f_{sec.} = f_{p1}-f_{p2}$). The directivity of secondary frequency is close to the ones of primary frequencies. This difference frequency sound is useful for practical applications in sediment profiling, depth sounding and communication. Parametric array gain or efficiency (generally ≤ 1%) is better as primary sound powers are higher, secondary frequency $f_{sec.}$ is higher, down shift ratio $(f_{p1}+f_{p2})/(2f_{sec.})$ is lower, and ($\alpha p$*Rr) is lower ($\alpha p$: mean primary sound attenuation coefficient; Rr: Rayleigh Distance).
**Split-aperture Correlation**: Target Angle Estimation. Beams of a quadrant array (apertures) are separately formed. The signals from the direction (azimuth: Ψ, Φ) will result in the phase contributions to the single-frequency directivity patterns functions of the array. With signal processing technologies, the spatial angle (Ψ, Φ), which can be computed quantitatively, indicates the target direction.
**Doppler Effect**: The Doppler Shift will be detected by BII broadband transducers to measure ship speeds, characterize marine currents, and track targets.
**Mills Cross and Multibeam**: Two lines array are perpendicular to each other; the outputs are multiplied or correlated together for scanning and positioning.
**Side Scan**: The fan-shaped beam covers wide across-track swath and provides high along-track spatial resolution in tens or hundreds meter range. Acoustic image of underwater bottom is achieved at grazing angles of incidence.
**Synthetic Aperture SONAR (SRS) and Synthetic Aperture Ultrasound (SAU)**: A long artificial array aperture is created from a single transducer in post-processing of the recorded signals to achieve higher spatial resolution.
**Synthetic Aperture Sequential Imaging**: a high-resolution image is formed by coherently compounding low-resolution images created by an array transducer.
**3D Imaging**: Mechanically scanned 3D transducers or 2D Matrix-array Transducers.
**Acoustic Imaging**: Microscopy, Holography, and Tomography.
**Thermoacoustics**: Conversion between acoustic (mechanical) energy and thermal energy which may be induced from electricity or microwave such as thermoacoustic tomography.

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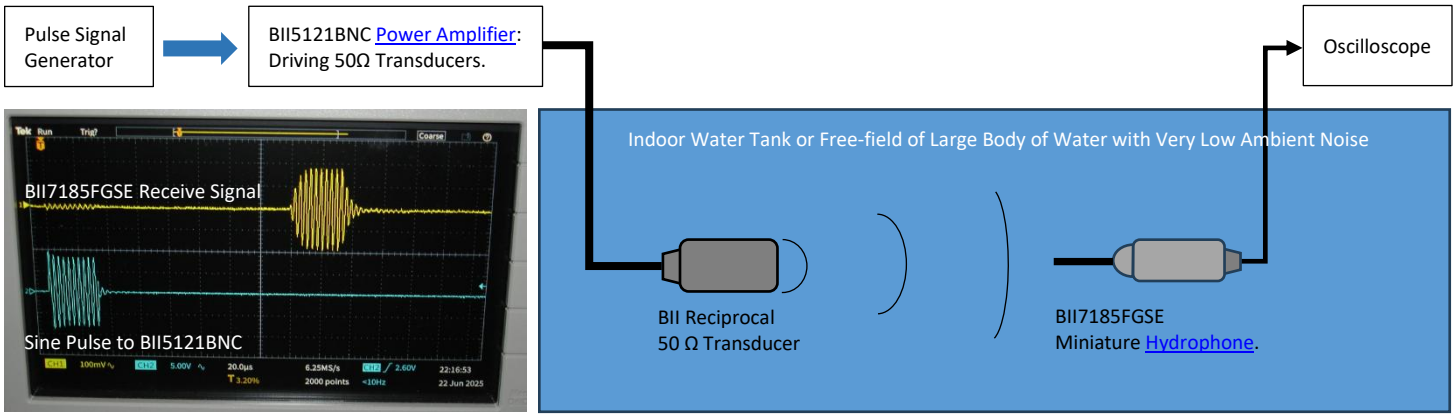
## Ψ Acoustic Transducers (0.1 Hz to 10 MHz): Underwater & Air SONAR, NDT, AE & HIFU Ψ

**TYPICAL APPLICATIONS**

Echo Sounder (Navigation/Object Avoidance, Depth/Distance Sounder, Wave-height Sensor), Target Strength Measurement, Seafloor-mapping, Sub-bottom Profilers, Side-scan SONAR, Fishery SONAR, Transponders, Artificial Acoustic Target, Positioning, Beacon, Communication and Telemetry, Seismology, Oceanography, Ocean Current Profiling, Acoustic Speedometers (Doppler SONAR), Sound Velocity Profiler, Marine Bioacoustics, Marine Animals, Acoustic Deterrent Devices, Flow Meter, NDT (Non-destructive Test), Acoustic Emission Detection, Diagnostic Ultrasounds, Ultrasonic Test and Analysis, High Intensity Focused Ultrasound, Material Study.

| | | | |
|---|---|---|---|
| **Hydrophone & Acoustic Sensor: Low Noise, Low Power, Miniature, Omni & Highly Directional, Beamforming, Deep Water, High Temperature.** | | | |
| » BII7000 | Omnidirectional Spherical Hydrophone | » BII7010 | Low Noise Broadband Hydrophone: 0.1Hz to 500kHz |
| » BII7020 | Line Array Hydrophone: 1Hz to 160kHz | » BII7040 | Hemispherical Hydrophone |
| » BII7550 | Split Beam Transducer: Target Angle Estimation | » BII7060 | Vector Hydrophone Array: Measurement of Bearing |
| » BII7070 | Directional Hydrophone (Conical Beam) | » BII7110 | Flush-Mounting Hydrophone |
| » BII7120 | Ultra-Low Noise Hydrophone: Below Sea-state Zero | » BII7140 | Acoustic Element for Array/Streamer/Beacon |
| » BII7180 | Miniature Hydrophone: Φ1.0 to Φ3.5mm Aperture | » BII7230 | AE Sensor: Detect Acoustic Emission |
| » BII7630 | Phased Array Transducer: Beamforming & Imaging | » BII7680 | Wide Beam Directional Transducer: 120°x30° View |
| **Marine Transducer (Transmit & Receive): Broadband, High Power, Omni & Highly Directional, Beamforming, High Temperature.** | | | |
| » BII7500 | High Power Piston Transducer | » BII7510 | Communication and Miniature Transducer |
| » BII7520 | Omnidirectional Spherical Transducer | » BII7530 | Low Frequency Transducer |
| » BII7540 | Parametric Array Transducer: Sediment Profiling | » BII7550 | Split Beam Transducer: Target Angle Estimation |
| » BII7560 | Echo Sounder Transducer up to 2MHz | » BII7570 | Side Scan Transducer: Interferometric and Parametric |
| » BII7580 | Ultrasonic Power Transducer: High Q | » BII7590 | Free Flooded Ring Transducer: Broadband, Deep Water |
| » BII7600 | Communication Transducer: Conical Beam | » BII7610 | Doppler Transducer: Speed Measurement |
| » BII7620 | Directional Low Frequency Transducer | » BII7630 | Phased Array Transducer: Beamforming & Imaging |
| » BII7640 | Scanning Transducer & Omnidirectional Transceiver | » BII7650 | High Intensity (HIFU) Transducer |
| » BII7660 | Multibeam Transducer: Imaging Sonar | » BII7670 | Underwater Annular Transducer in Pipes |
| » BII7680 | Wide Beam Directional Transducer: 120°x30° View | » BII7690 | NDT & Imaging Transducers: High Resolutions |
| » BII7700 | Hemispherical Transducer | » BII7710 | Scanning SONAR Transducer: 360° Search |
| » BII7720 | Flush-Mounting Transducer | » BII7730 | Broadband Single or Dual-Element Transducer |
| » BII7740 | Annular Array Transducer: Sidelobe Suppression & Focusing | » BII7760 | Spherical Sector Directivity Transducer: up to 60° |
| | | » BII7770 | Mechanical Scanning SONAR Transducer |
| **Air Transducer (Transmit & Receive): Air-coupled NDT, Material Study, Navigation, Ranging, Measurement and Control.** | | | |
| » BII7900 | Ultrasonic Air Transducer: up to 140°C (284°F) | » BII7910 | Air Array Transducer: Electronic Beam Focusing |
| **High Temperature Hydrophones and Transducers: Service Temperature up to 200°C/392°F.** | | | |
| » BIIHTTX | High Temperature Hydrophones and Transducers (Up to 198°C/392°F) | | |
| **Acoustic Instrumentation: Preamplifier, Filter, Power Amplifier, Impedance Matching, Transmit and Receive System, Pulsing-Echo System,...** | | | |
| » BII1000 | Hydrophone & Ultrasonic Preamplifier | » BII4000 | Signal Generator for SONAR, NDT, NDT Ultrasound |
| » BII2000 | AGC (Automatic Gain Control) Amplifier | » BII5000 | Power Amplifier: Sonar, HIFU, NDT, ... |
| » BII2100 | Transmit & Receive System: Sonar & Ultrasound | » BII6000 | Impedance Matching for Transducers |
| | | » BII8010 | Ultrasound Pulser & Receiver |

**System Performance of an Underwater Acoustic System in a Small Body of Water (Indoor Water Tank).**





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## Basics on Choosing Acoustic Transducers.

1. **Frequency Range**: Filters, -3dB Bandwidth/$Q_m$, fs; 2. **Noise**: Ambient Noise, Hydrophone Self-noise, Filters, Acceleration Response; 3. **Directional Response Pattern:** Single, Dipole, Linear/Planar/Conformal Arrays, Elements in Series or Parallel; 4. **Sounds Level/Dynamical Range/Cavitation/Focusing**: Sensitivity/FFVS, Preamps; TVR, HIFU, Sinusoidal and Pulsing Power; 5. **Output/Connectors**: Differential, Single-ended; Coax, XLR, TRS, DIN, Wire Leads, Underwater Connector, MIL-5015, etc.; 6. **Cable**: Wire Bundle, Coax, PUR/PVC/Rubber Jacket, Twisted Pair, Shielded, Unshielded. 7. **DC Power and Consumption:** Working/Service Time; 8. **Environmental Factors**: Hydrostatic Pressure/Deployment Depth, Service Temperature, Cable, Mounting/Installation, Connectors; 9. **Impedance Matching**: 100Ω/50Ω/8Ω/5Ω; 10. **Transmit & Receive**: TR Switch, Separated High Power Projector and Low Noise Receiver, Pulse-Echo/Echo-sounding/NDT; 11. **Subject Properties**: Liquids, Ocean/Lake/River Water, Air/Gas, Solids/Plastics/Metal/Ceramic/Composites, etc.; 12. **Signal Conditioning/Array Processing**: Preamps, Power Amplifiers, Filters, T/R Switching, Beamforming/Amplitude Shading/Beam Steering/Side-lobe Suppressing, etc.. 13. **Signal Type**: Tone Burst (Sinusoidal) Excitation, Chirp Pulse, Square Wave Pulse, Spike (Shock) Pulse, Coded Excitation (Barker/Golay), Continuous Signals, Arbitrary Signals, Aquatic/Marine Animal Sounds, Ambient and Ship/Vehicle Noises, etc.

## Low Frequency Sounds in the Ocean at 1 Hz to 1 kHz.

Low Frequency Sounds between 1Hz to 1kHz undergo little attenuation in ocean and lakes: $1.2x10^{-7}$ at 1Hz, 0.0002 at 10Hz, 0.0015 at 100Hz, 0.07 at 1kHz, in dB/km, proximately. The major propagation losses are Spreading Loss, Absorption and Scattering at boundaries such as seafloor sediments. The sounds being trapped in deep sound channel or SOFAR channel avoiding losses from both top and bottom boundaries can propagate very big area with very low loss. These low frequency sounds contain valuable information on their sources and propagation areas such as Weathers (Winds, Rains, Surface Waves, Ice, Storms, ...), Geological Process (Earthquakes, Tsunamis, Moving of Tectonic Plates and Crusts...), Marine Animals (Whales, Dolphins, Fish, Invertebrates, ...), Anthropogenic Activities (Shipping, Harbor, Oil and Wind Energy Extraction, Air Guns, ...).
Besides sounds detection or monitoring with deployment at 1000m depth, the distributed hydrophone network in shallow water (at a specific depth) can also be used to detect and monitor upward sounds being refracted from SOFAR channel.

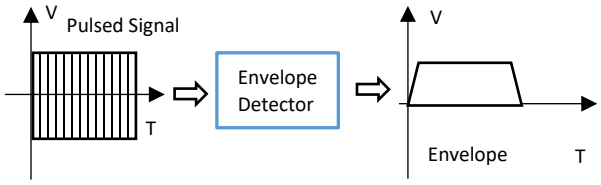
## Signal Processing

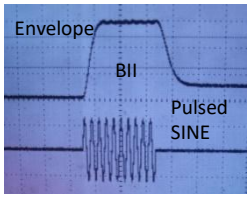
**Sonar Signal Envelope Detector** According to Nyquist–Shannon sampling theorem: If the highest frequency in the original signal is f, the lower bound on the sampling frequency for perfect signal reconstruction is 2f, called Nyquist sampling rate. To get better resolution such as underwater acoustic image, high carrier frequency is used in several hundred kHz to several MHz. This imposes cost on electronic processing circuit such as A/D converter and data storage. An Envelope Detector removes high frequency carrier signal and extracts the low frequency envelope. Low-cost electronic system can be used to sample and analyze the envelope.

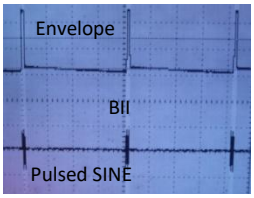
**Typical Applications**

High Frequency Scanning, Side Scan and Imaging Sonar
Fishery/Plankton Sonar, Sediment Penetration/Parametric Sonar
Echosounder, Navigation Sonar, Sea-floor Mapping Sonar
Target Strength Measurement, Abundance Estimate

**Envelope Detection**

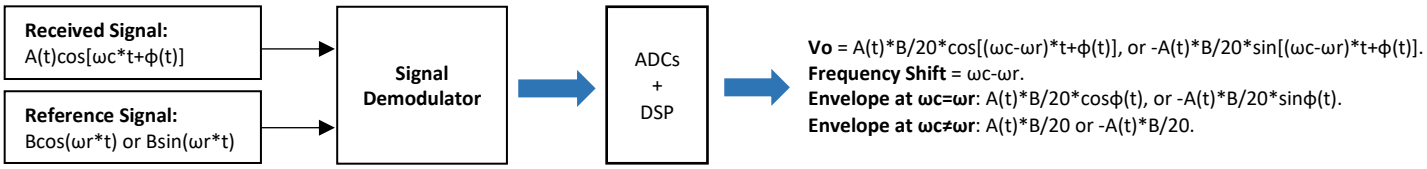


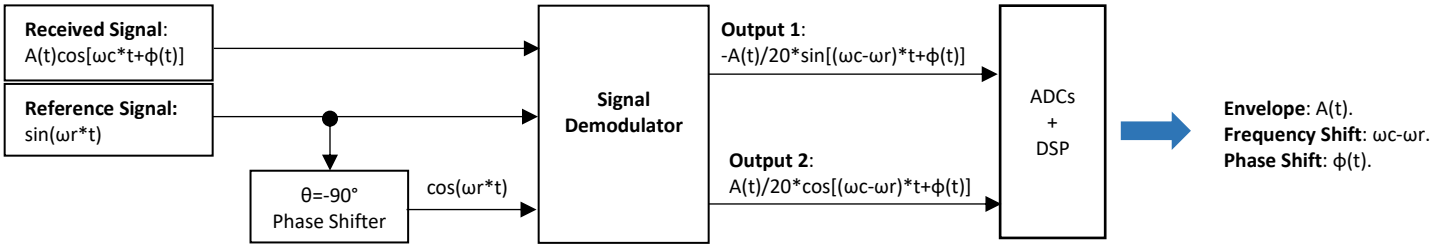




**Signal Demodulator** The useful information of a known narrowband signal is not contained in the carrier frequency, but in its modulation. A Signal Demodulator demodulates a known narrowband signal such as pulsed SINE, FSK and CHIRP around its carrier frequency fc in time domain and keeps only the meaningful low frequency content of the signal and thus lowers the sampling rate of A/D converter and reduces the amount of sampled digital data. The demodulated signal contains in-phase and quadrature components which describes the received signal truthfully. The envelope, frequency shift and phase shift can be extracted with signal processing in software for estimation of target range, bearing, speed and size. Besides, A Signal Demodulator can also be used to convert ultrasound to audible sounds for real-time listening and searching of marine animals, SONAR sources, acoustic tags, pingers, etc.

**Typical Applications:** Communication, Echo Sounding; Correlation Receiver, Doppler SONAR, Speed Measurement; Target Angle Measurement, Split-Aperture SONAR.




**t**: Time; $\omega_c$: Frequency of Received Signal; $\omega_r$: Frequency of Reference Signal; **A(t)**: Amplitude of Received Signal; **B**: Amplitude of Reference Signal; **ϕ(t)**: Phase Shift between Received Signal and Reference Signal.

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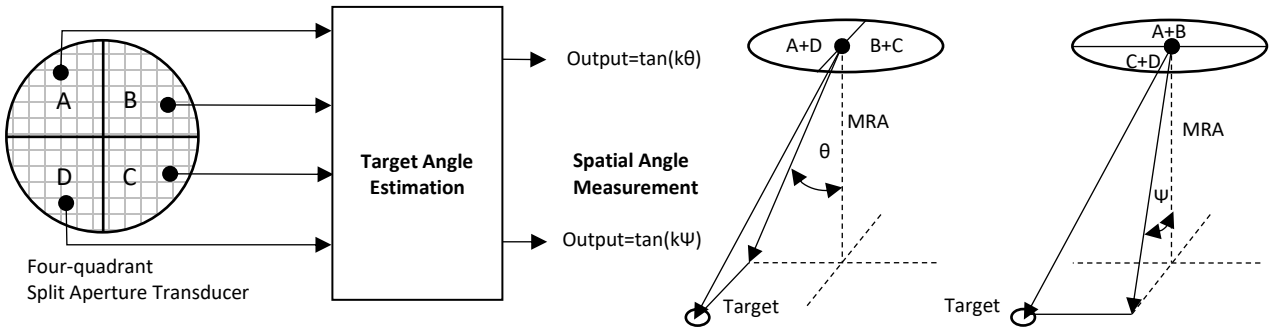
**Target Angle Estimation** is a four-quadrant split aperture correlator which works with a four-quadrant split beam transducer to estimate the direction of arrival of a plane wave sound (or, measure the spatial angle of the sound) and determine the angular position of the target relative to the acoustic axis of the transducer.
**Typical Applications:** Target Tracking and Searching, Homing Torpedoes; Navigation, Positioning, Obstacle Avoidance; Fishery Sonar; Seafloor Slope Mapping.




**K:** Angle Sensitivity = Phase Shift/Spatial Angle, transducer's parameter. **θ and Ψ**: Spatial Angles of a Sound Source Relative to MRA of the Transducer. **MRA**: Maximum Response Axis of Transducers, or **Acoustic Axis**.

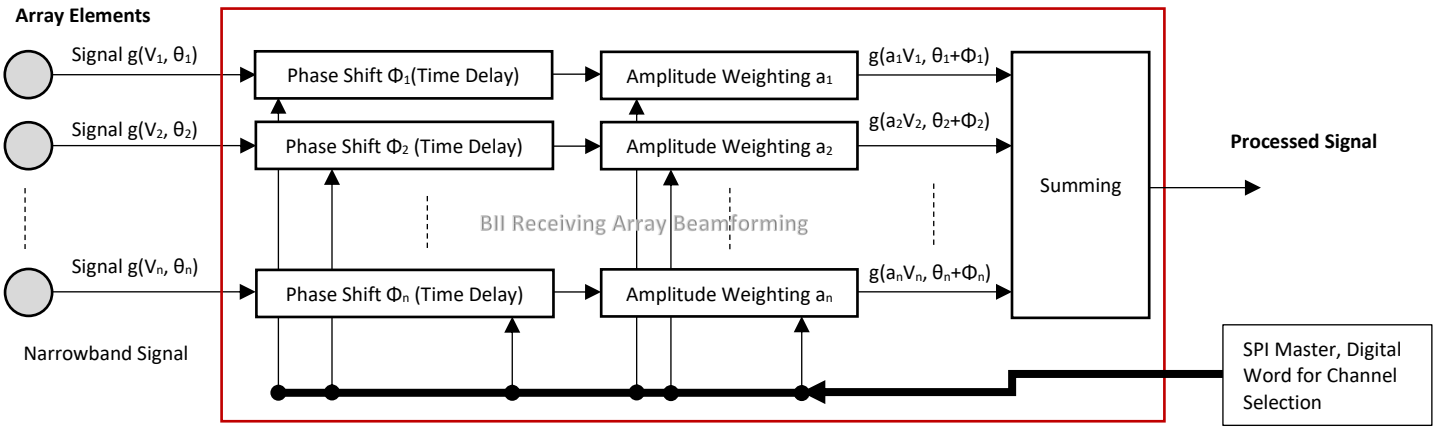
## Array Beamformer

**Array Beamforming: Beam Steering and Array Shading/Weighting (Sidelobe Suppression) for Narrowband Signals**
Appropriate phase shifts can be imposed on the array signal paths to steer the main lobe to the desirable direction. Aperture response is tuned with amplitude shading/weighting to provide the most desirable directional pattern for a particular application: a desirable beam width and response at main lobe, and suppressed responses at sidelobes, or vise versa. Array elements could be discrete elements of one transducer, or discrete hydrophones and projectors.
Array beamformers for receiving and transmitting narrowband sounds can be implemented with digital beamforming in software.
Wide View of Field ±90° (frequency dependant); Weighting Laws: Triangular, Dolph-Chebyshev, Cos, Cos², Hamming ...; Linear, Planar and Conformal (Spherical and Cylindrical) Array.

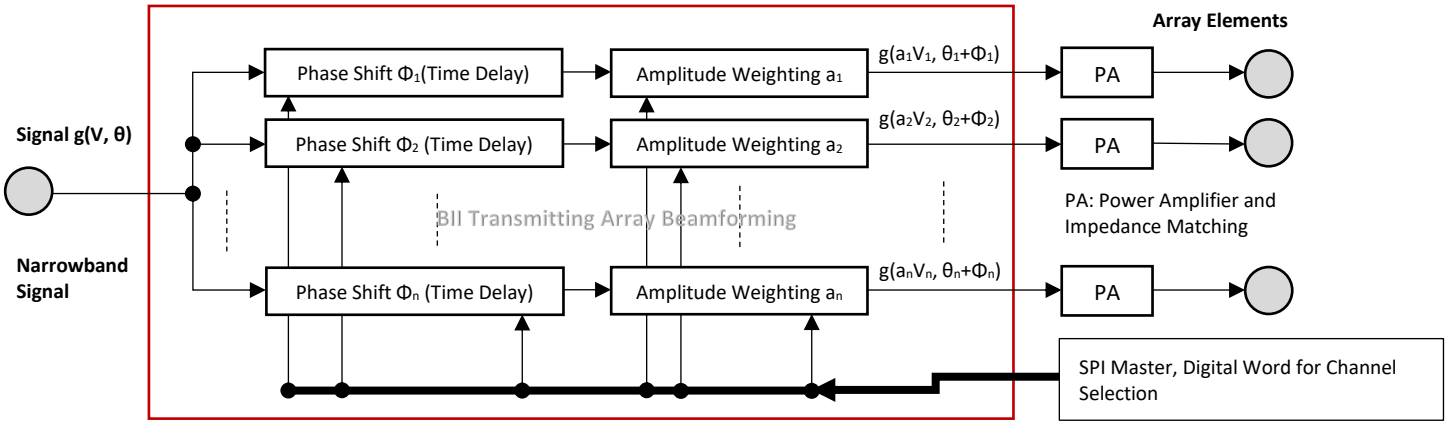
**Typical Applications**

| | | |
|---|---|---|
| Array Focusing, Mills Cross | Delay Compensation Caused by "Moving" | Bearing, Location, Acoustic Positioning |
| Navigation, Obstacle Avoidance | Scanning and Imaging Sonar, Fishery SONAR Scanning View of Field | Communication, Beaconing |

**Structure of Receiving Array Beamforming**
It is recommended that the signals are bandpass filtered before they pass to digital beamformer.




**Structure of Transmitting Array Beamforming**

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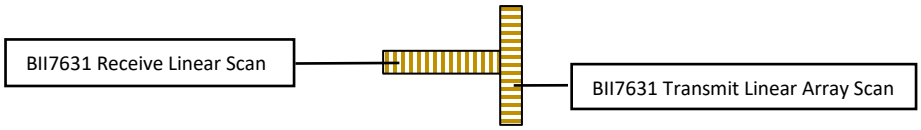
**Combination of BII Acoustic Transducers to a New Transducer (illustration ONLY)**

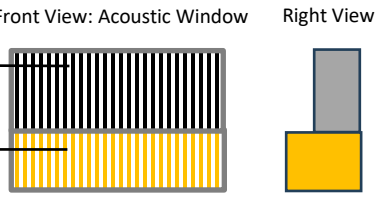
3D "T" Type Imaging Multibeam Transducer: Two BII7631 Linear Phased Array (Rectangular Aperture).




**2D Imaging Multibeam Transducer: one BII7631 Linear Phased Array (Rectangular Aperture) and one BII7682 Wide Beam Directional Transducer (Curvilinear or Cylindrical Sector Aperture).**

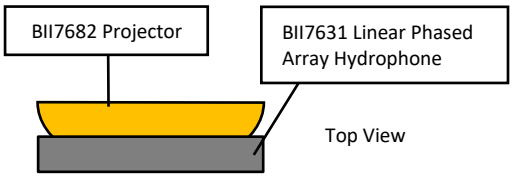
**BII7631 Linear Phased Array Hydrophone**: Electrically Scanning.

**BII7682 Projector (Curved Surface)**: Wide Beam up to 120°x30° View Field.



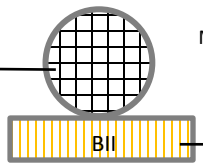







**Echo-ranging or Scanning Transducer: one BII7682 Wide Beam Directional Projector (Cylindrical Sector Aperture) and one bespoke BII7730 Hydrophone.**

**BII7730 Bespoke Hydrophone**:
1. Narrow Conical Beam, Highly Directional.
2. Low Noise High Sensitivity.
3. Side Lobe Level: ≤ -30 dB.

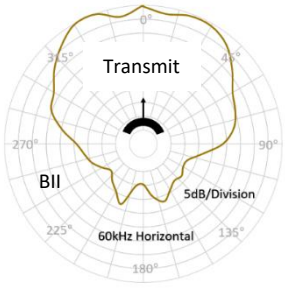


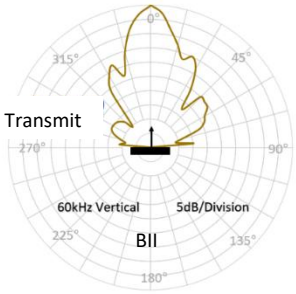

Mechanically Scanning

BII7682 Multi-element Projector:
1. Wide Horizontal Beam up to 120° View Field.
2. Narrow Vertical Beam 10° to 30° View Field.

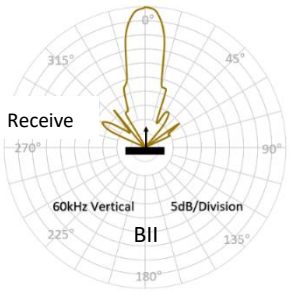
**Echo Ranging Transducer, typical directivity Pattern. Illustration ONLY at 60 kHz.**

Transmit Beam Pattern

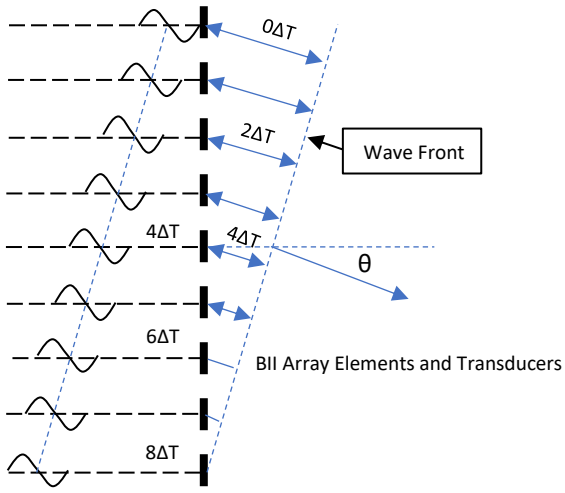


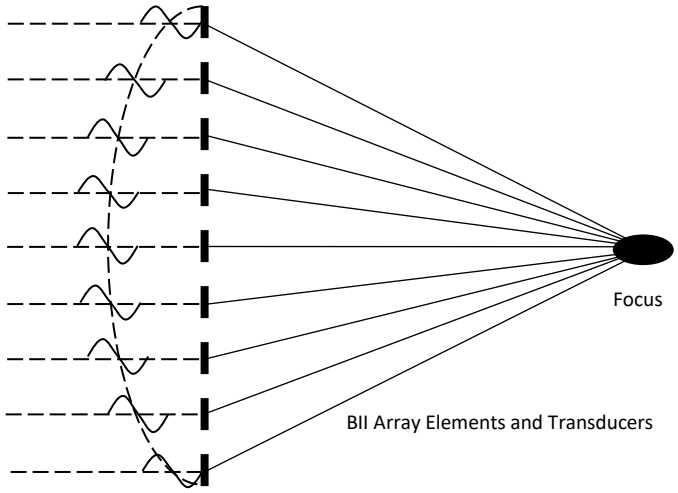

Receive Conical Beam Pattern



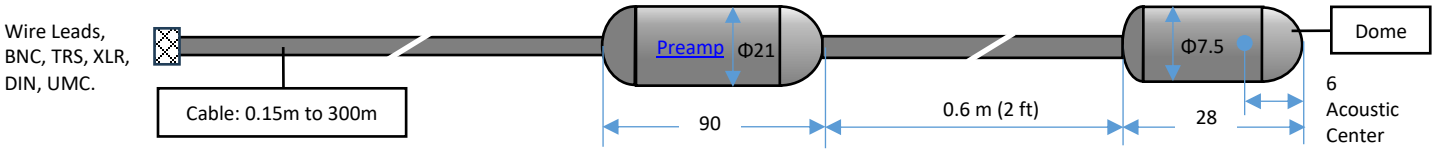

**Linear and Planar Array Beam Steering**




**Linear and Planar Array Beam Focusing**




**Hydrophone as Array Element: Free Hanging with Smooth Domes for a Linear Discrete Array. Illustration Only, Size Scale is NOT 1:1.**




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

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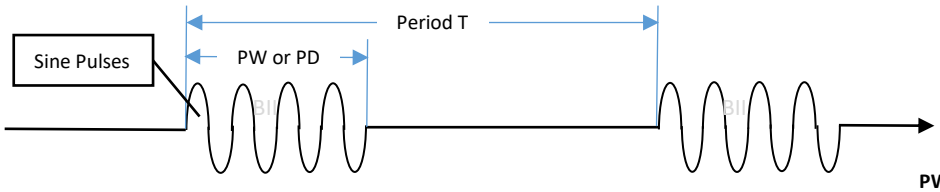
## Typical Signals for Active SONAR, Ultrasound, HIFU (High Intensity Focused Ultrasound) and Communication

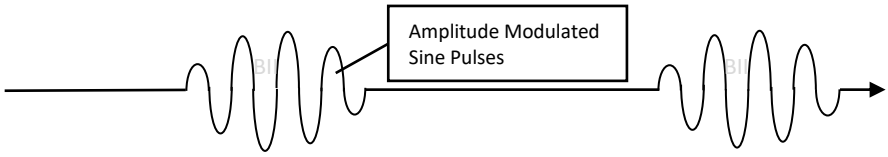
BII4000 series signal generators are embedded and standalone components/modules which generate SINE pulses, Pulse Trains, or Spike Pulses for Pulsing-Echo acoustic systems (SONAR, NDT, Diagnostic ultrasound...) and underwater communication system, and feature low power, high accuracy, and long-term stability.

**Burst SINE (BS) or SINE Pulse (BS)**

| **Pulsed/Burst SINE (or Rectangle Modulated)** | **Pulsed/Burst Amplitude-Modulated SINE** |
|---|---|
| Pulsed SINE $s(t) = A\sin(2\pi f_0 t)$, if $0 \le t \le PW$. $s(t) = 0$, if $PW < t \le T$. | Pulsed SINE $s(t) = A(t)\sin(2\pi f_0 t)$, if $0 \le t \le PW$. $s(t) = 0$, if $PW < t \le T$. |



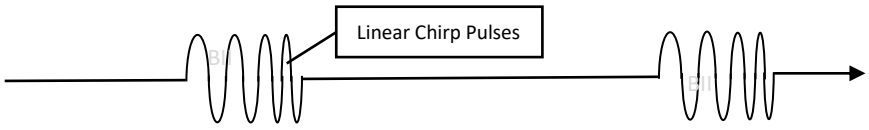





**PW**: Pulse Width or **PD**: Pulse Duration.
**PRR**: Pulse Repetition Rate. **Pulse Signal Period T** =1/ PRR.
**Duty Cycle D** = PW/T = PW * PRR.
**Bandwidth $\Delta f_{-3dB}$ of SINE Pulses** ≈ 0.89/T = 0.89 * PRR.
The amplitude A(t) of the signal can be modulated with different laws such as Gaussian-shape Envelope to improve resolution in both time and frequency domains.

**Burst FM (BFM, Frequency Modulation) or Chirp Pulse (CP)**

| **Linear Pulsed Chirp** | **Hyperbolic Pulsed Chirp** |
|---|---|
| $s(t) = A*\sin(2\pi(f_0 + m(t-PW)/2)t)$, if $0 \le t \le PW$. m: Modulation Index.<br>$s(t) = 0$, if $PW < t \le T$. | $s(t) = A*\sin(2\pi f_0 * m * \log_e(1+(t-PW/2)*m)$, if $0 \le t \le PW$. m: Modulation Index.<br>$s(t) = 0$, if $PW < t \le T$. |



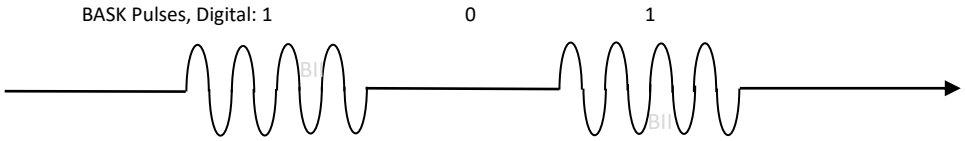

Comparing with SINE Pulses:
Chirp-Pulse SONAR System has higher SNR gain, better time resolution, heavier signal processing, and is much more complex.
-3dB width of Main lobe: $\delta t = 0.886/B$, B: signal Bandwidth.

**Burst BASK (Binary Amplitude Shift Keying) or BASK Pulse**

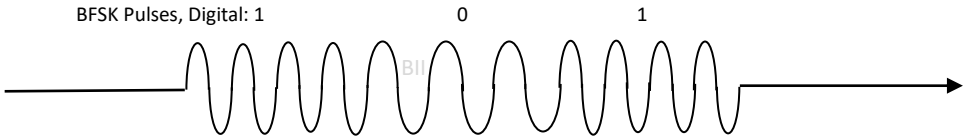
Burst BASK $s(t) = A\sin(2\pi f_0 t)$, if $0 \le t \le PW$ and High Logic 1.
$s(t) = 0$, if $0 \le t \le PW$ and High Logic 0.
$s(t) = 0$, if $PW < t \le T$.

**Burst BFSK (Binary Frequency Shift Keying) or BFSK Pulse**

Burst BFSK $s(t) = A\sin(2\pi f_1 t)$, if $0 \le t \le PW$ and High Logic 1.
$s(t) = A\sin(2\pi f_2 t)$, if $0 \le t \le PW$ and High Logic 0.
$s(t) = 0$, if $PW < t \le T$.



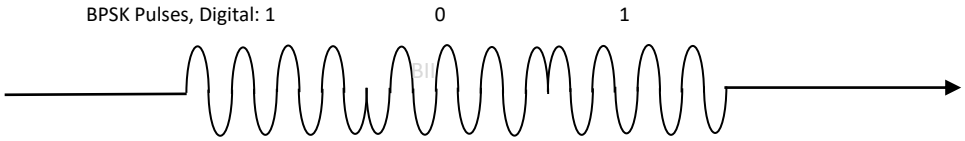

Underwater Communication




Underwater Communication

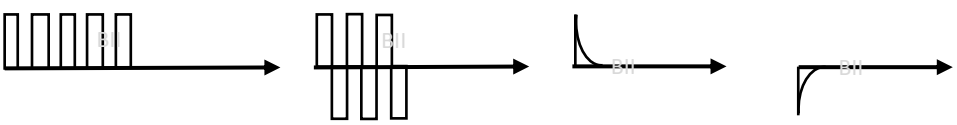
**Burst PM (Phase Modulation) or PM Pulse**

| **Burst BPSK (Binary Phase Shift Keying)** | **Burst QPSK (Quadrature Phase Shift Keying)** |
|---|---|
| Pulsed BPSK $s(t) = A*SIN(2\pi f_0 t + \Phi(t))$, if $0 \le t \le PW$.<br>$s(t) = 0$, if $PW < t \le T$.<br>$\Phi(t) = 0$ for High Logic 1. $\Phi(t) = \pi$ for low Logic 0. | Pulsed QPSK $s(t) = A*SIN(2\pi f_0 t + \Phi(t))$, if $0 \le t \le PW$.<br>$s(t) = 0$, if $PW < t \le T$.<br>$\Phi(t) = 0, \pi/2, \pi$, or $3\pi/2$. |




Underwater Communication
Accurate Time Measurement
High Time Resolution and Processing Gain

**Burst Rectangular Pulse (BRP), Burst Square Signal (BSS), and Positive or Negative Voltage Spike (PVS or NVS).**



Burst Rectangular Pulse (**BRP**) Burst Square Signal (**BSS**) Positive or Negative Voltage Spike (**PVS or NVS**)

**Square Signal** can deliver 1.414 times electrical energy to transducer comparing with SINE Pulses. **Pulse and Square Signal system** has much higher electrical efficiency than SINE pulsing system. **Voltage Spike** has highest resolution in time domain for ultrasonic measurement.

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## Frequency Comparison of Underwater Acoustic Systems, NDT and HIFU.

| Applications | Typical Frequency |
|---|---|
| Human Hearing | 20 Hz to 20 kHz |
| Underwater Ambient Noise | < 10 Hz (Infrasonic): hydrodynamic processes.<br>10 to 500 Hz: distant commercial shipping traffic.<br>500 to 50,000 Hz: sea-surface agitation, wind, and breaking waves. |
| Underwater Communication | 1 to 100 kHz |
| Fish finder SONAR | 50 to 200 kHz |
| Sub-bottom Profiling (SBP) | 500 Hz to 20 kHz |
| Underwater Doppler SONAR | 38 kHz to 3 MHz |
| Side-scan SONAR | 100 kHz to 1 MHz |
| High-Intensity Focused Ultrasound (HIFU) | 0.5 to 20 MHz |
| Medical Ultrasound | 1 to 20 MHz |
| Industrial Ultrasound, NDT. | 0.5 to 25 MHz |
| Higher frequencies provide better resolution but are absorbed more quickly, reducing their useful range. | |

## Comparison of Acoustic Continuous Sounds and Pulsing Sounds

| Characteristics | Continuous Sounds | Pulsed Sounds |
|---|---|---|
| Transmission | Continuous | Short bursts |
| Average power | High | Lower |
| Peak power | Moderate | High |
| Range measurement | Poor | Excellent |
| Velocity measurement | Excellent | Good |
| Echo separation | Difficult | Easy |
| Data communication | Possible with modulation | Commonly used |
| SONAR | Doppler sonar | Echo sounding, fish finding, mapping |
| Medical ultrasound | Continuous Doppler | Imaging and pulsed Doppler |

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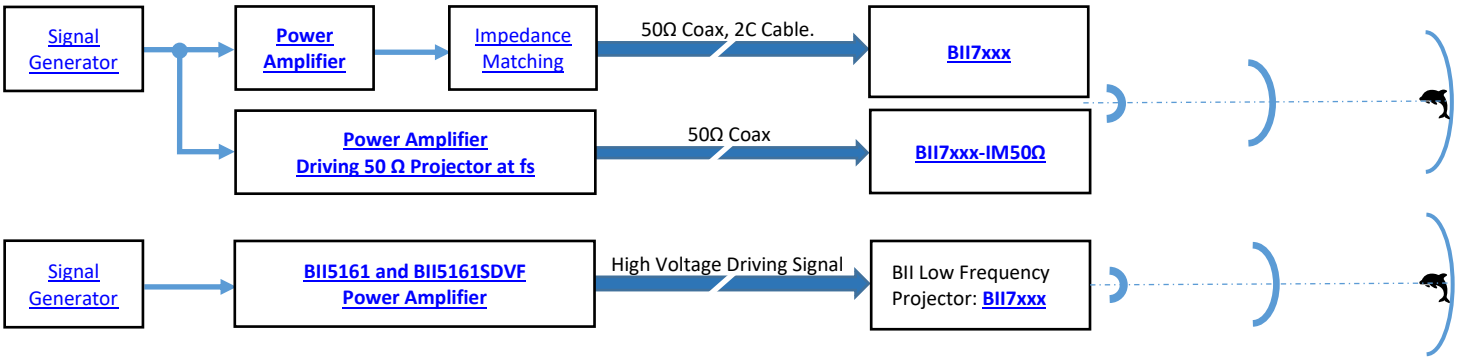
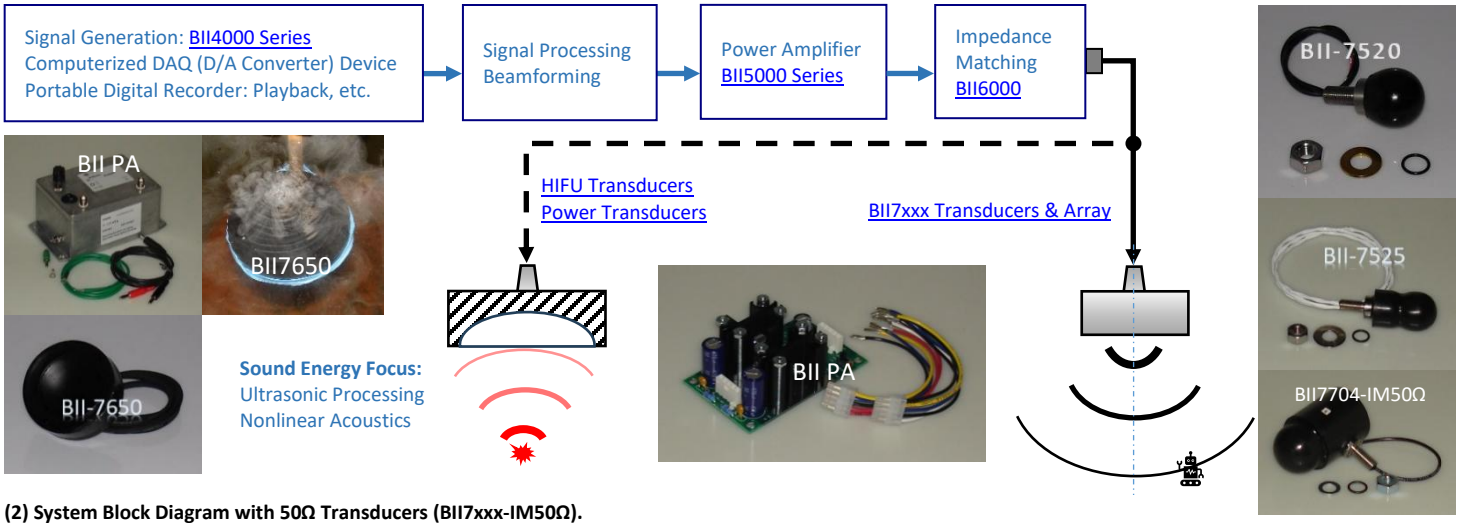
**BII Components in SONAR (Marine and Air), Power Ultrasonic, and HIFU (High Intensity Focused Ultrasound) System**

Linear & Nonlinear Acoustics: SONAR/NDT/AE/HIFU, Bioacoustics, Navigation, Communication, Oceanography, Seafloor-Mapping, Sub-bottom Profiling, Material Study.

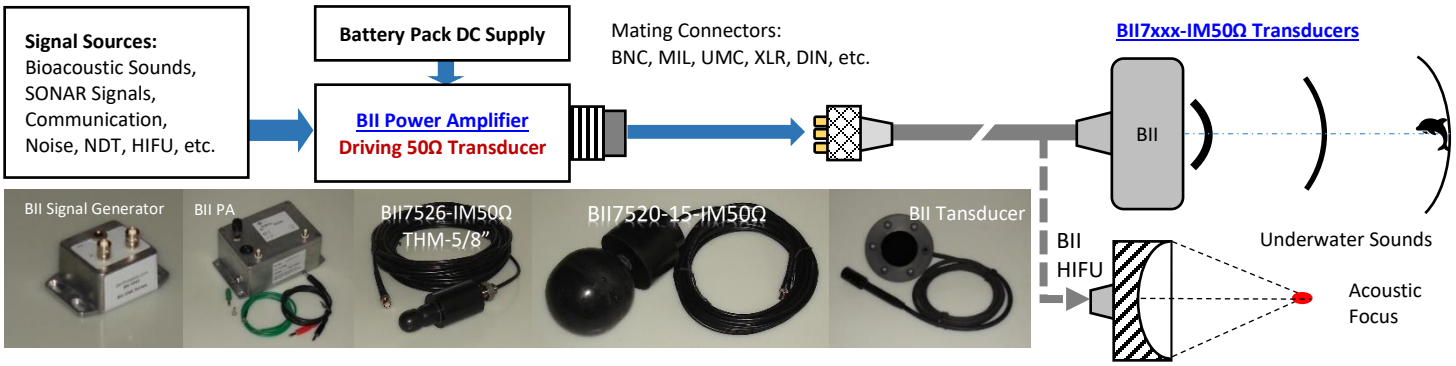
**Generation of Underwater or Ultrasonic Sounds.** IM50Ω: Impedance Matching to 50Ω.



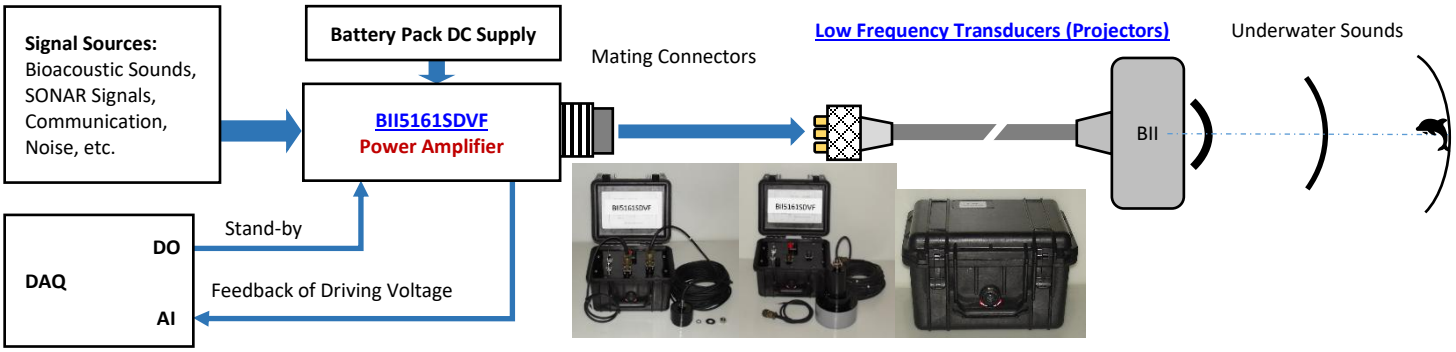

**(1) System Block Diagram with Individual Components.**




**(2) System Block Diagram with 50Ω Transducers (BII7xxx-IM50Ω).**




**(3) Generate Low Frequency Sounds as low as 100Hz.**

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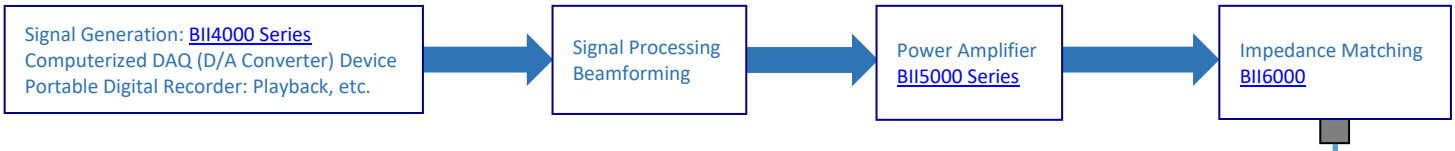
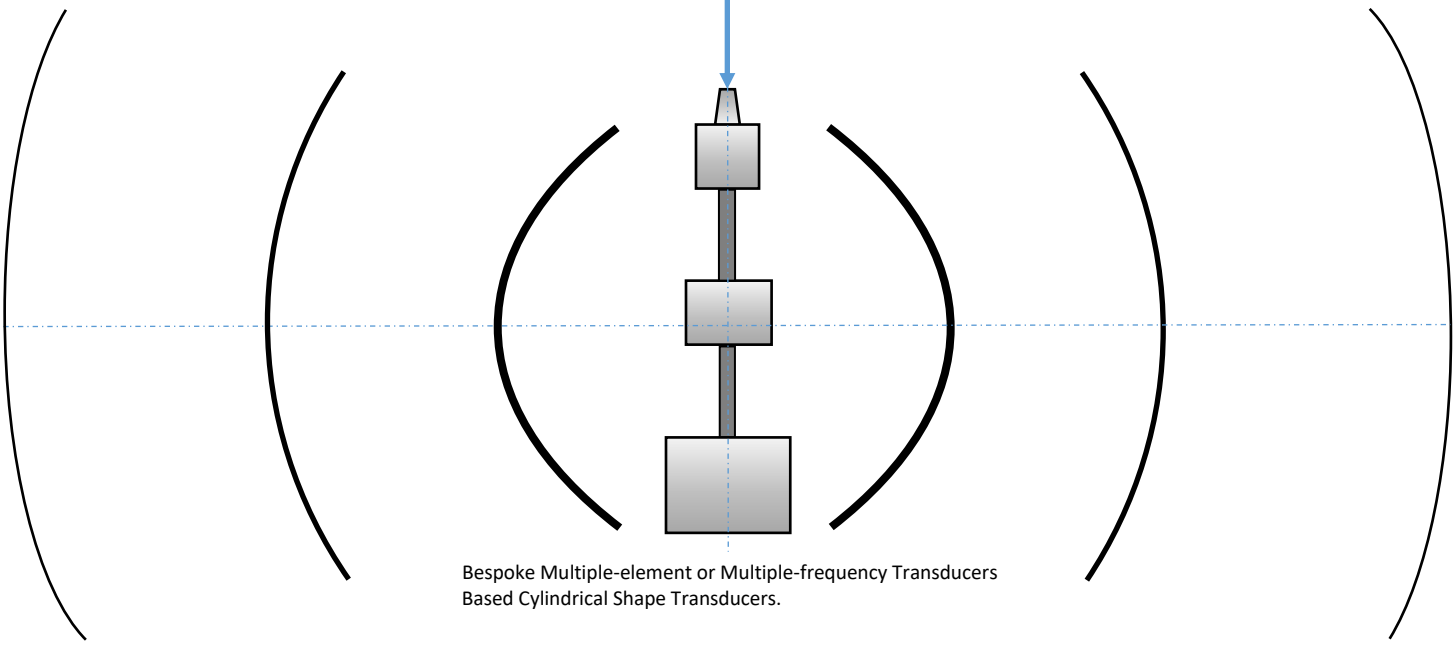
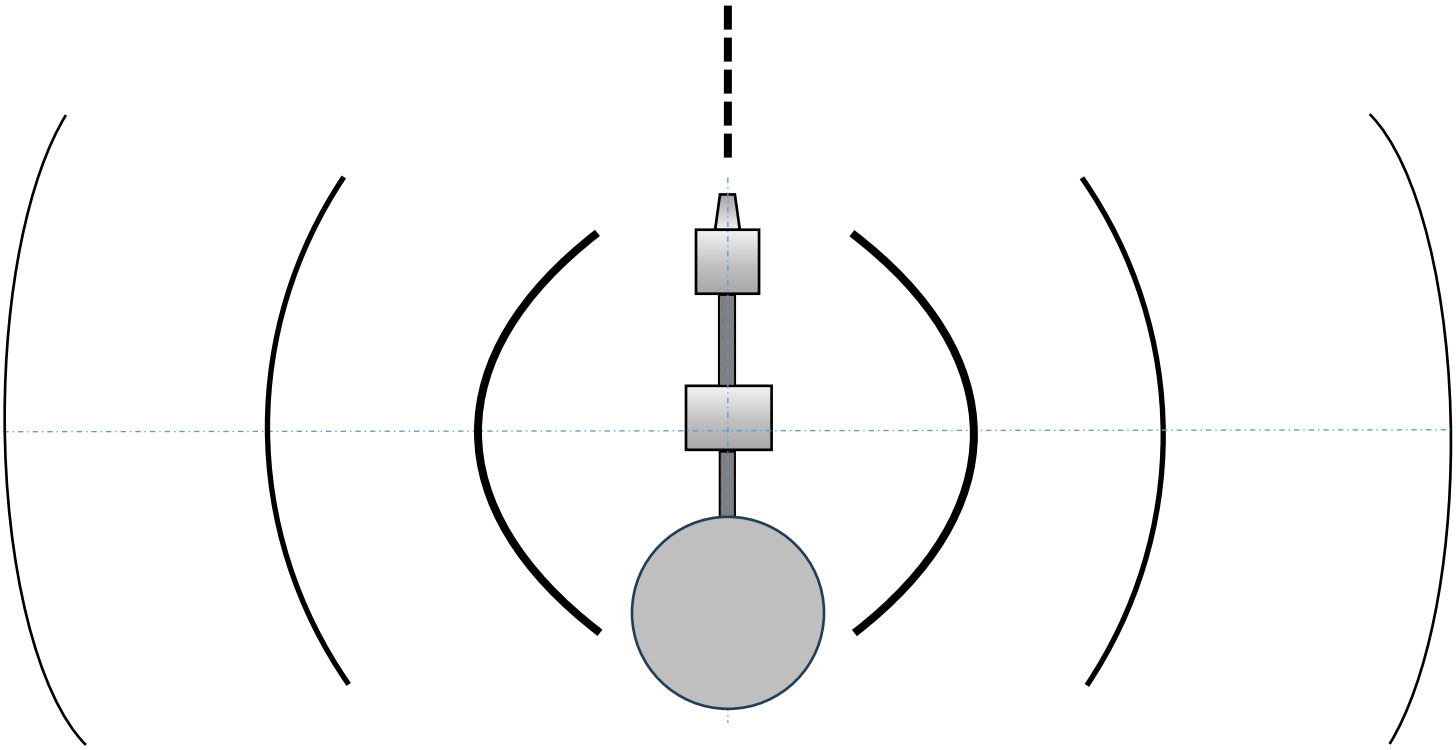
**(4) System Block Diagram with Individual Components based on Multiple-element or Multiple-frequency Transducers.**




Most multiple-element transducers are of dual or triple-elements to achieve much wider bandwidth and several optimum operating frequencies.



Bespoke Multiple-element or Multiple-frequency Transducers
Based Cylindrical Shape Transducers.



Bespoke Multiple-element or Multiple-frequency Transducers
Based Cylindrical and Spherical Transducers.

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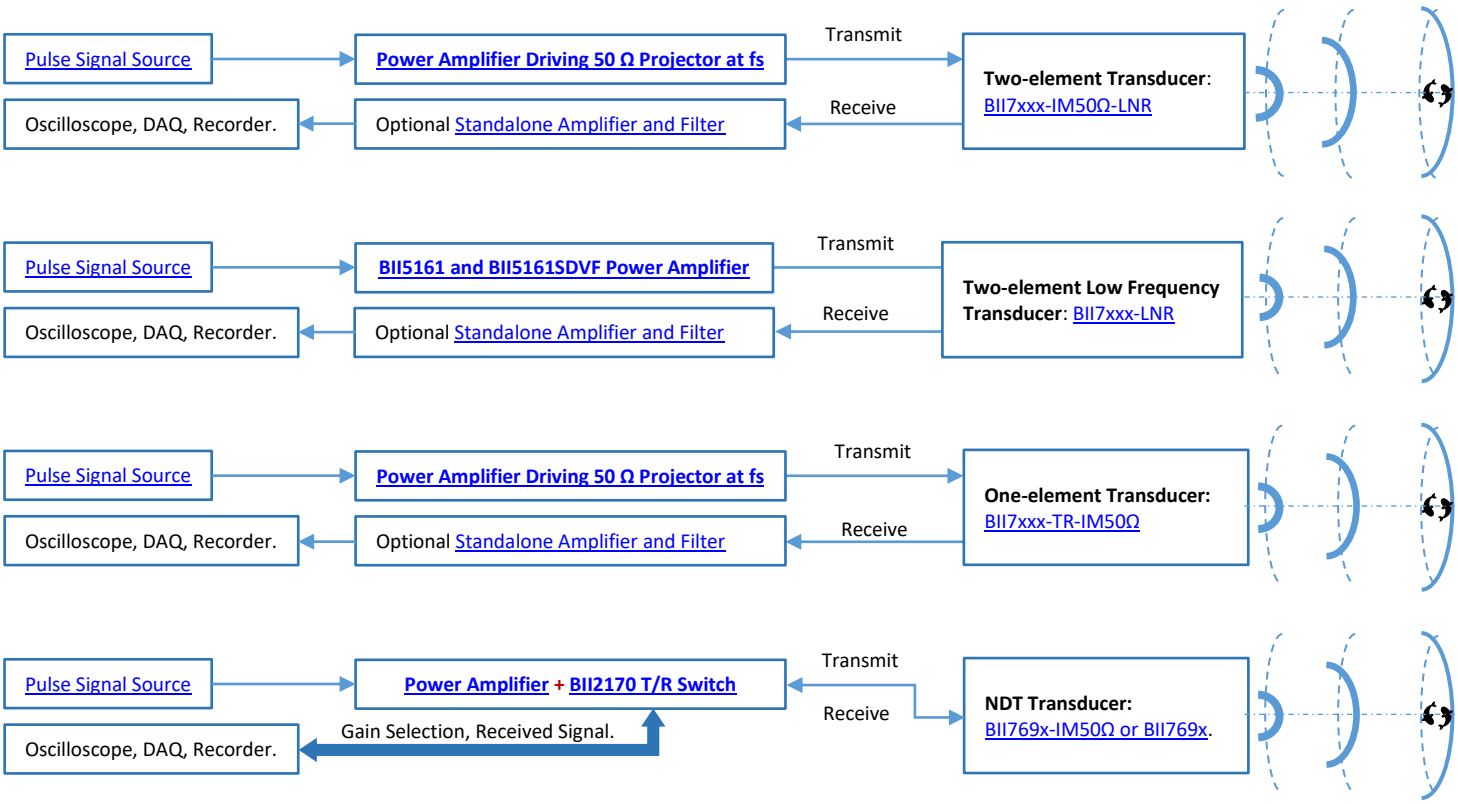
**Transmitting and Receiving Sounds (Pulsing Acoustics): Echo-sounding, NDT, Communication, ...**

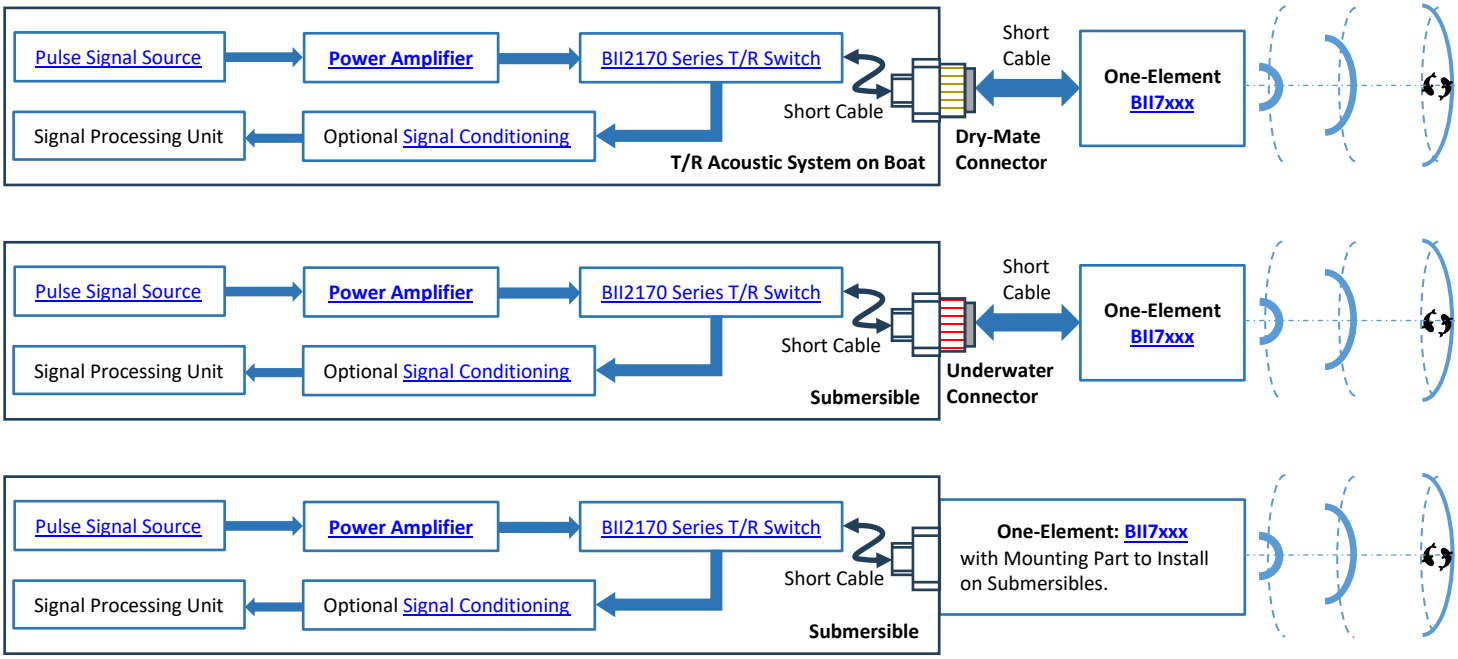
**IM50Ω**: Impedance Matching to 50Ω; **TR**: Transmit and Receive Switching with built-in low noise preamp and bandpass filter; **LNR**: Built-in separated Low Noise Receiver.

**Transmitting and Receiving Underwater and Ultrasonic Sounds:**




**Alternatives of Transmitting and Receiving Underwater or Ultrasonic Sounds for Short Cables between Transducers and Power Amplifiers.**

Short Cable here means its capacitance has little effect on the transducer sensitivity, and its adverse effects on the transducer can be neglected.





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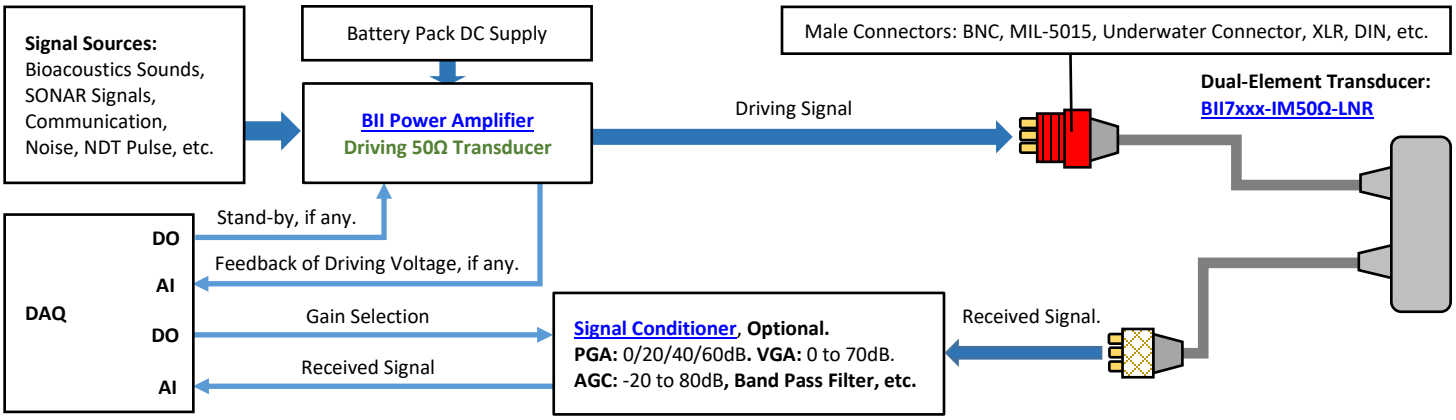
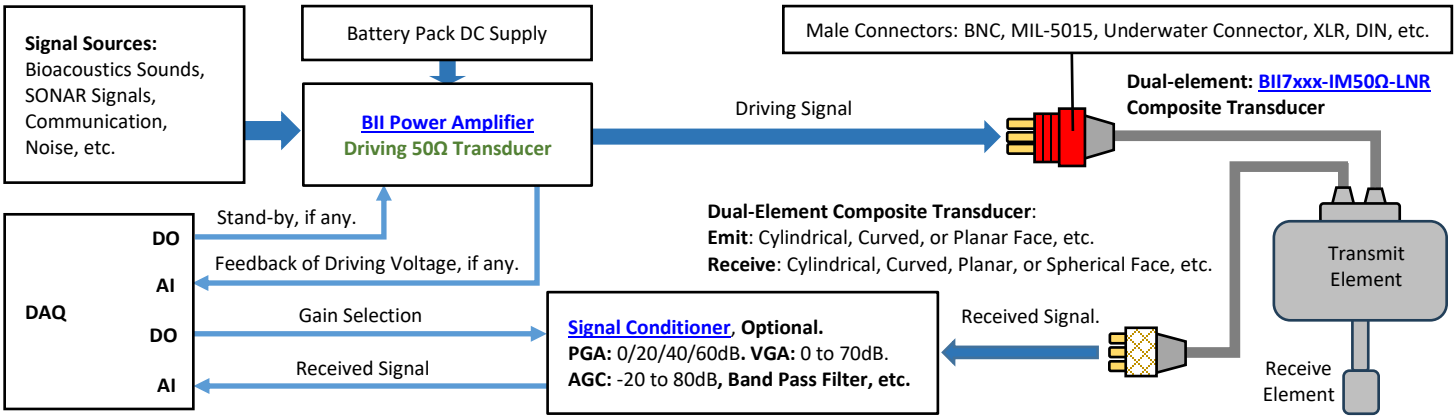
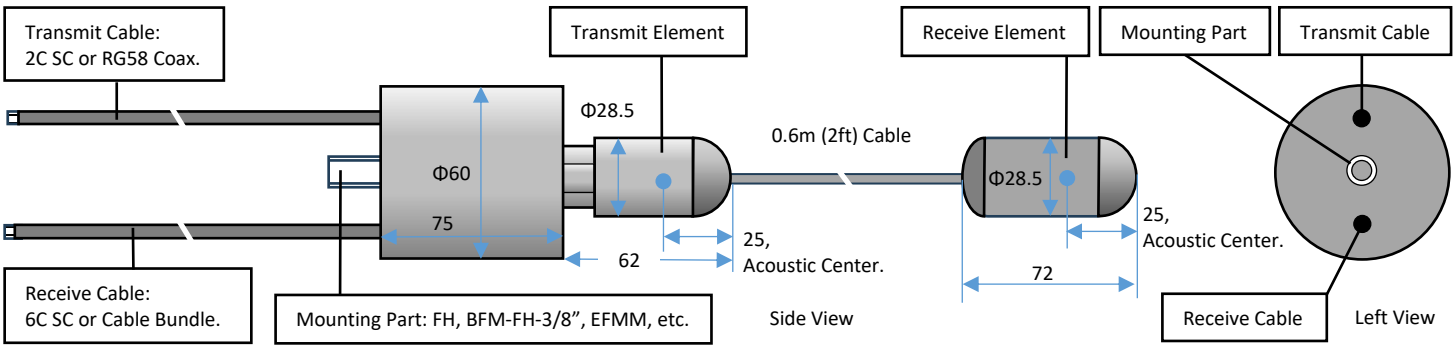
**System Block Diagram of Transmitting and Receiving Sounds of Dual-Element Transducers: A Simple Configuration. DO:** Digital Outputs**, AI:** Analog Inputs**.**



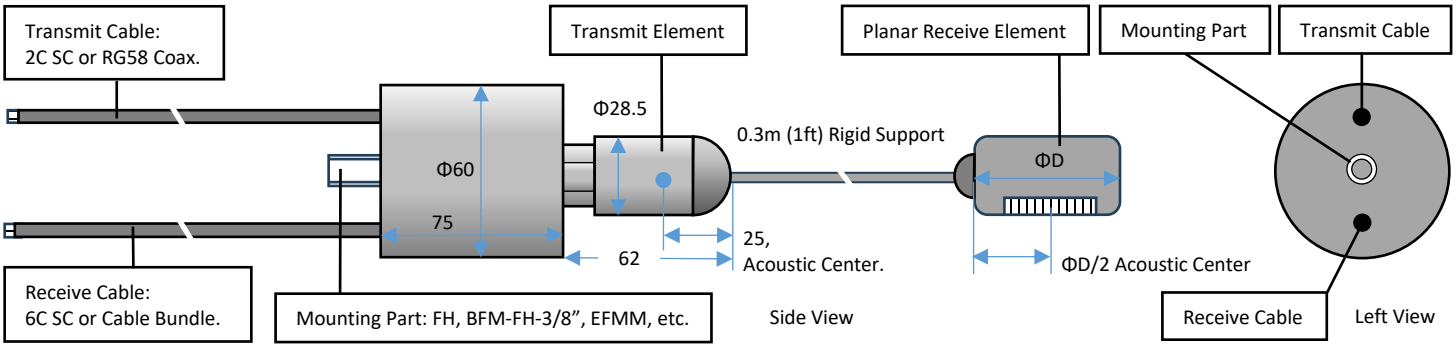




**Some Configurations of Dual-Element Transducers BII75xx-IM50Ω-LNR (**Sizes are for illustration ONLY and vary with different transducers.**)**

1. **Omnidirectional Transceiver**: Transmit Omnidirectional Sounds in Horizontal Plane, Receive Omnidirectional Sounds in Horizontal and Vertical Planes.




2. **Omnidirectional Projector and Directional Receiver**: Transmit Omnidirectional Sounds in Horizontal Plane, Receive Sounds in Vertical or Horizontal Plane.

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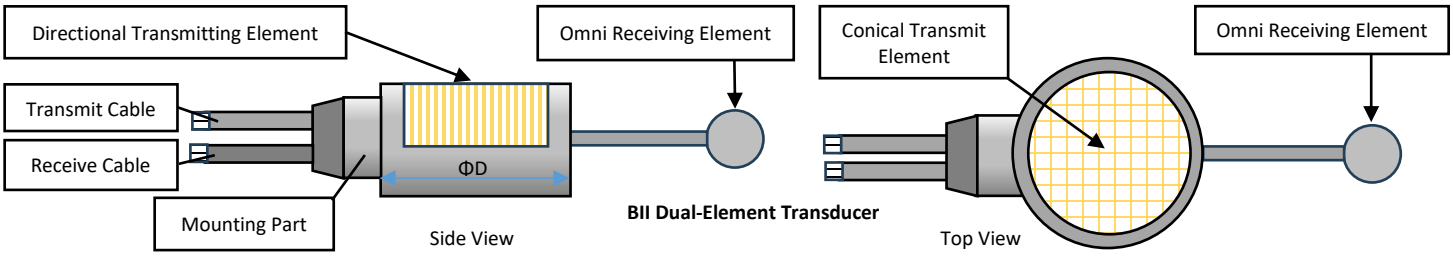
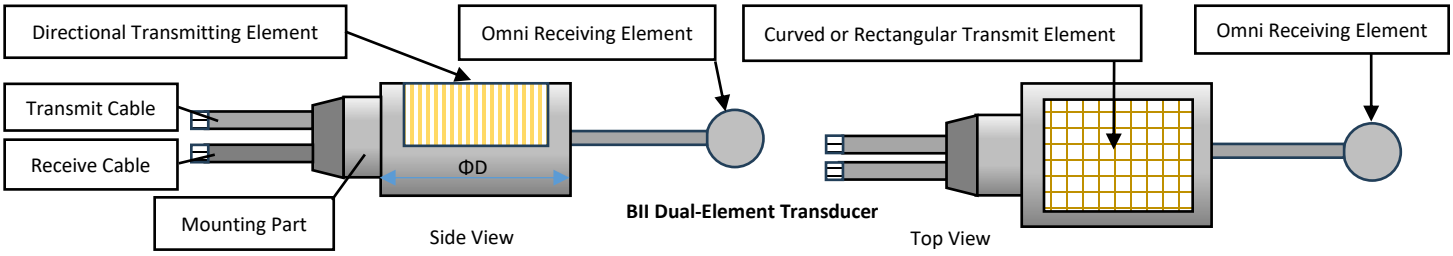
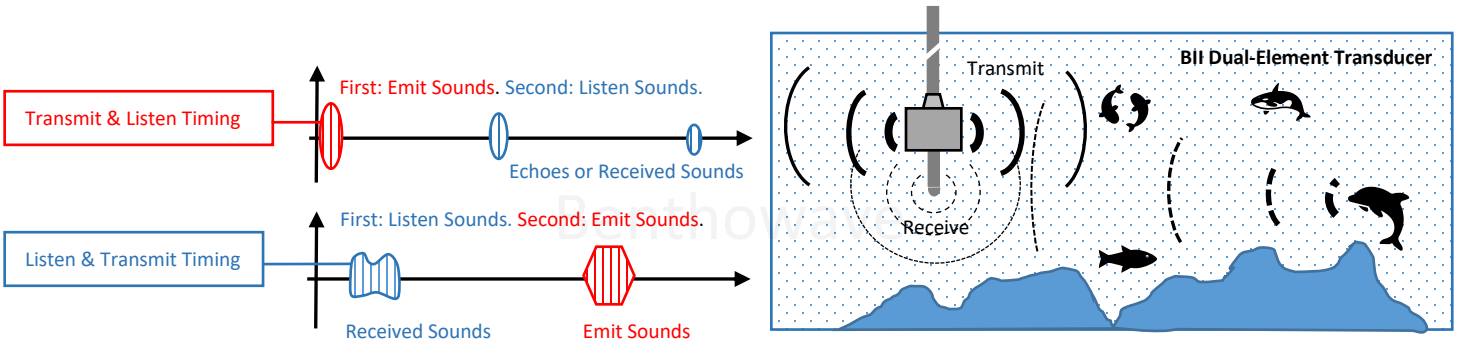
3. **Directional Projector and Omni Receiver**: Transmit Directional Sounds in Horizontal Plane, Receive Omnidirectional Sounds in Vertical and Horizontal Plane.



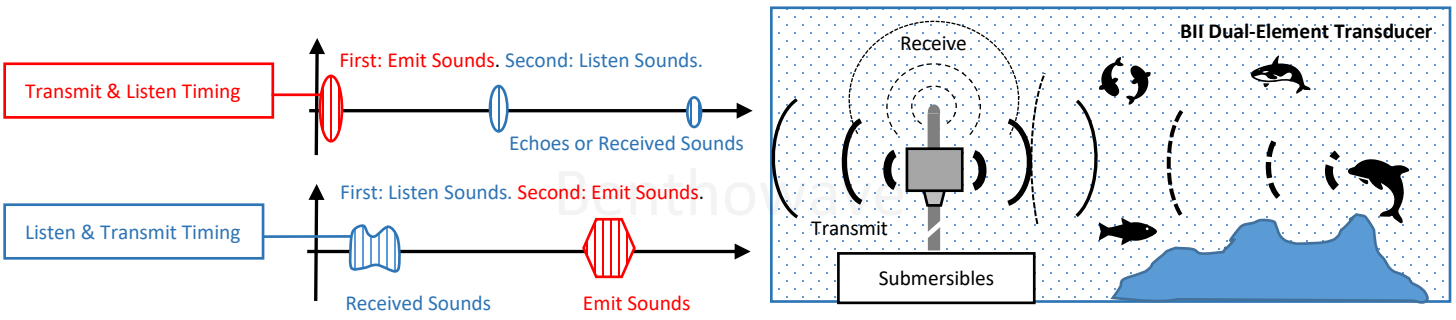




**Some Applications of Dual-Element Transducers on Underwater Communications**

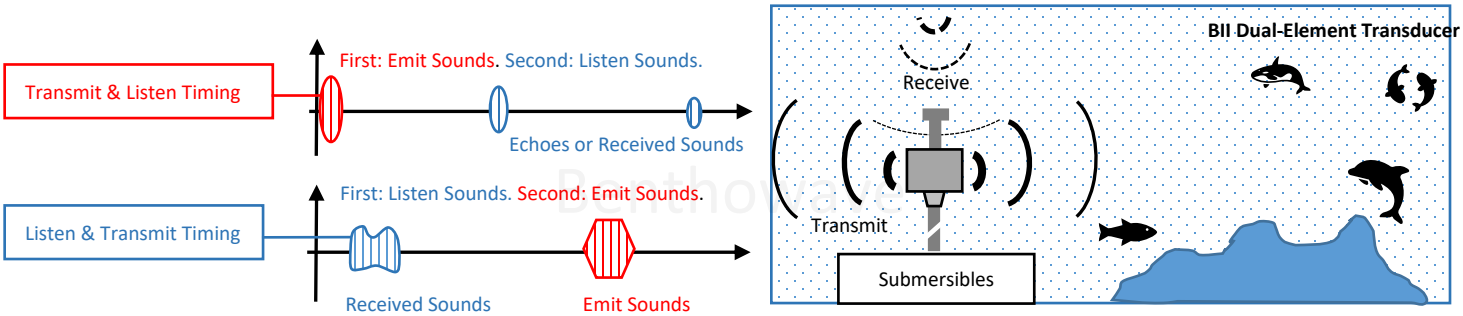
**1. Communication System: Transmitting Omnidirectional Sounds Horizontally and Receiving Omnidirectional Sounds in Horizontal and/or Vertical Planes.**




**2. Communication System: Transmitting Omnidirectional Sounds Horizontally and Receiving Omnidirectional Sounds in Horizontal and/or Vertical Planes.**




**3. Communication System: Transmitting Omnidirectional Sounds Horizontally and Receiving Directional Sounds in Vertical Plane.**

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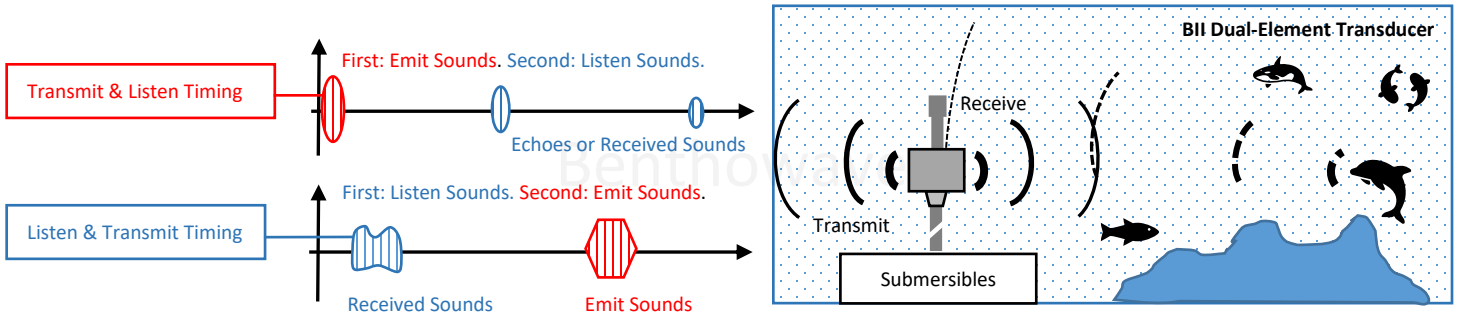
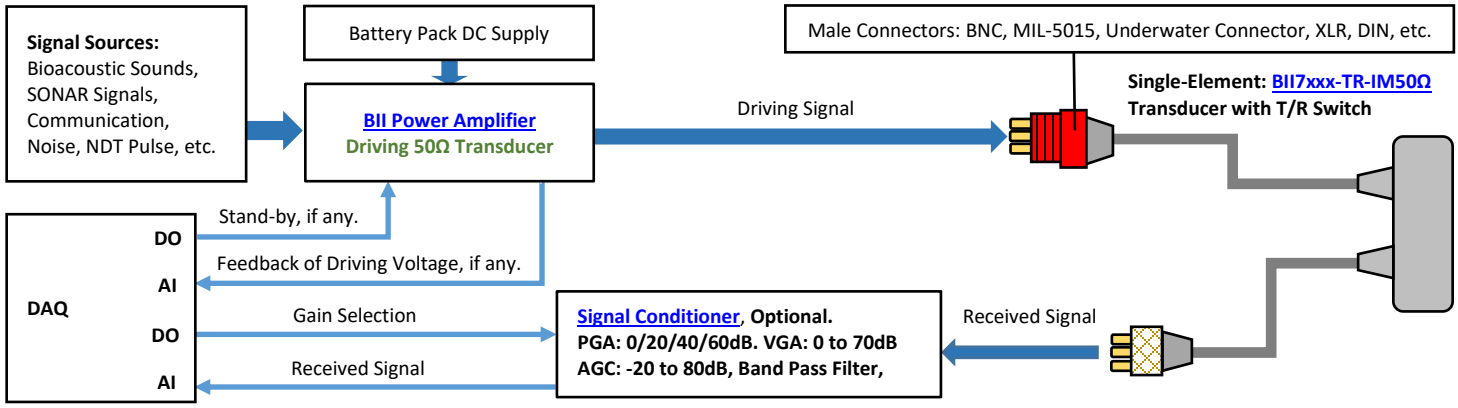
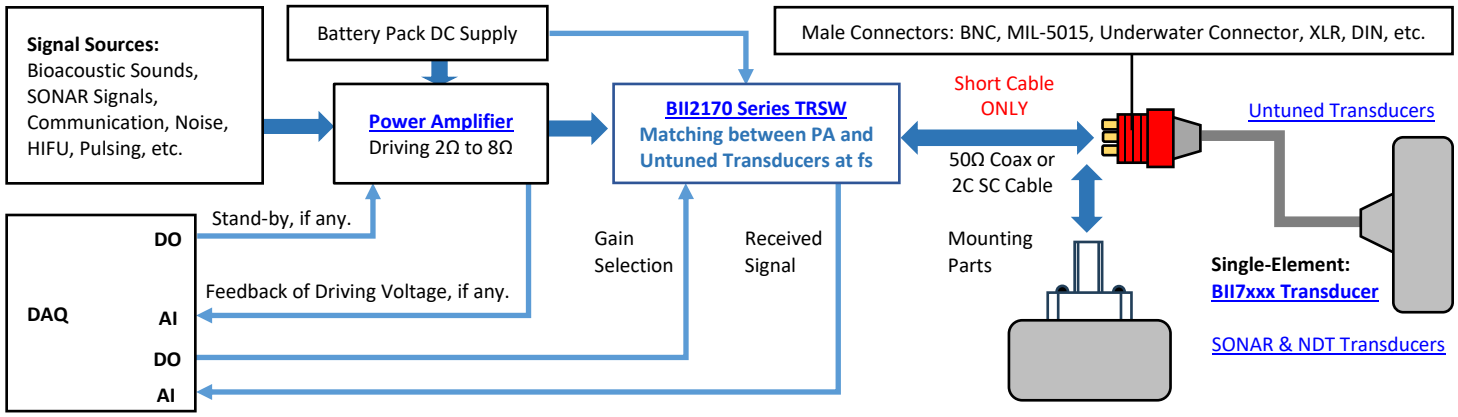
**4. Communication System: Transmitting Omnidirectional Sounds Horizontally and Receiving Directional Sounds in Horizontal Plane.**




**System Block Diagram of Transmitting and Receiving Sounds for Single-Element Transducers: A Simple Configuration. DO:** Digital Outputs**, AI:** Analog Inputs**.**




**Alternatives of System Block Diagram of Transmitting and Receiving Sounds of Single-Element Transducers: A Simple Configuration for SONAR and NDT Transducers**




**Single-Element NDT Transducers BII7690 Series.**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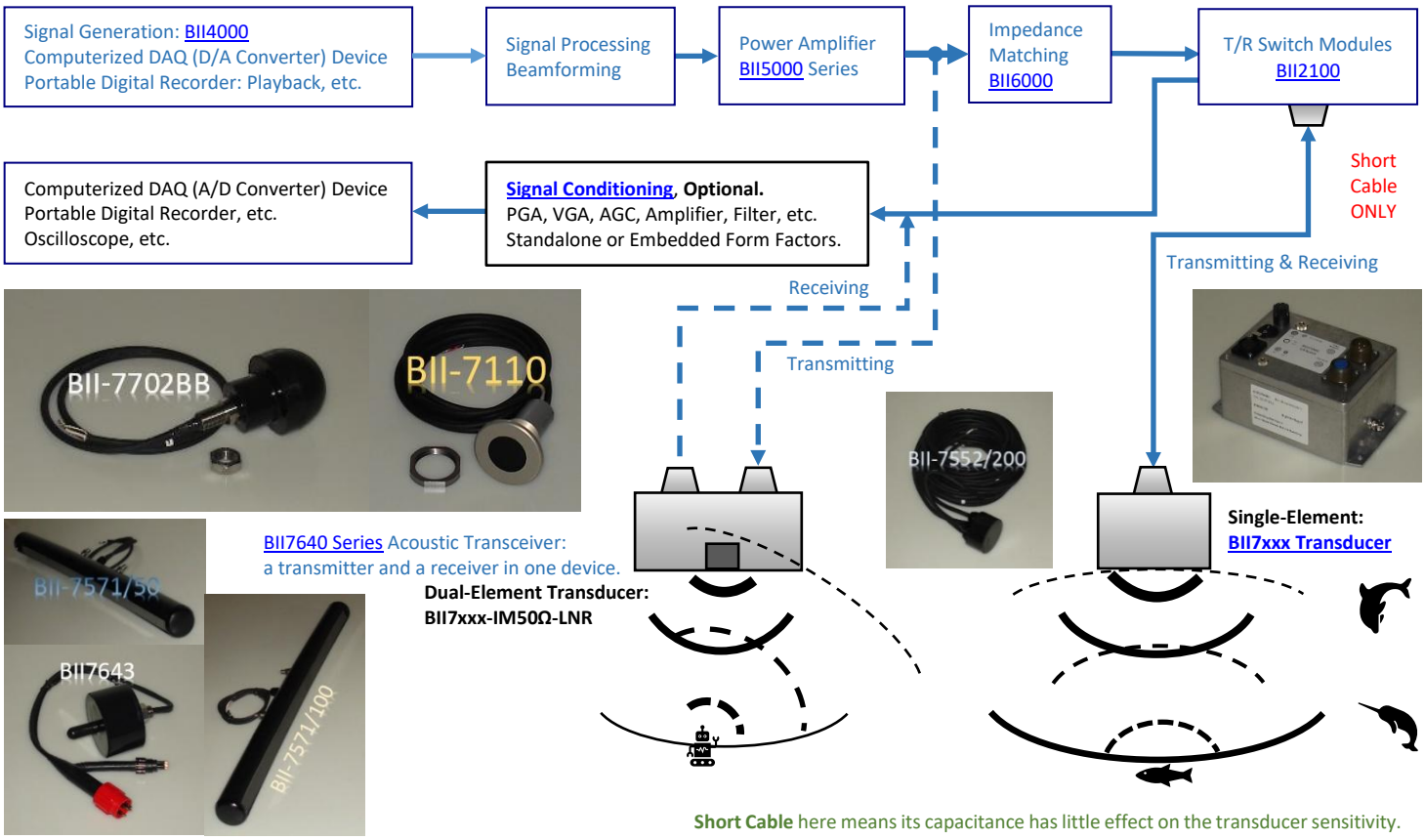
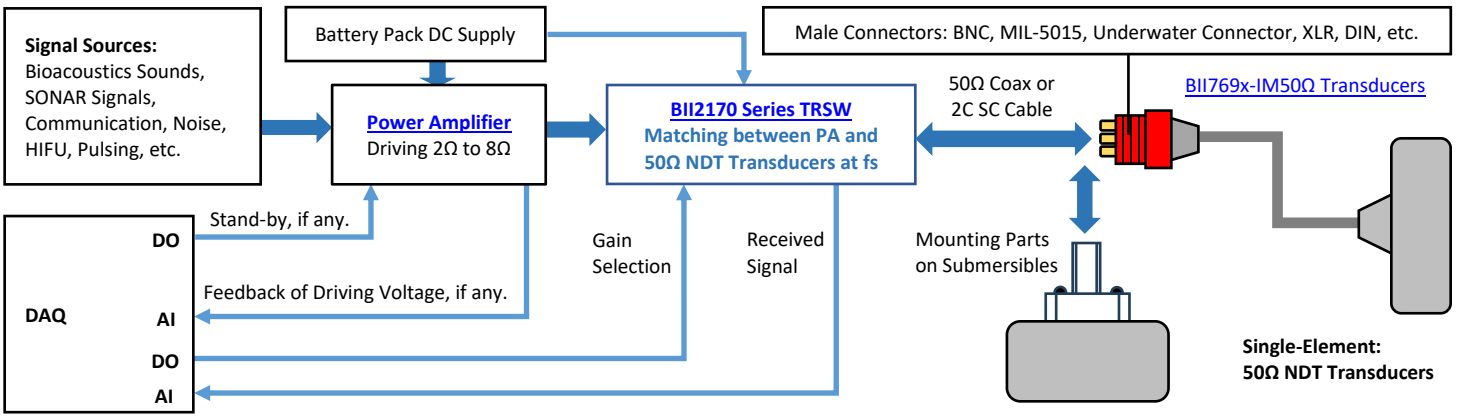
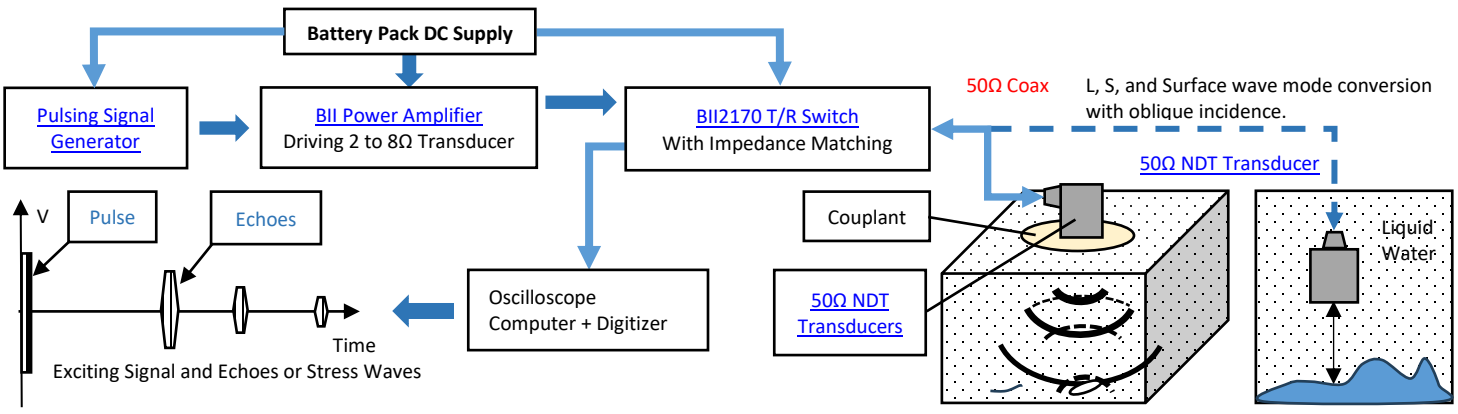
**System Block Diagram with Individual Components (Single-Element Untuned Transducers BII7xxx and Dual-Element Transducer: BII7xxx-IM50Ω-LNR).**




**Short Cable** here means its capacitance has little effect on the transducer sensitivity.

**System Block Diagram with 50Ω NDT Transducers (BII769x-IM50Ω).**

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## Receiving Sounds and Waves

BII manufactures wide range of hydrophones (Underwater Microphones) and AE/NDT sensors for underwater and ultrasonic applications from 0.1 Hz to 10 MHz, and they are completely waterproof, corrosion-resistant and withstand high levels of salinity. Two packages are available: Hydrophones (Sensors) without Signal Conditioner and Hydrophones (Sensors) with built-in Signal Conditioner.


**Low Noise:** Lower than sea-state 0
**Miniature:** Acoustic Aperture size Φ0.8mm
**Sidelobe Suppression**: ≤-30dB, Bespoke
**Phased Array**: Beamforming/Steering/Focusing
**Ocean Depth**: up to 1000m

**Low Power:** 40 to 350μA quiescent current for battery powered instruments
**Broadband:** Detect signal up to 3MHz
**Directivity:** Omnidirectional and Directional, Custom-fit
**High Temperature**: up to 120°C or 248°F and 198°C/392°F
**Projector**: Hydrophones without preamp can be used as low power sound sources

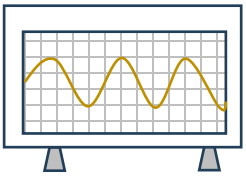
Computerized DAQ (A/D Converter) Device
Portable Digital Recorder, etc.
Oscilloscope, etc.

Signal Conditioning, Optional.
PGA, VGA, AGC, Filtering, etc.

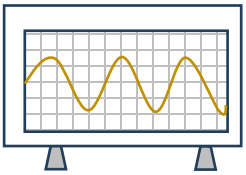
Hydrophones, Transducers, Arrays.

**Low Noise Hydrophone:** Detect unknown sounds and narrowband known sounds.
1. 0.01 Hz to 300 kHz.
2. Self-Noise level below Sea State Zero.
3. Programmable Sensitivity FFVS.
4. Custom-fit to specific known sound sources such as pingers, locators, acoustic tags, etc.

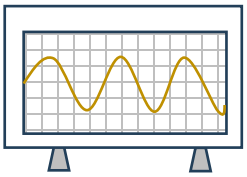

**Typical Components of an Acoustic Receiving System.** Depending on the requirements of the system, the signal conditioner is optional.



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



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



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


Thru-Hole Mounting, End-face Mounting, Flush Mount, or Underwater Connector, ...

Autonomous underwater vehicle (AUV), Unmanned underwater vehicles (UUV), Diving bell, Submersible container, etc.

Signal Conditioning: Amplification, PGA, VGA, AGC, Filtering, ...

Computerized Instruments: Data Recording, Analysis, Control, Communication, etc.

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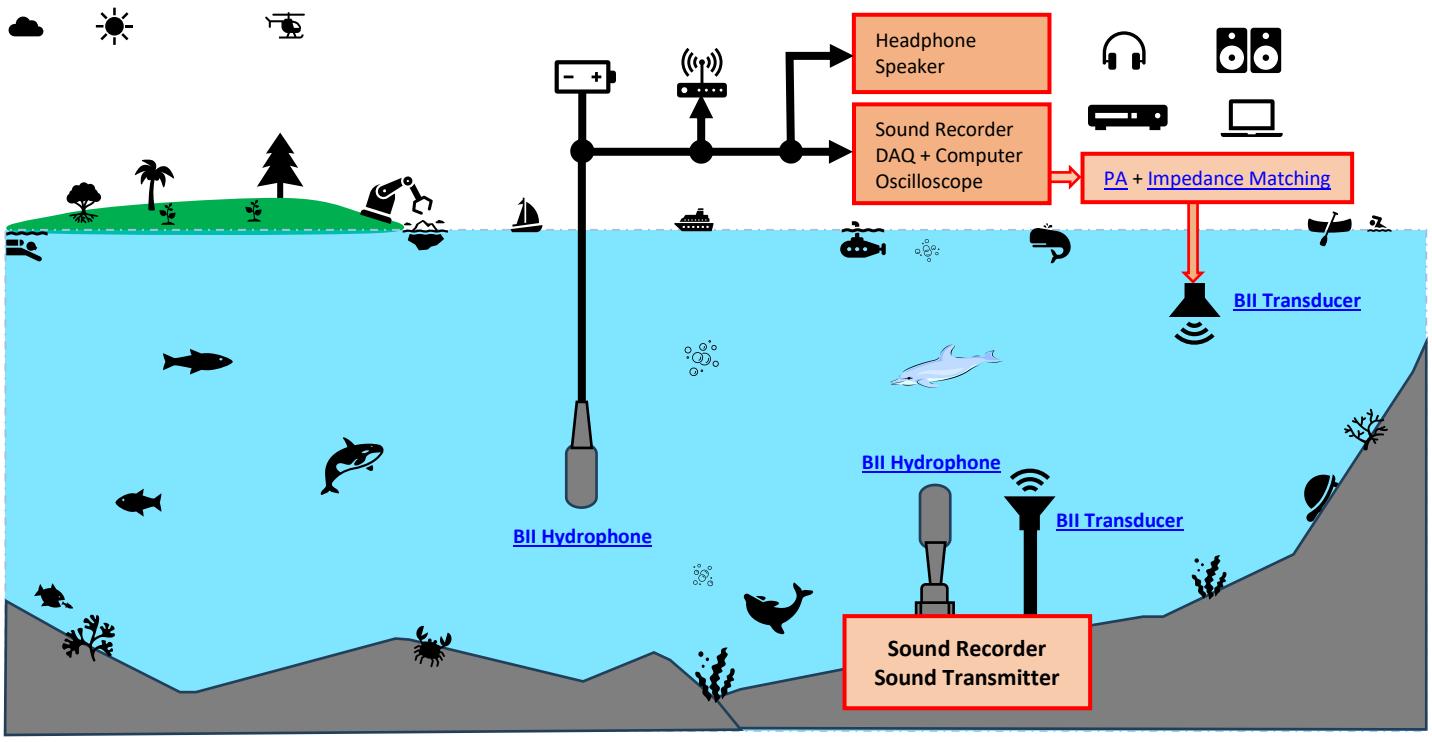
## Underwater Sound Listening, Recording, and Communication

**BII7120 Series Low Noise and Low Frequency Hydrophone: Noise Level Below Sea State Zero**

BII's low noise hydrophones are optimized to possess self noise levels below sea-state zero with omnidirectional response in low frequency range and toroidal response in high frequency range. Its streamlined hemispherical dome minimizes drag force and hydrodynamic noise. The power consumption can be customized to be 600μA quiescent current at 5VDC for battery powered underwater instrumentation. A spatial array of multiple hydrophones can be set up for directional measurement system. The hydrophones can measure underwater sounds and pressure fluctuations down to 0.1Hz: Surface Waves (Wave-height Sensor), Turbulences, seismic, ocean traffics, industrial noises, precipitations, biologics, ... With these low power hydrophones, battery and system lifetimes are extended, and lighter portable systems with lower-capacity batteries can be achieved. Its compact small size avoids interferences to acoustic field under test. The preamplifier integrated in the hydrophone can drive cable up to 200m without signal loss. Available cable terminals include audio connectors (TRS, XLR), BNC, and underwater mateable connectors. The housing and mounting part are corrosion resistant plastics and/or stainless steels.




**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... |

**Typical Configuration for Long Term Deployments of Underwater Sound Recorder.**

BII7000 Spherical Series, BII7010 Cylindrical Series, BII7040 Hemispherical Series, BII7070 Planar Series, BII7120 Cylindrical Low Noise Series + Low Power Preamp BII1067 (1.1mA, +2.7 to +24VDC, 20 to 40dB Gain, 1Hz to 350kHz Bandwidth.) or BII1011.

⟷ Cable + Underwater Mateable Connector (Pins)
Recorder Supplies DC Power to Hydrophones

Underwater Sound Recorder.

### 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, **twisted pair cable and balanced signal or differential signal** is recommended to reduce EMI noise.

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).

What if the mating connector of my DAQ module or recording device is NOT available from BII?

1. Buyer may order BII products with wire leads, and buyer assembles the mating connector to the cable end.
2. A connector adaptor might be assembled by BII by customization, and BII ships the adaptor to buyer as accessory of the device. Please contact BII for customizations.
3. 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.

How do I use Gain Selection wires 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.

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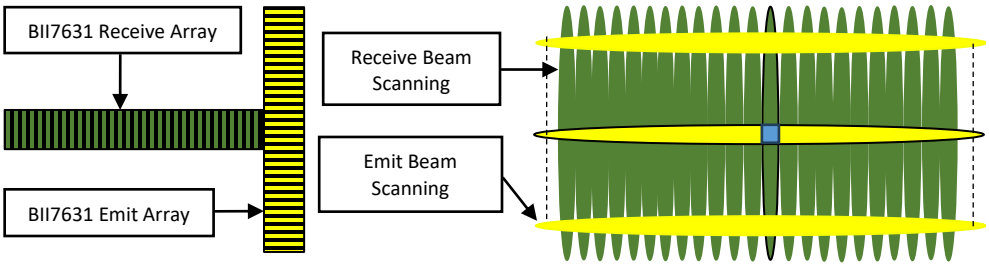
## Underwater Sounds Scanning: Positioning, Tracking, Navigation and Imaging

**Typical Applications:** 2D Imaging Sonar, Object/Target Positioning and Tracking, Obstacle Avoidance, Fishery Sonar, Navigation, Underwater Robotic and Vehicle.

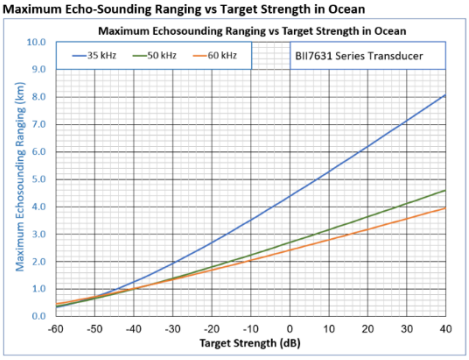
**BII7630 Series Phased Array Transducer, Underwater Scanning: Positioning, Tracking, Navigation and Imaging**

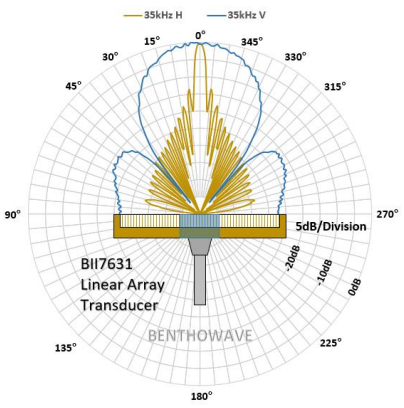
**Beamforming and Total Focusing Method (TFM)**: Phased array transducers are rectangular (linear) array with custom-fit along-length beamwidth and cross-length beamwidth for uses in oceanography such as location, tracking and search of underwater sound sources in hundreds or thousands meter range, and in acoustical imaging and diagnosis in millimeter range such as biomedical study, NDT & AE, and material study. With dynamic focusing (Total Focusing Method TFM), both resolution and sensitivity are improved in detecting flaws or defects and acoustic imaging. Along-length beam can be steered and focused in ±75° range with array beamforming technology. Multiple beams at different directions can also be formed simultaneously with digital beamforming technology. The side lobes along length can be suppressed with amplitude shading or weighting. Two or four array hydrophones can be used to set up "T" type cross array functioning as **Target Angle Estimation System** with Mills Cross technique. High resolution image can be formed with the technology of **Synthetic Aperture Sequential Imaging**. A phased line array transducer (projector) and a phased array hydrophone can work as a multibeam SONAR with Mills Cross technique. Multiple transducers can be wired in parallel electrically to set up a longer line array for reducing along-length beam width in low frequency range.

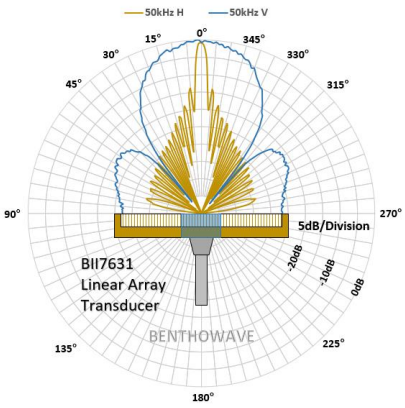
**2D "T" Type Imaging Multibeam Transducer: Two BII7631 Linear Phased Array (Rectangular Aperture).**

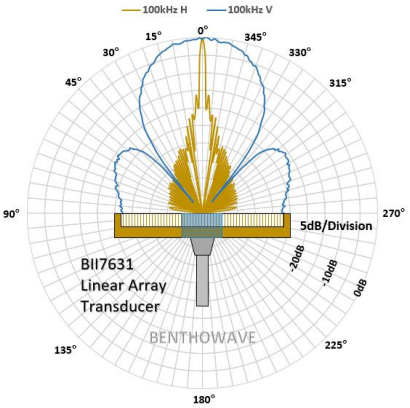



Maximum Echo-Sounding Ranging vs Target Strength in Ocean



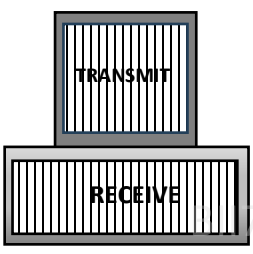

Echo intensity of blue intersection area of a emit beam (yellow colour) and a receive beam (green colour) provides the average depth and backscattering information of the intersection area. Hundreds of tightly spaced echoes can be implemented from a single acoustic ping.

BII7660 Series **Multibeam Transducer: 2D Imaging Sonar, Positioning, Tracking, and Navigation.**

BII7660 series high frequency high resolution multibeam transducers are designed for uses in 2D image Sonar, underwater floor/bottom mapping, sector scanning, navigation, object detection, target tracking, obstacle avoidance in tens or hundreds meter range. Emitting aperture (one element) and receiving aperture (32 or 64 elements) operate independently. The curved emitting element emits a broad fan-shape beam to insonify a large sector of interest (field of view), the linear receiving array has fan-shape beam perpendicular to the emit-beam and can be steered electrically to scan the area of interest. Both emit and receive array are broadband to support broadband SONAR signals (such as SINE Pulses, FM/Chirp Pulses, Ricker Pulses, etc.). Acoustic sweeping (2D scanning) of the horizon or vertical can be achieved with digital beamforming technology.

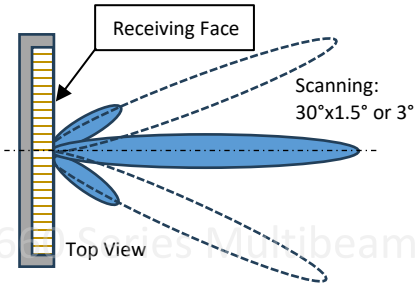
**Transducer**

Front View



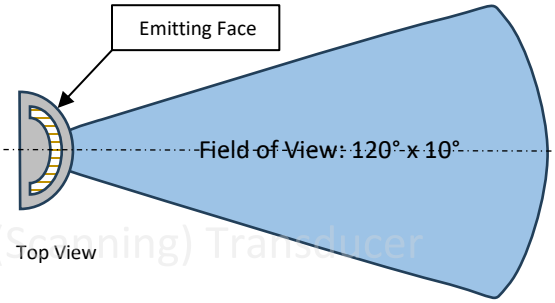

**Receiving (Linear Aperture to Scan)**

**Steering Fan-Shaped Beam**
Rectangular Aperture, 32 or 64 Elements.

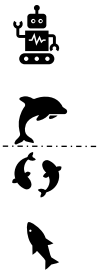



**Transmit: Curved Array (Wide Beam, Insonifying Wide Area of the interest)**

**Curved Aperture**
1 Element




**Subjects**



BII7660 Series Multibeam (Scanning) Transducer

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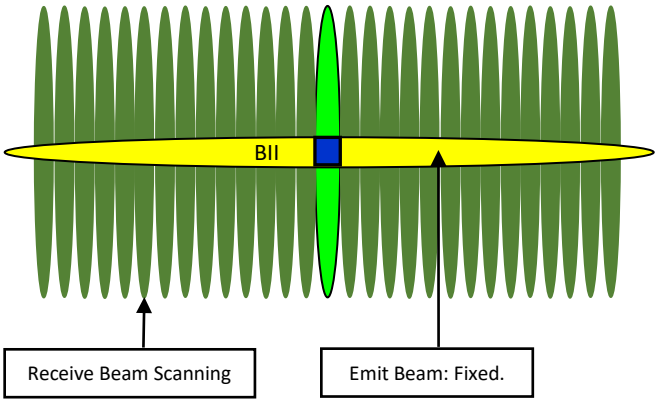
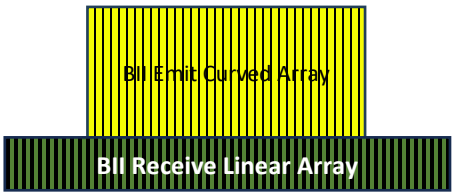


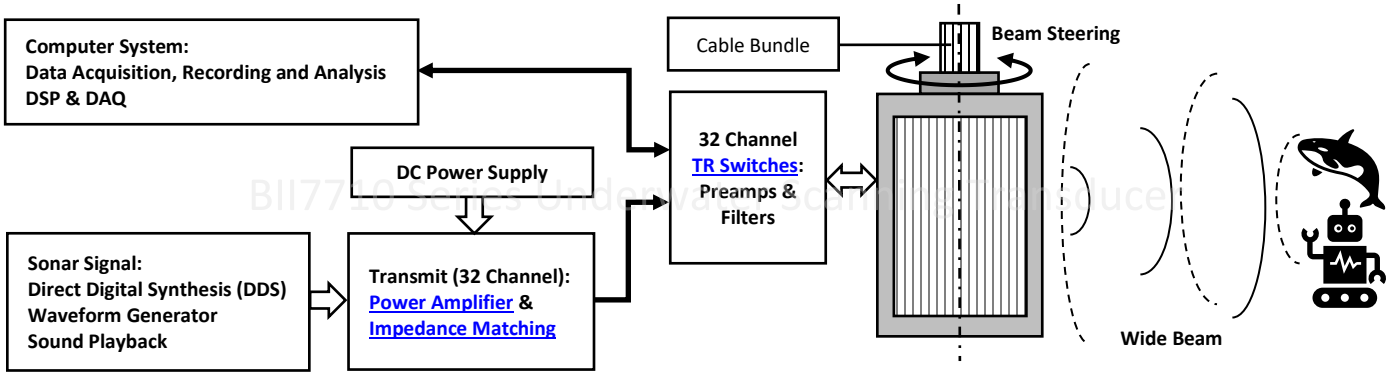



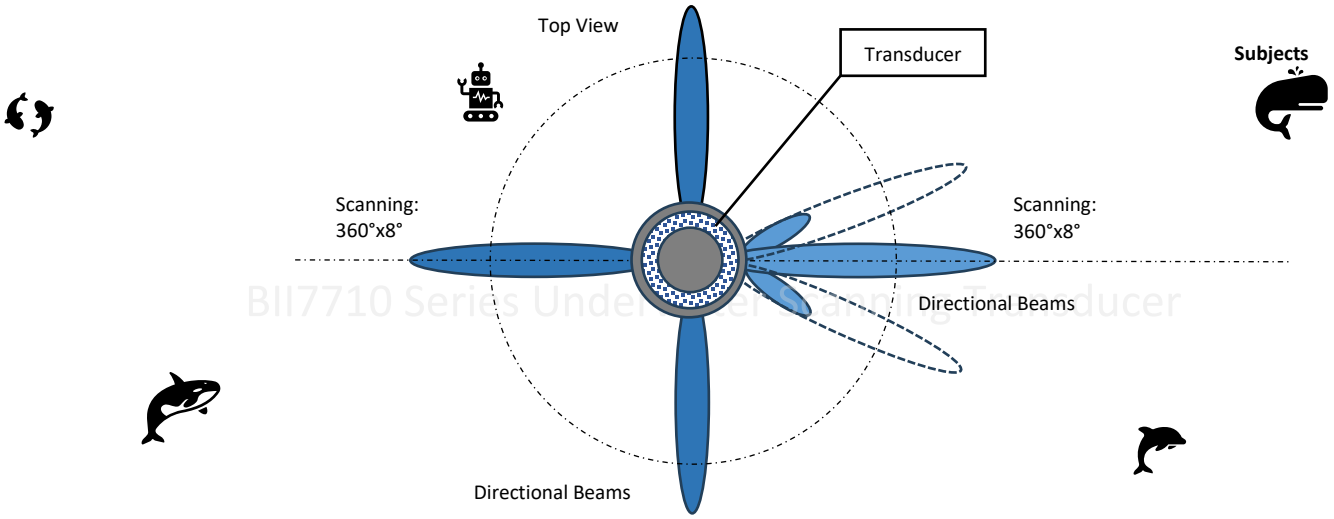


BII MultiBeam Transducer = Curved Array + Linear Array
Echo intensity of the blue intersection area of a emit beam (yellow colour) and a receive beam (green colour) provides the average depth and backscattering information of the intersection area. Hundreds of tightly spaced echoes can be implemented from a single acoustic ping.

**BII7716 Series Scanning SONAR Transducer: 360° View Field in Horizontal Plane, 360° Search: Tracking, Locating and Navigation.**
**Scanning SONAR Transducer for 360° Search**
Underwater Scanning Transducers are underwater 32-element cylindrical array transducers (Transmitting Sounds and Listening sounds), and directional beams are implemented with subarrays for scanning. Typical applications are acoustic positioning, tracking, echo locating, and navigation in horizontal plane in the ocean, rivers, and lakes. The Scanning SONAR Transducers provide efficient solution to detect and locate fish schools and targets in the horizontal plane about hundreds and thousands of meters with 360° searching. The transducers have superior performances for use in shallow water and near surface fishing. The subarray that operator determines sends out a pulse of narrow beam sound in specific directions and receive the echo reflected from targets; or, in passive listening mode, it searches the sounds emitted from sound sources with highly directional beam.

**Tracking, Locating and Navigation:**




**BII7770 Series Underwater Mechanical Scanning Transducer: Tracking, Locating, Navigation, Communication, and Artificial Acoustic Target.**
The Underwater Scanning Transducer integrates a wide beam projector and a narrow beam low noise directional hydrophone for mechanical scanning SONAR. Typical applications are long range acoustic positioning, tracking, echo locating, navigation, communication, and artificial acoustic target in horizontal or vertical plane in the ocean, rivers, and lakes.

**Sound Ranging of Full-duplex and Half-duplex Communication**: around 4.0 km depending on the transducer types, ambient noise, receiver's noise and sensitivity, etc.
Target strength of a 10"-length (0.25m) fish is about -35 dB. Echo Ranging of BII7771 and BII7772 to this fish is around 1.2 km.

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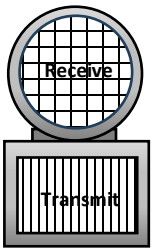
Target strength of a dolphin is about -20 dB.
Target strength of a whale is about 0 dB.
Target strength of seamounts is from +30 to +60 dB, say 30dB.

Echo Ranging of BII7771 and BII7772 to this dolphin is around 1.7 km.
Echo Ranging of BII7771 and BII7772 to this whale is around 2.6 km.
Echo Ranging of BII7771 and BII7772 to seamounts is around 3.6 to 4.1 km.

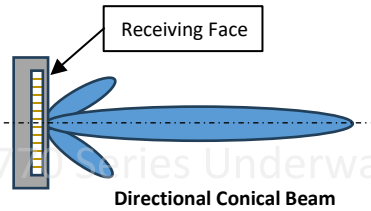
**Transducer**

Front View



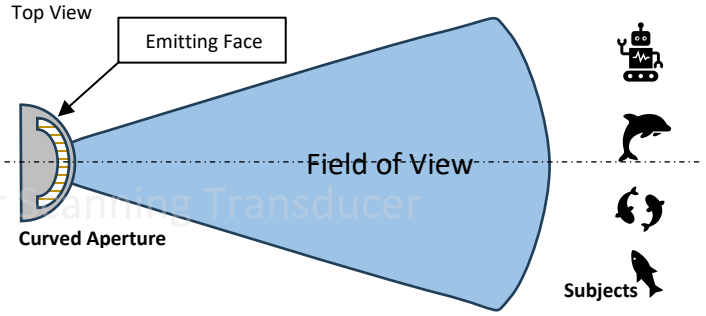

**Receiving (Circular Aperture)**

Top View

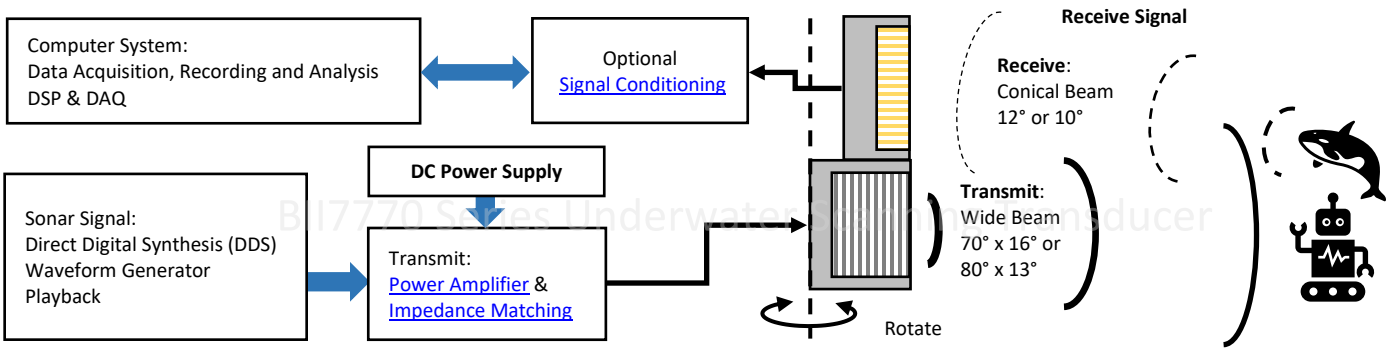



**Transmit: Curved Array (Wide Beam, Insonifying Wide Area of the interest)**

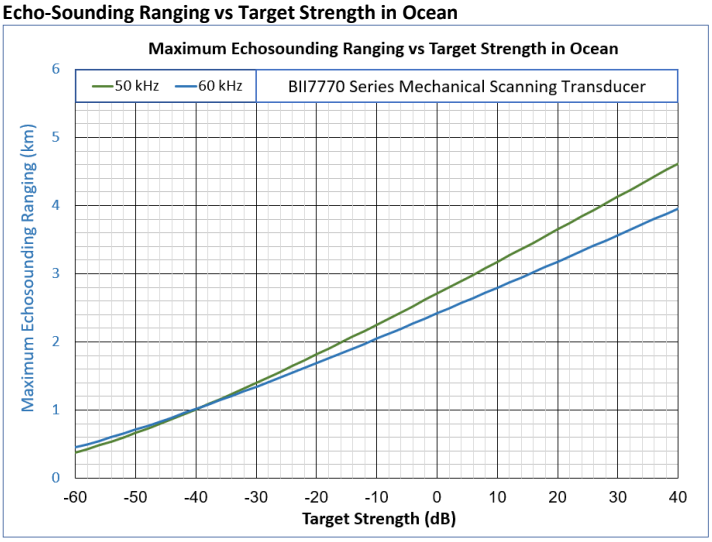
Top View



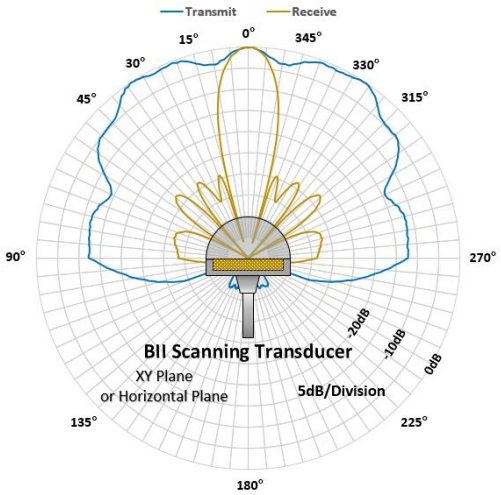


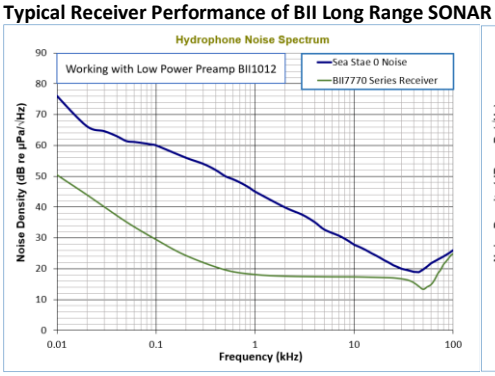

**Echo-Sounding Ranging vs Target Strength in Ocean**

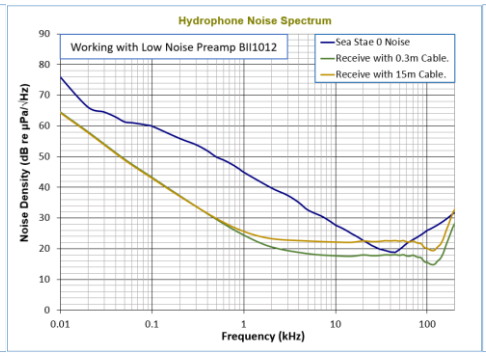


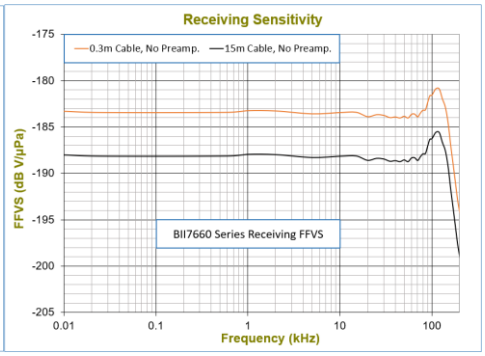

**Directional Response in Horizontal Plane: BII7772 60kHz.**




**Typical Receiver Performance of BII Long Range SONAR Transducers.**

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## Line (Linear) Array Hydrophone and Transducer

**BII7020 Series Line Array Hydrophones: Toroidal Directivity Response.**

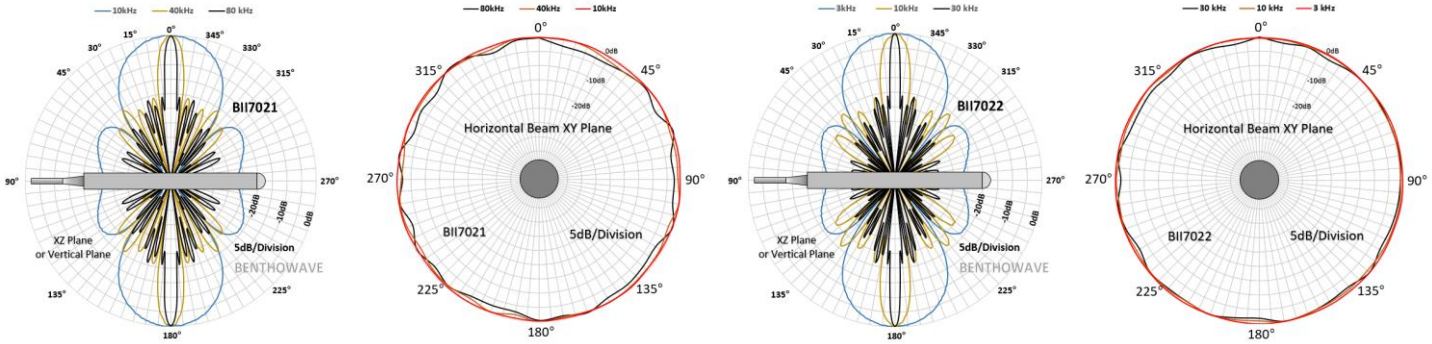
A BII's line (linear) array hydrophone averages sound pressures along its length as a spatial filter and utilize built-in amplitude shading/weighting to reduce side-lobes. Its toroidal directivity response makes it a great gear to detect and search underwater sound sources omnidirectionally with its main lobe and reject the noises in other directions. Smooth domes and housing reduce interferences to acoustic field under test.

**Split-aperture correlators** based online arrays implement target angle estimation. The narrow beamwidth along the length provides direction information of the sound sources and reject the unwanted noises coming from other directions, the omnidirectional response cross the length covers large area to search. Two- or four-line arrays can be used to set up "T" or "+" type cross array functioning as a Target Angle Estimation System with Mills Cross techniques which provides accurate bearing information of sound sources.

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

For applications of beam steering (Digital or FFT Beamforming), please deploy multiple BII7021 arrays, BII7010 hydrophones, or BII7140 hydrophones to configure discrete linear or planar arrays.

**Directivity Pattern**




**BII7570 Series Side-scan Transducer and Linear Transducer**

BII7570 Series Linear, Side Scan, Interferometric (Phase-measuring) and Parametric Transducers: Sea-floor Mapping and Sub-bottom Profiling.

**Linear Transducer:** Bespoke fan-shaped beam provides wide view area in across-track planes and high spatial resolution in along-track planes. Sidelobe ≤ -21 dB.

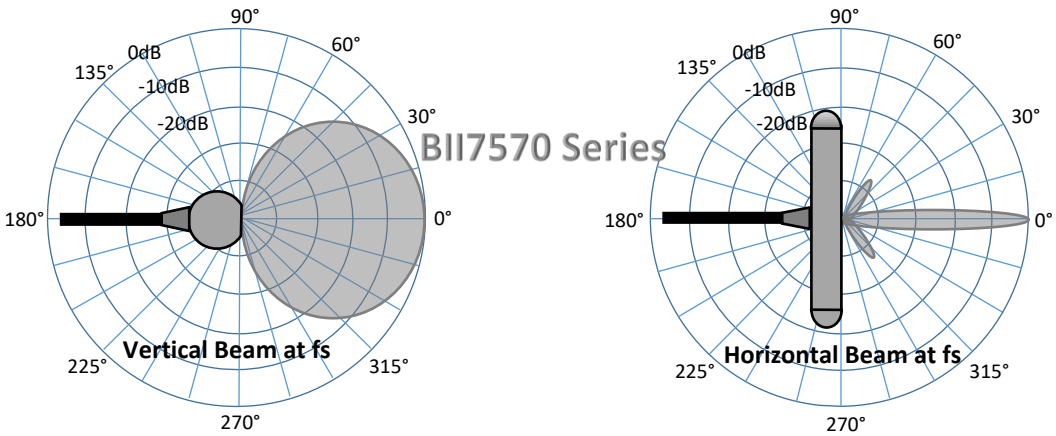
**Conventional Side Scan**: BII's side scan transducers with fan-shaped beam are designed for use in underwater imaging, sea/river/lake-floor mapping, target location, mine hunting, fisheries... The beam covers wide across-track swath and provides high along-track spatial resolution in tens or hundreds meter range. Acoustic image of underwater bottom is achieved at grazing angles of incidence. High resolution image can be formed with the technique of **Synthetic Aperture Imaging**. Multiple frequencies are available in one transducer.

**Interferometric (Phase-measuring) Side Scan:** The phase differences of received signals are detected by multiple linear receive arrays paralleling to the linear transmit array. After ambiguity is removed with proper techniques, the direction of arrival (DOA) and location of the scatterer can be accurately determined.

**Parametric Side Scan:** When two underwater sound waves of different primary frequencies $f_{p1}$ and $f_{p2}$ ($f_{p1}>f_{p2}$) propagate in the same direction, they interact with each other to create low frequency sound wave of secondary frequency $f_{sec.}$ ($f_{sec.} = f_{p1}-f_{p2}$). The directivity of secondary frequency is close to the ones of primary frequencies. This difference frequency sound is useful for practical applications in sediment profiling, depth sounding and communication. Parametric array gain or efficiency (generally ≤ 1%) is better as primary sound powers are higher, secondary frequency $f_{sec.}$ is higher, down shift ratio $(f_{p1}+f_{p2})/(2f_{sec.})$ is lower, and $(\alpha p*R_r)$ is lower ($\alpha p$: mean primary sound attenuation coefficient; $R_r$: Rayleigh Distance). Attenuation/absorption coefficient of sediments is frequency dependent around 0.06f to 0.6f (dB/(m*kHz)).

**Typical Applications:** Sea/River/Lake-floor Mapping, Target Location Underwater, Fisheries, Direction of Arrival, Mine Hunting.

**Directivity Pattern**: illustration ONLY. Please refer to -3 dB beam width of a specific transducer.

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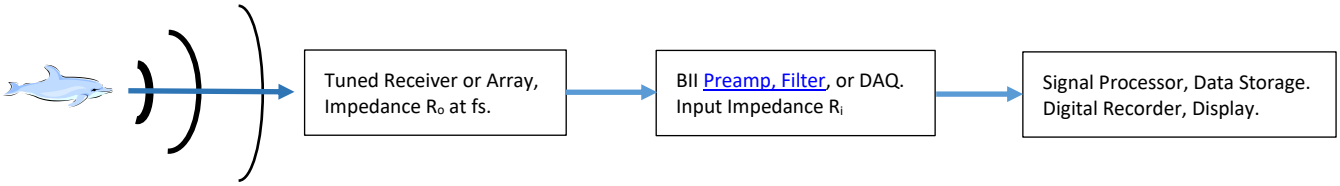
**Tuned Transducer: Optimum Receiver with Maximum SNR**

**Tuned Transducer as a Receiver**

Tuned transducers (hydrophones, AE sensor, NDT receivers, etc.…) are band pass sound receivers and projector operating around resonance fs, which feature broadband, possible maximum power transfer from the transducer to preamplifier, and offer flexible solutions to special transducer demanding in underwater acoustics and NDT (Non-destructive Test).

Impedance of a tuned transducer is resistive at fs.




**Three Major Operations of tuned receivers: Impedance matching $R_o = R_i$, Open Circuit $R_i >> R_o$, and $R_o < R_i << \infty$.**

**a. Impedance matching between the transducer and its signal conditioning circuit:**

**1. Sound energy being reflected from the transducer is minimized.**

**2. Maximum power transfer from transducer to preamplifier or signal conditioner.**

**Advantages**:

Broaden the bandwidth, reduce impulse rings, increase spatial resolution in tracking, positioning, and NDT applications.

Reduce mutual interaction among array elements in an array. Reduce interference to incident acoustic waves.

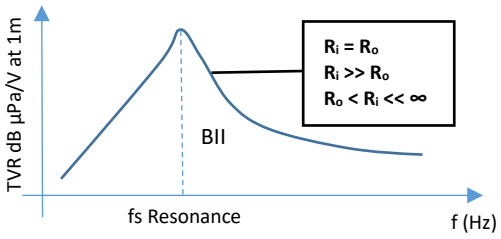
**Disadvantage**:

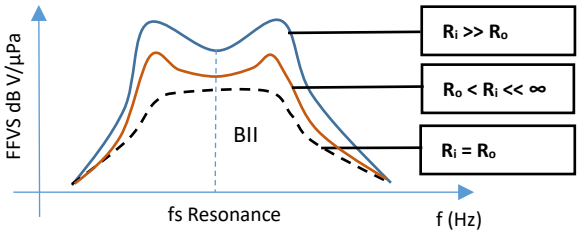
The sensitivity drops 6 dB around fs comparing to OCV (open circuit voltage).

**b. Input impedance of signal conditioner $R_i >>$ transducer impedance $R_o$:**

Output voltage of receiver is OCV (open circuit voltage).

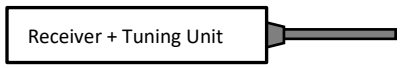
**Typical TVR and FFVS of Tuned Transducer:**



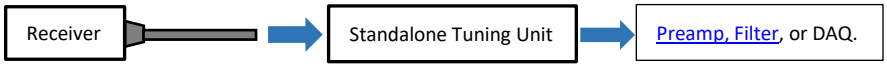




**Tuned Receiver Structure**:

1. Tuning Unit integrated inside receiver housing




2. Receiver + Standalone Tuning Unit




**How to order:**

**a. Customize BII Standard Transducers**:

1. First, check online datasheet or contact BII to get fs information of the transducer (hydrophones, AE sensors, NDT Transducers, etc…).
2. Append **TT** to part number of a transducer. for example:
   BII7011TT is tuned BII7011 hydrophone. BII7004TT is tuned BII7004 hydrophone. BII7074TT is tuned BII7074 hydrophone.

**Note: 1. The tuned transducer (or receiver) is NOT recommended to operate far from its fs resonance.**

**2. The size of tuned transducer might be bigger or longer than its original ones. Contact BII if the size is important to your applications such as array spacing.**

**b. Customize a New Transducer.**

1. Determine frequency of the interest or fs.
2. Determine directivity response of the receiver.
3. Is a preamplifier necessary? Yes, if the signal is weak. No, if the sound level is strong.
4. Determine or compromise bandwidth, reflection, and overshoot with operating condition: $R_o = R_i$, $R_i >> R_o$, or $R_o < R_i << \infty$.
5. Integration or standalone tuning unit?
6. Contact BII with your specs for new customized receivers.

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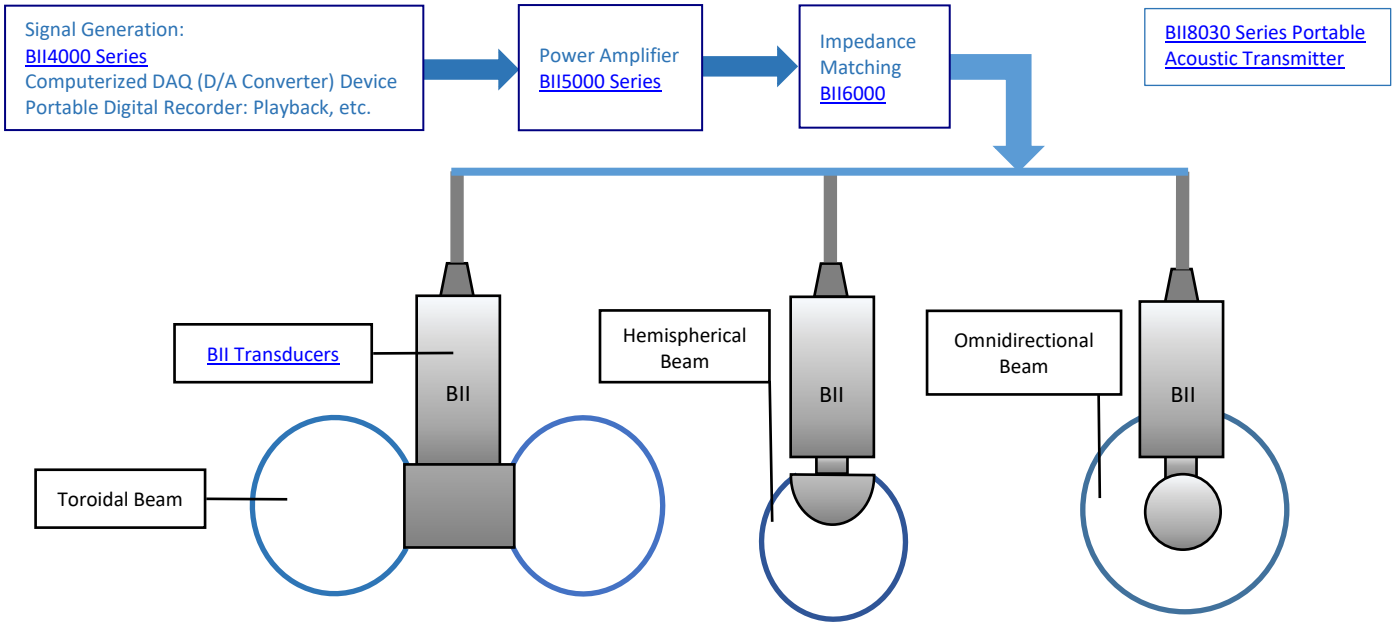
## Underwater Beacons: Pingers, Repeaters, and Transponders

**DESCRIPTION**

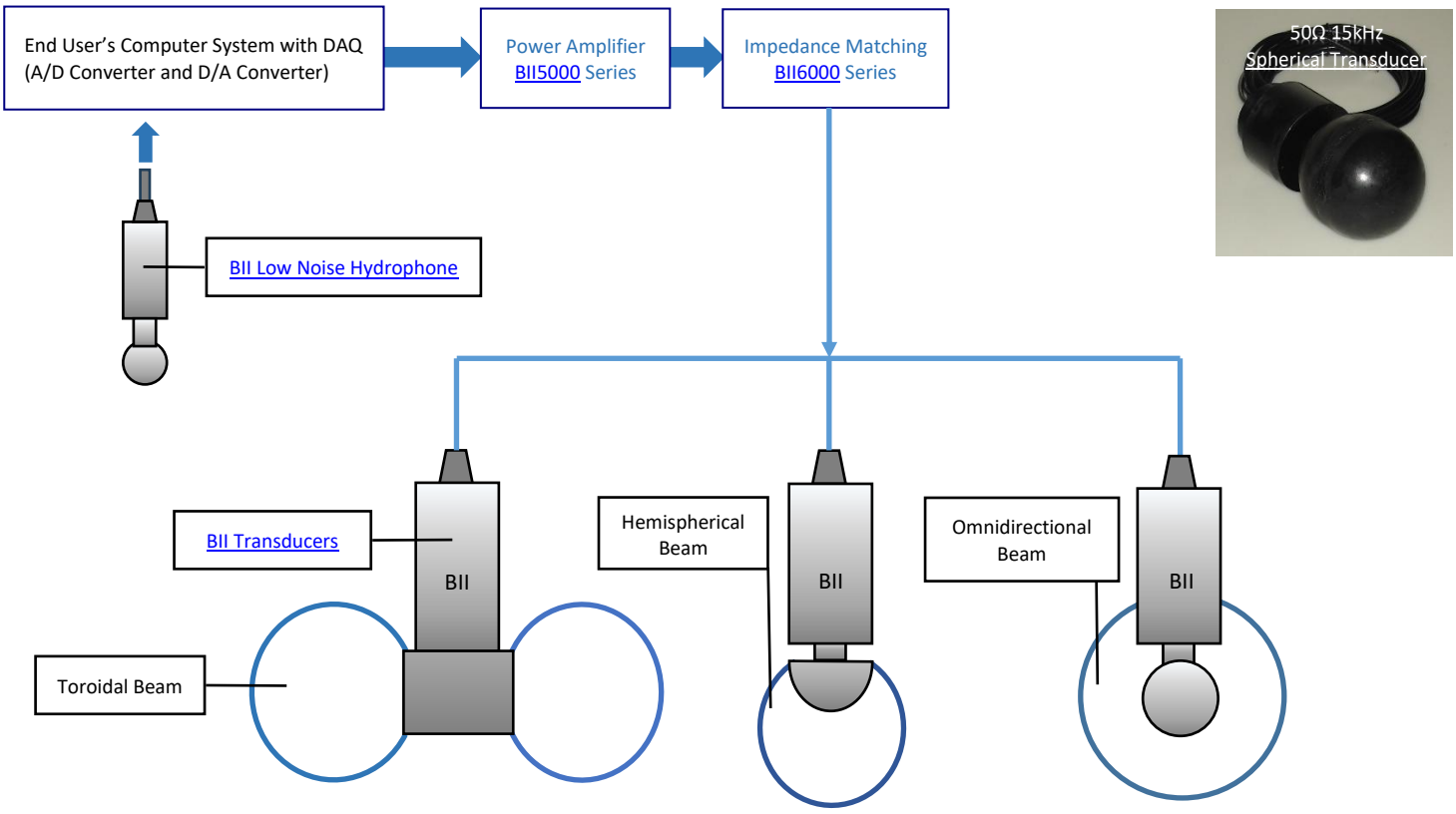
Underwater Beacons are broadband acoustic transmitters and/or receivers. BII components are ready for you to implement and develop unique and proprietary pingers repeaters, and transponders: Underwater Communication and Positioning, Acoustic Locator and Release, Pilot Sound Sources, Artificial Acoustic Target, Long and Short-Range Navigation.

**Pingers Setup:**




### Repeater and Transponder Setup:

Repeaters and Transponders include a low noise hydrophone with suitable directivity patten for receiving an incoming acoustic sound from a remote station or a sound source such as a pinger and a submarine. Buyer's computer samples and processes incoming signals to synthesize a new signal as an echo signal, an "answer" signal, or a "command" signal. the computer outputs the new signal to sound transmitting system which consists of a power amplifier, an impedance matching device, and a transducer (projector).







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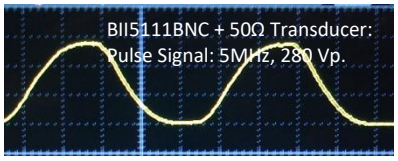
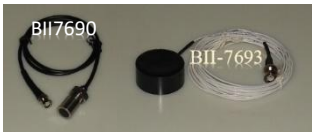
## Acoustical Measurements: Pulsing and Receiving for Physical Acoustics, NDT, and AE.




Acoustical measurements include:
1. Time Measurements such as Frequency f = 1/$T_0$, Bandwidth B = Δf at -3dB Points, Time Delay Δt.
2. Spatial-Size Measurements such as Sound Path Length L, Wavelength λ, Schlieren Image Distribution, etc.
3. Measurement of Energy Dissipation such as Attenuation of Sound Amplitude during Spatial Propagation, Impedance Change, Damping Decrement, Bandwidth, etc.




Sound velocity C and attenuation coefficient α are two fundamental quantities. Propagation of a plane wave in a medium:

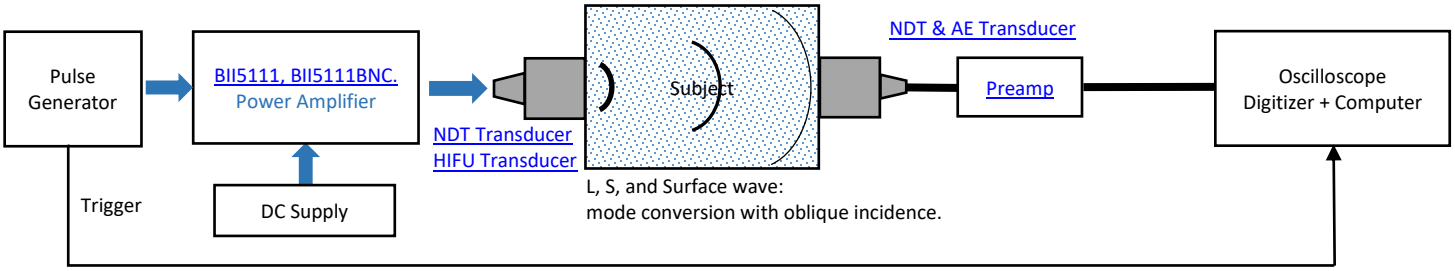
$$A_x = A_0 e^{j\omega(t-x/C)} e^{-\alpha x}$$

$A_0$: Amplitude of Sound Pressure, Particle Velocity, or Density. ω = 2πf. t: Propagation Time. x: Displacement from Origin to Measuring Position.
C and α of sound waves propagating in a medium are the macroscopic manifestation arising from the interaction between sound waves and one or more properties of the material. With accurate C and/or α, some of mechanical, thermal, electrical, magnetic, and optical properties of the material can be determined qualitatively or quantitatively.
Typical ultrasonic (elastic or stress) waves used in measurements:
1. Compressional (Longitudinal, or L) Wave.
2. Shear (Transverse or S) Wave.
3. Surface (Rayleigh) Wave.
4. Lamb, Stonely, and Scholte Waves, etc.
5. Wave Mode Conversion with Wedge at Critical Incident Angles.

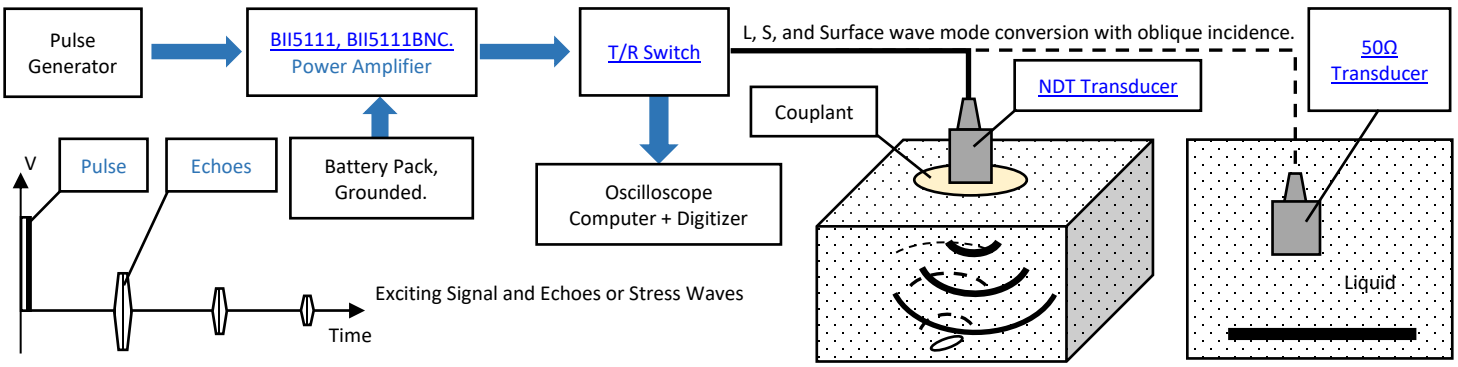

BII manufactures broadband (low $Q_m$) longitudinal transducers (planar wave and focused wave) with fundamental $f_s$ up to 10 MHz (usable at 3rd harmonics or up to 30 MHz), and bespoke Acrylic or Plexiglas (or other engineering plastics such as Polystyrene, Nylon, PTFE, etc....) Wedge for wave mode conversion.

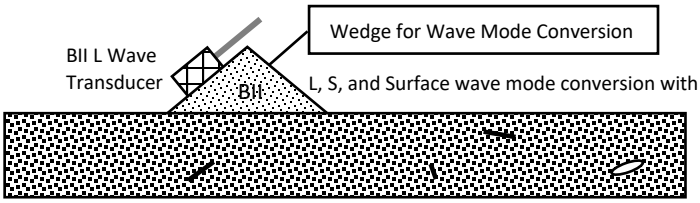
| **Useful Formula and Parameters for Ultrasonic Transducers** | | |
|---|---|---|
| **Q**: Lumped System Quality Factor; **λ**: Wavelength; **D**: Aperture Diameter; **FWHM**: Full Width at Half Maximum. | | |
| Best Axial Resolution ≈ 0.95Q*λ. | Best Lateral Resolution = Minimum Beam Width ≈ FWHM = 1.4λ*F/D. | Near Field Length N = $D^2/(4\lambda)$. |
| Rayleigh Distance = $\pi D^2/(4\lambda)$. | Fraunhofer Zone Distance = $2.3D^2/(4\lambda)$. | Angle of Divergence = $\sin^{-1}(1.22\lambda/D)$ |
| **Wave Mode Conversion at Oblique Incidence:** L, S, Rayleigh (Surface), Lamb, Stonely, and Scholte Waves, Snell's Law: $\sin\theta_L/C_L = \sin\theta_L'/C_L' = \sin\theta_s'/C_s'$. | | |
| **Immersion Testing from Water to Steel:**<br>First Critical Angle: 15°, compressive wave to shear wave mode conversion.<br>Second Critical Angle: 27°, shear wave to surface wave mode conversion. | **Contact Testing from Plexiglas to Steel:**<br>First Critical Angle: 28°, compressive wave to shear wave mode conversion.<br>Second Critical Angle: 58°, shear wave to surface wave mode conversion. | |

(1) **NDT Pulser**.




(2) **NDT Pulser and Receiver.**





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## AE Detection System

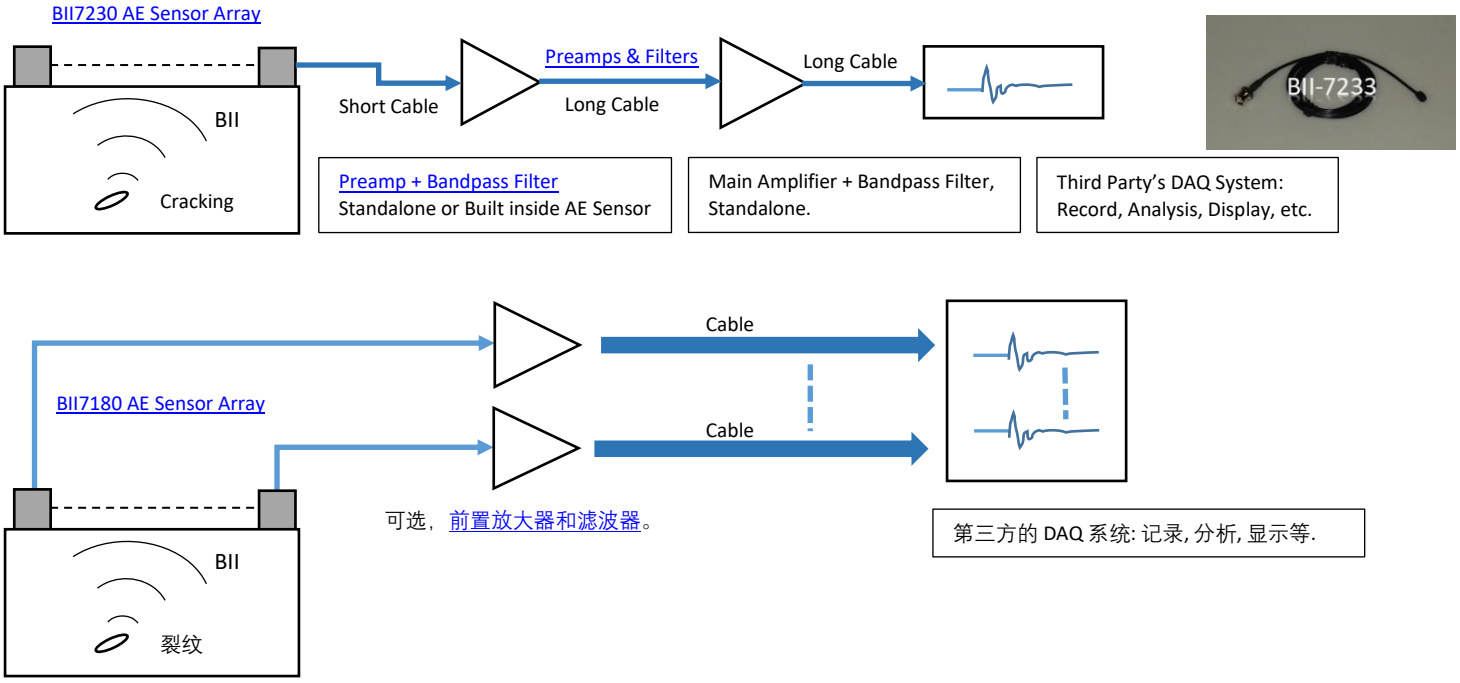
**BII7230 Series:** AE Sensor without built-in preamp. Acoustic aperture: Φ2 to Φ12.7 mm, 1 kHz to 1.2 MHz. FFVS sensitivity is calibrated in water.
**BII7180 Series:** AE Sensor with built-in preamp. Acoustic aperture: Φ1 to Φ3 mm, 90 Hz to 3.5 MHz. FFVS sensitivity is calibrated in water.

BII AE acoustic sensors detect wideband stress wave released by the structure (Macro or Micro) deformation, cracking, leaking, chemical reaction etc... They can be used as contact sensors and immersion sensors to detect AE sources up to 200°C (392°F) in air and liquids (or water), or as embedded AE sensors. Phase arrays can be configured with these small-aperture AE sensors to position the AE sources. When AE sensors are used in air, the couplant (water, gel, grease, oils, adhesives, and commercial couplant.) is a necessary material to provide efficient acoustic coupling between the sensor face and the piece under test (DUT).

**Typical Applications**

| | | | |
|---|---|---|---|
| Examination of Structure | Control and Monitoring of Manufacturing Process | Material Study | Health Monitoring of Structure |

**AE Detection System**





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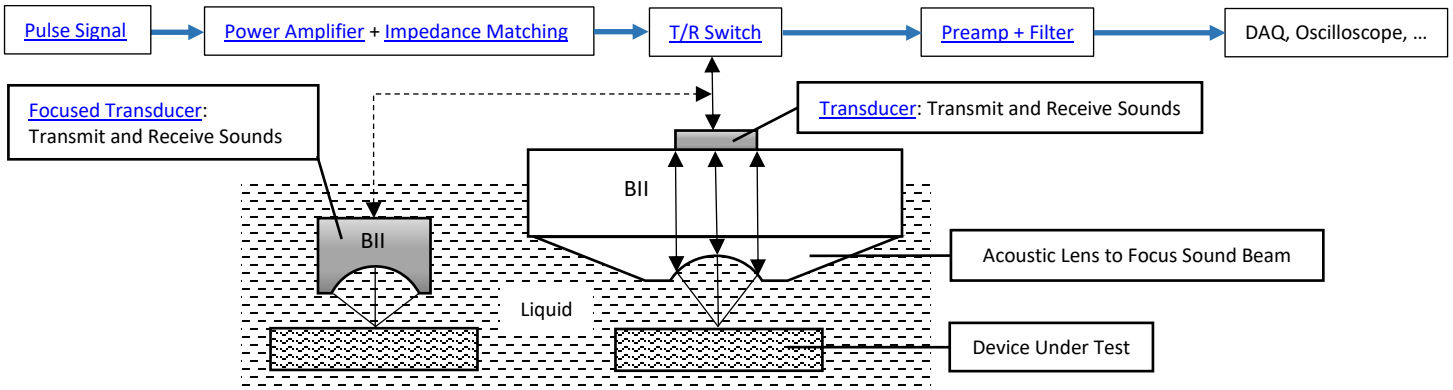
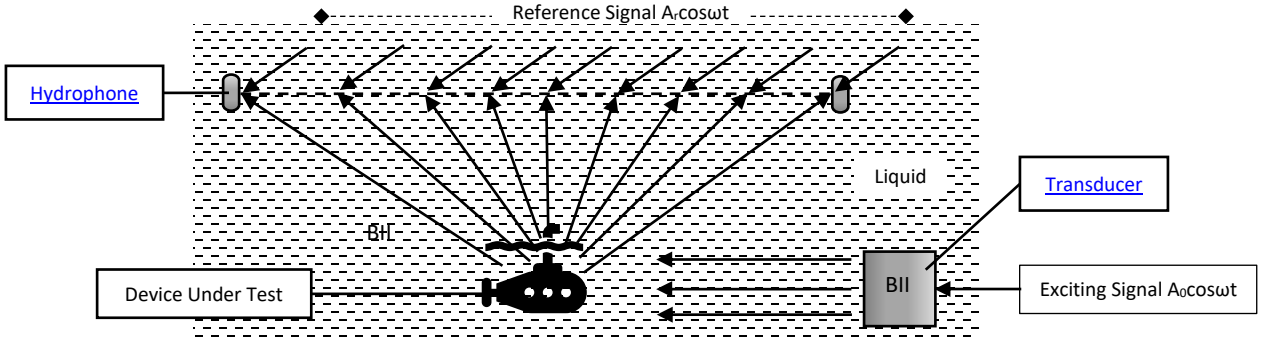
## Acoustical Imaging: Microscopy, Holography, and Tomography

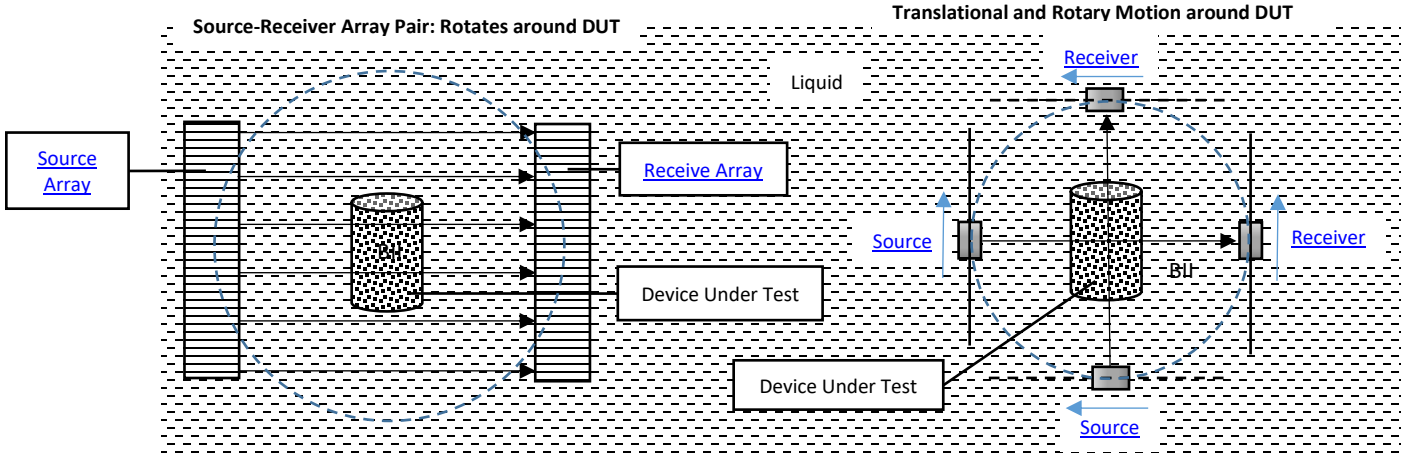
### Acoustic Reflection Microscope



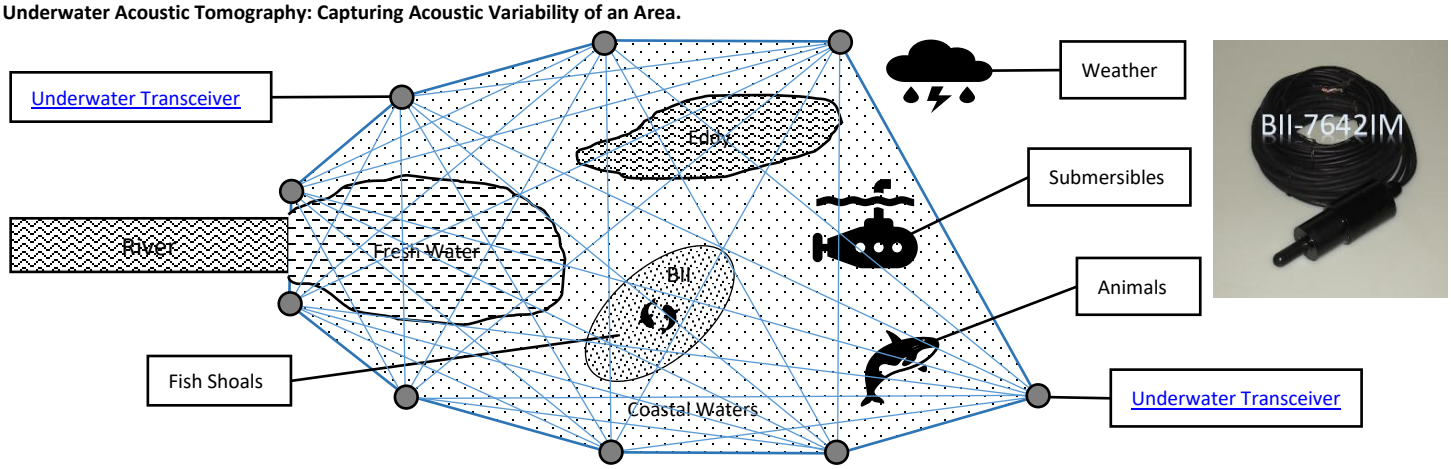

### Acoustic Holography




### Acoustic Transmission Tomography




### Underwater Acoustic Tomography: Capturing Acoustic Variability of an Area.

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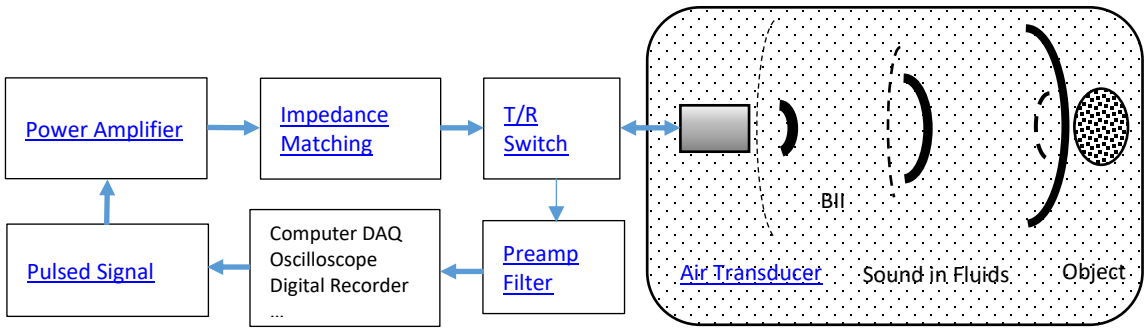
## Ultrasonic Air Transducer: Planar and Electronic Focusing, 30 to 300 kHz, -40°C to 140°C (-40°F to 284°F) is available.

BII's air transducers featuring low to medium $Q_m$ in air are for air-coupled NDT (Non-destructive Testing), navigation, ranging, measurement and control, and characterization of airlike fluids (gases) and materials such as woods, plastics, rubber, foam, and composites. Transducers are water-proofed to withstand 50m water depth at least. Sounds generated with Ultrasonic Air Transducer propagate in air or airlike fluids (gases) and materials.

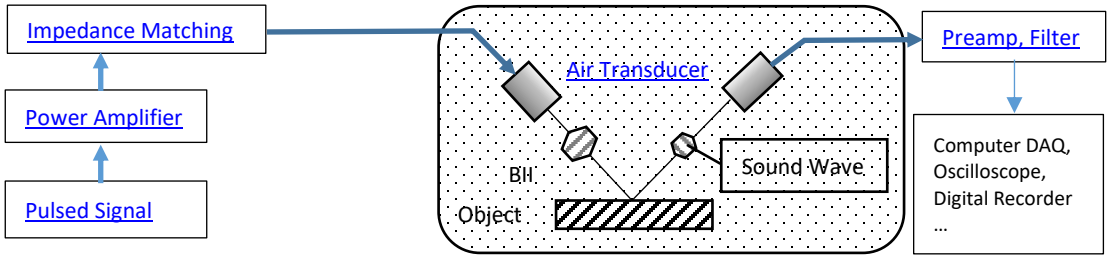
| **Typical Applications** | |
|---|---|
| Measurands influence propagation time, phase, and attenuation. | Measurands influence reflection, refraction, scattering and transmission. |
| Robotics, Proximity Detection, Sound Ranging, Material Study<br>Level Measurement, Speed Measurement, Leak Detection<br>Edge Detection, Web Guiding System, Air-Coupled NDT | Counting, Monitoring, Remote Control, Alarming, Motion Detection<br>Automatic Sizing, Sorting & Positioning of Parts, Ultrasonic Testing and Analysis<br>Surface/Profile Characterization and Quick Scanning for Quality Control |

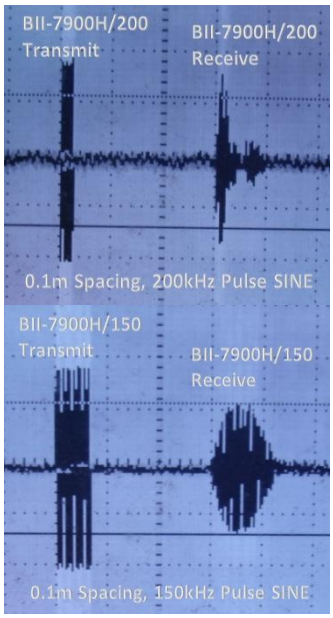
**Pulse-Echo System: SONAR in Air and Airlike Fluids**



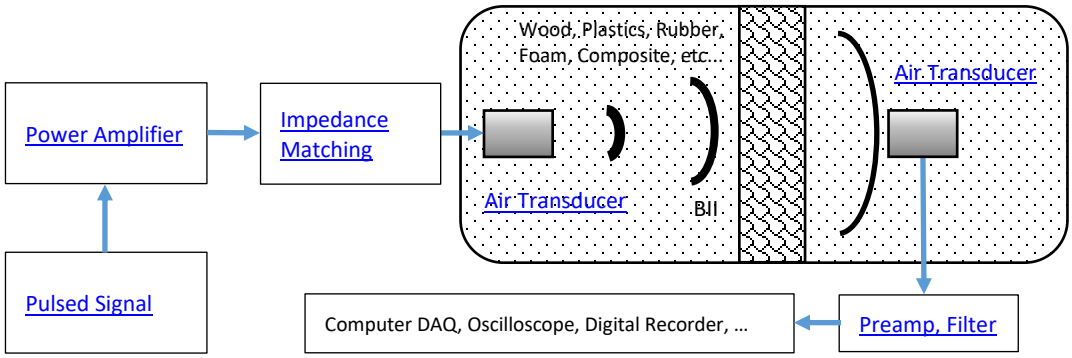


**Pulse-Reflection System in Air and Airlike Fluids**

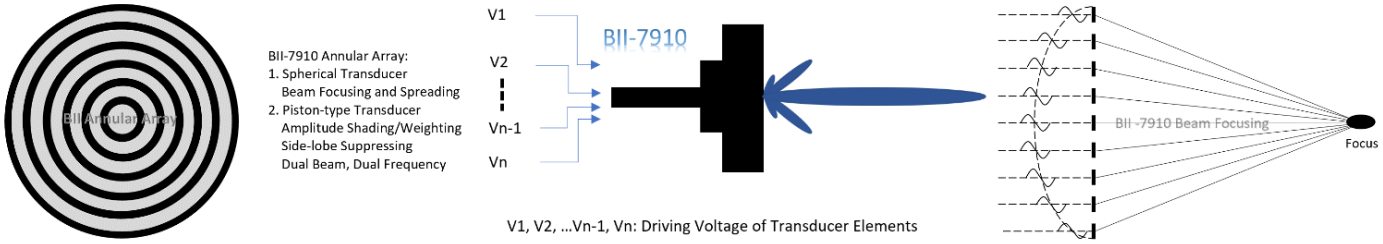



**Pulse Transmission System: Information Transmission through Air, Airlike Fluids and Material.**




**Air Array Transducer: Electronic Beam Focusing**

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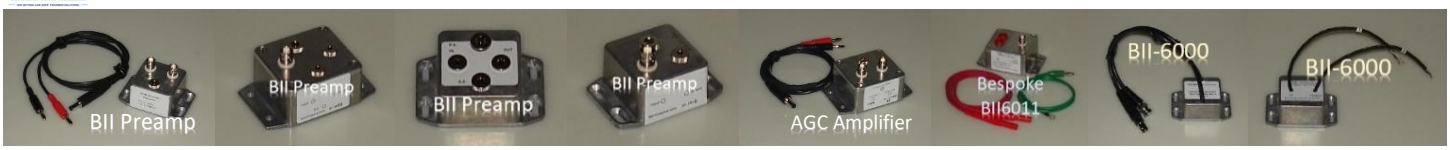
| Absorption of Sound in Air at 20°C (68°F), Relative Humidity: 10%, 1 atm. | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Frequency (kHz) | 30 | 40 | 50 | 70 | 100 | 120 | 150 | 200 | 250 | 300 | 500 | 1000 |
| Absorption (dB/m) | 0.3 | 0.4 | 0.5 | 0.7 | 1.8 | 2.5 | 4.0 | 6.5 | 10 | 16 | 43 | 200 |

The radiation impedance of air or airlike fluids is quite low to cause energy efficiency of an air transducer is quite low. More than 96% of electrical energy of the driving signal is transformed to heat inside the transducer. When the temperature inside a transducer approximates curie temperature of the piezoelectric material at high driving voltage, the piezo material is destroyed beyond repair.

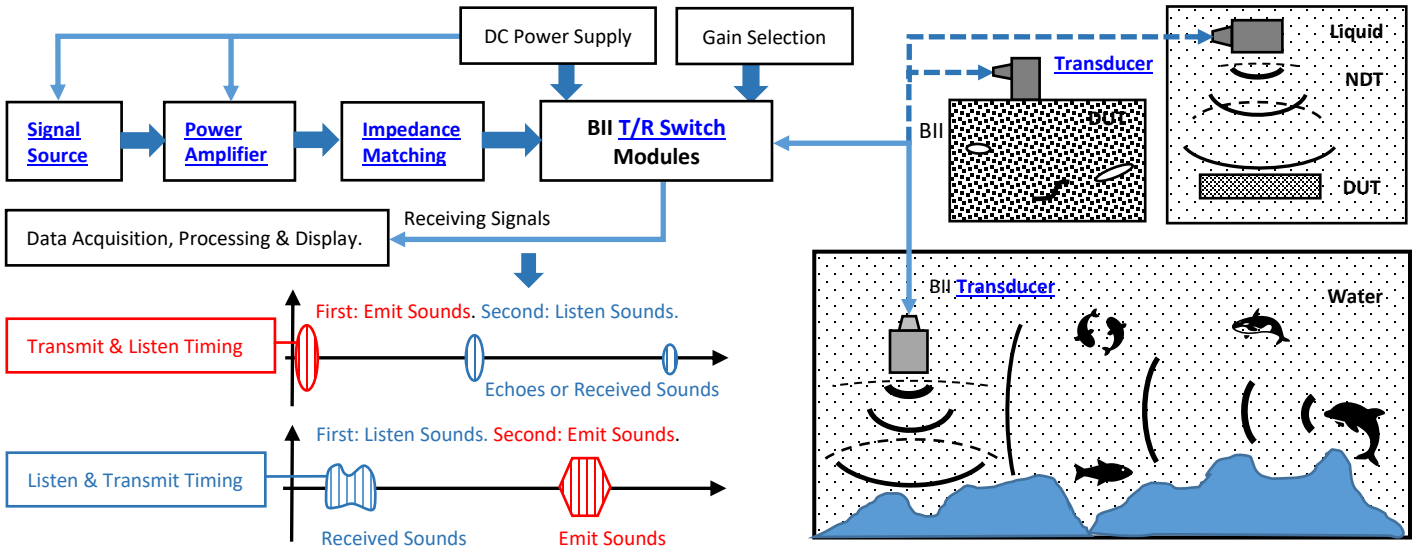
Pulsed driving signal allows the transducer to cool down by itself in ambience. But generally, the materials used in an air transducer are non-metal which have low thermal conductivity comparing to metals such as aluminum. Therefore, **the pulse duration (width) and duty cycle of a driving signal must be chosen carefully to allow the transducer cooling down by itself in surroundings. Otherwise, the transducer will be damaged beyond repair.**




## BII Signal Processing Components

| BII Components | Main Functions |
|---|---|
| BII1000 Series | **Preamplifiers with built-in Filters**: amplify or attenuate electrical signals generated by piezoelectric sensing elements.<br>**VGA** (Variable Gain Amplifier) for TVG (Time Variable Gain) Applications: compensate transmission loss in active SONAR and ultrasound system.<br>Preamp Types: Fixed Gain, Digitally Programmable Gain, Variable Gain. |
| BII2000 Series | **AGC (Automatic Gain Control) Amplifier:** Compensate the propagation losses of water, air, and solids automatically. |
| BII2100 Series | **Transmit and Receive Switching Module** with built-in impedance matching, preamp, and filter. |
| BII4000 Series | **Signal Generator** for Acoustic Systems of SONAR, NDT, HIFU… |
| BII5000 Series | **Power Amplifiers**: Drive SONAR, HIFU, and Ultrasonic NDT Transducers. |
| BII6000 Series | **Impedance matching and tuning** between power amplifiers and piezoelectric transducers. |

**Block Diagram of a Typical Pulse-Echo Acoustic System and a Transponder/Communication Acoustic System.**





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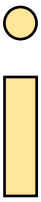
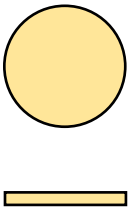
**Piezoelectric Materials and Shapes**

High d constant (strain or charge constant) is desirable for piezoelectric materials to emit large sound pressures or stress waves, high g constant (voltage constant) is desirable in materials to have high voltage or charge sensitivity in response to a sound pressure or stress, high k (electromechanical coupling factor) and low $Q_m$ (mechanical quality factor) are desirable in materials to have a broadband response of emitting and/or receiving sounds (or stress waves). BII manufactures acoustic transducers (Hydrophones and Projectors) with following piezoelectric ceramics.

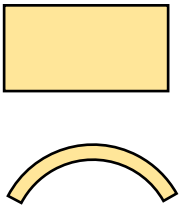
| **Material:** | **Features** (exclusive to the piezoelectric materials used in BII products.) |
|---|---|
| Composites:<br>PZT, PT, or PN + Passive Material Matrix. | Highly anisotropic.<br>High $k_{33}$, $g_{33}$ and $g_h$.<br>Low $Q_m$, broadband.<br>High power as sound projectors; High sensitivity as sound receivers.<br>-40 to 140 °C (-40 to 284 °F).<br>  |
| Hard PZT, Modified $Pb(Ti,Zr)O_3$: | High k, high d, low loss, high power transducers.<br>-100 to 250 °C (-148 to 482 °F) applications. |
| Soft PZT, Modified $Pb(Ti,Zr)O_3$: | High k, high g, broadband, high sensitivity hydrophones and sensors.<br>-100 to 250 °C (-148 to 482 °F). |
| Lead Titanate PT, Modified $PbTiO_3$: | Highly anisotropic, $k_t/k_p \geq 10$, high $g_h$, high power.<br>Great resistance to depoling by electric field.<br>-40 to 300 °C (-40 to 572 °F). |
| Lead Metaniobate PN, Modified $PbNb_2O_6$: | Low $Q_m$, high frequency broadband and pulsing transducers.<br>-100 to 400 °C (-148 to 752 °F). |
| Barium Titanate BT, Modified $BaTiO_3$: | High power SONAR (duty cycle ≤ 1%).<br>Medium $d_{33}$ and $g_{33}$, low $g_{31}$, high N.<br>Great resistance to depoling by compressive stress.<br>-20 to 80 °C (-4 to 176 °F).<br>Lead free. |
| Bismuth Layer Structure BiT, Modified $Bi_4Ti_3O_{12}$: | High frequency transducers. Anisotropic, $k_t/k_p \geq 4$.<br>Low $k_t$ and $k_{33}$, low d constant, medium g constant.<br>-100 to 500 °C (-148 to 932 °F).<br>Lead free. |
| The features mentioned above are for piezoelectric materials only. The features of BII transducers (Hydrophones and Projectors) depend on piezoelectric materials, passive materials, mechanical and electrical structure, loading medium, etc.. | |

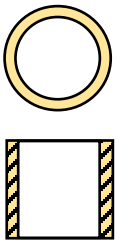
Besides standard product lines, BII manufactures transducers with bespoke piezoelectric materials listed above to meet your requirements. Shapes of piezoelectric materials: Bar/Rod, Round Disk, Rectangular Plate, Curved Shell, Tube (Cylindrical Shell), Sphere, Hemisphere, Convex Shell, Concave Shell, Composite, and custom-fit piezo shapes. Following piezo elements are listed with Top View and Front View.


Bar


Disk (Round Plate)


Rectangular Plate


Cylindrical Shell (Curved Shell)


Tube (Cylindrical Shell)

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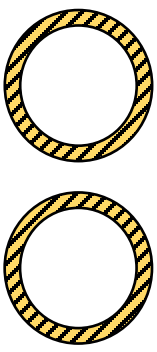
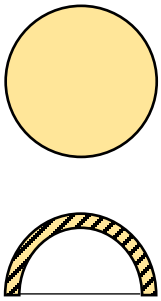
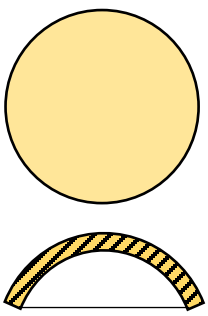
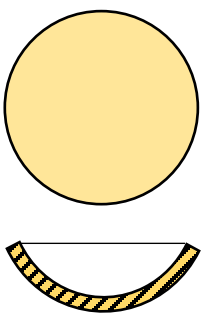
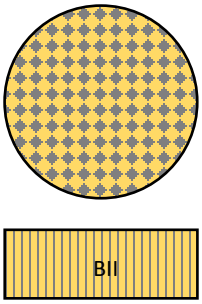

Spherical Shell


Hemispherical Shell


Concave Spherical Shell


Convex Spherical Shell



Piezoelectric Composite

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## Magnetic Materials and Cores

The impedance (or admittance) of a piezoelectric transducer (a projector or a hydrophone) is frequency-dependent ranging from hundreds kΩ to several Ω, and is capacitive, resistive, or inductive at different frequency ranges. An impedance matching and tuning unit is a necessary device to change the impedance of the transducer in a specific narrow frequency range to meet the load requirements of a power amplifier for maximum and efficient power transfer (high power factor) from the electric to the mechanical, or to match the input impedance of a preamplifier for maximum and efficient power transfer from the mechanical to the electric, or achieve optimum source resistance for minimum noise figure NF. Besides, BII also manufactures custom-fit voltage step-up transformers for measurement of ferroelectric and piezoelectric materials.

Magnetic and air cores manufactured at BII are designed for impedance matching between piezoelectric transducers (SONAR, NDT, HIFU, AE) and power amplifiers. The core geometries include Toroid, Cylinder and Plane (PCB Based), and are customized to fit for BII transducers.

**Features of BII's magnetic cores:**

1. **Frequency.** 30 Hz to 50 MHz with ferromagnetic cores; up to 100 MHz with air core.
2. **Cooling**. Thermal conductive performances are improved with special thermal compounds to avoid over-heating.
3. **Bs and Air Gap.** Magnetic B/H curve are customized to increase the capacity of power conversion between electric field and magnetic field.
4. **Core Loss.** The hysteresis and eddy-current losses are minimized with suitable materials and sizes.
5. **Insulation.** Insulation voltage among windings ≥ 1200 $V_{rms}$. Insulation voltage between windings and core surfaces ≥ 2000 $V_{rms}$.
6. **EMI Radiation**. Toroid cores minimize the RF radiation.
7. **Miniaturization.** The cylinder cores provide the smallest size options for small transducers.
8. **Service Temperature.** -40 to 140 °C (-40 to 284 °F). Custom-made cores working from -40 to 287 °C (-40 to 550 °F) are available.
9. **Planar Cores.** Inductive planar devices (based on PCB) are available to fit for some special transducer constraints in high frequency range.

**Toroid** **EE** **Cylinder** **Plane (PCB Based)**

**Manufacturing of Cores:**

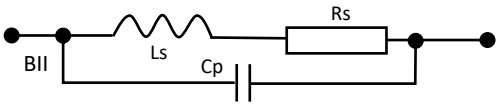
1. Stacked Laminations 2. Tape-wound Cores 3. Powder Cores 4. Printed Circuit Boards (PCB)

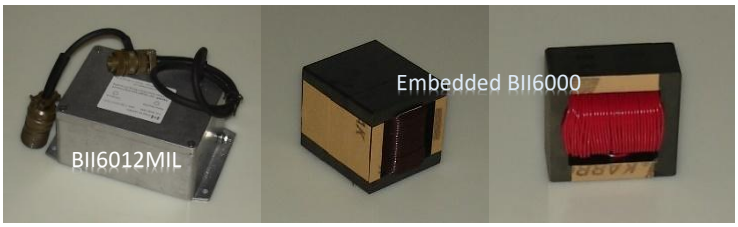
Besides BII's cores, soft magnetic cores from world-wide manufacturers are used to make inductive components for impedance matching from 30 Hz to 10 MHz.

**Testing of the Inductive Components:**

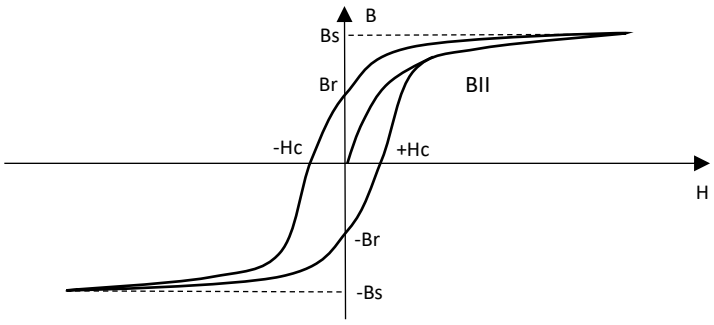
1. Inductance, Q, Turn Ratio of Transformer, Leakage Inductance, Frequency Response, Impedance vs. Frequency, Lumped Equivalent Circuit Model.
2. Insulation.
3. Service Temperature.

**Equivalent Circuit of Magnetic Cores with Windings:**




**Typical B-H Curve (Hysteresis)**




$Eddy\ Current\ Loss: W_{ec} \propto B^2 f^2 A_e^2$
$Hysteresis\ Loss\ W_H \propto B_{max}^n f,\ \ n = 1.6 \sim 2.0.$
Anomalous Loss $W_a$ is determined by core geometry, H, and dB/dt.

High-power magnetic material for uses from 30 Hz to 20 kHz:
Amplitude $\mu_a$ = 1300, maximum $\mu_{max}$ = 7500, $B_s$ = 1.4 T at H = 800 A/m.

$$Air-gapped\ Core: Effective\ Permeability\ \mu_e \approx \frac{Effective\ Length}{Air\ Gap\ Length} = \frac{L_e}{G}$$

$$Energy\ stored\ in\ magnetic\ field\ w_m = \frac{B^2 V_c}{2\mu_r \mu_0} = \frac{1}{2} L i^2$$

$$Energy\ stored\ in\ shunt\ capacitance\ C_0\ of\ piezoelectric\ transducer\ w_c = \frac{1}{2} C_0 V^2$$

**Magnetic Properties of Typical Ferromagnetic Materials Used at BII, at 25°C unless Specified Otherwise.**

| Material | $\mu_{max}$ | $\mu_i$ | Saturation Bs (T) | Hysteresis/Core Loss $W_H$ | Coercivity $H_c$ (A/m) | Curie Temperature |
|---|---|---|---|---|---|---|
| Purified Iron | 180,000 | 10,000 | 2.15 | 30 J/m³ at d.c. | 4 | 770 °C |
| Iron | 5,000 | 150 | 2.15 | 500 J/m³ at d.c. | 80 | 770 °C |
| Electrical Steel | 50,000 | 350 | 1.5 | 32 W/lbs at 1kHz, 1.5T, 100°C | 48 | 740 °C |
| Powder Alloy | 20~300 | 14~150 | 1.0~1.5 | 1.7 W/cm³ at 0.2MHz, 0.1T, 100°C | 20 ~ 180 | 500 °C |
| Soft Ferrite MnZn | 4800 | 2200 | 0.49 | 0.215 W/cm³ at 0.5MHz, 50mT, 100°C | 21 | 210 ~ 300 °C |
| Soft Ferrite NiZn | 2800 | 750 | 0.52 | 0.500 W/cm³ at 3.0MHz, 30mT, 100°C | 40 | 260 ~ 350 °C |

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## Acoustic System Performance and Designs

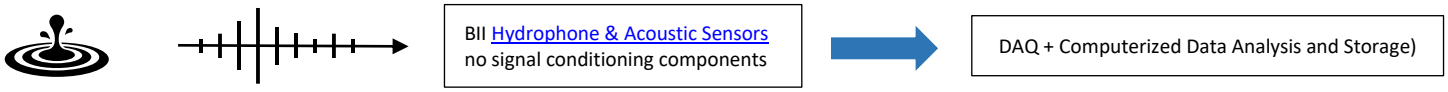
**Low-Power Acoustical Measurements**

Generally, field-deployed, hand-held, and portable acoustical measuring instruments (Underwater Sound Recording, Sonobuoy, Bottom-moored Hydrophones, Autonomous Underwater Vehicles, NDT Tester, AE Material Health Monitors, etc.) use batteries (non-rechargeable or rechargeable) as DC power sources which requires low-power components to extend service time.

BII manufactures low current and low power preamplifier with built-in electronic filters.

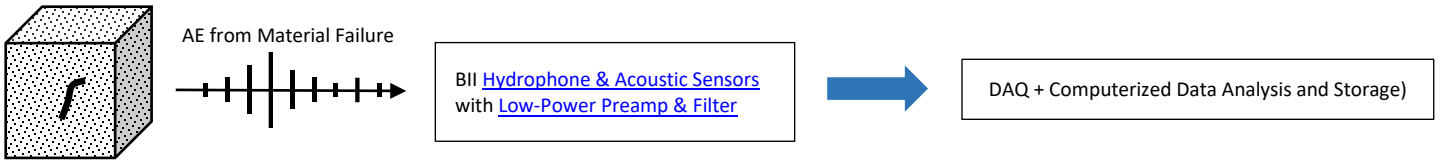
**1. Hydrophones or acoustic sensors without signal conditioning components detect loud sounds.**

In this case, the hydrophones or acoustic sensors does not need any electronic energy, or its power consumption is 0 watt.




**2. Hydrophones or acoustic sensors with signal conditioning components detect weak sounds.**

In this case, the hydrophones or acoustic sensors consume electronic energy to amplify the signals and reject noises.




**3. Low-Power Preamp and Filters.**

BII1060 Series Low Power Low Noise Preamplifiers for acoustical instruments: Hydrophones, Air Transducers, Acoustic Emission Sensors, and Ultrasonic Transducers (Non-destructive Testing). Uses in underwater sound (oceanography and hydrography), sonic and ultrasonic engineering, electroacoustics, communication, bioacoustics, exploration seismology and seismic wave, physical acoustics, acoustical Imaging, and measurements of ferroelectric and piezoelectric materials.

| **Features** | |
|---|---|
| Low Supply Current: 40 µA.<br>Wide Supply Voltage: +2.7 to +30 VDC.<br>Low Voltage and Current Noise: 7nV/√Hz, 1.0fA/√Hz, at 1 kHz. | Single-ended and Differential Output.<br>Driving Long Cable: 200 m.<br>Bespoke Gain 0 to 60 dB and Bespoke Built-in Filters. |

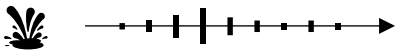
Please refer to Choose a DC Power Supply for BII Devices for more info on calculation of service time of a battery-operated system.

**Low-Noise Acoustical Measurements**

In acoustic measurement the ultimate limit of detectability of weak sounds is confined by noises (ambient noises and electrical noises) - unwanted signals that obscure the desired signals.

Roughly, both ocean ambient noises and electrical noises decrease when frequency increases. Besides, when bandwidth of a system is wider, more noises couple into the system to sum up to be higher noise level at its output. Therefore, a bandpass filter is necessary to reject noises outside the frequency range of the interest.

To avoid noise variation resulting from different signal conditioning circuit, hydrophones (acoustic sensors) with built-in preamp should be used in low-noise acoustical measurements.

BII Low Noise Hydrophones Sensors → DAQ + Computerized Data Analysis and Storage)

Sound & Stress Wave → Hydrophone / NDT Receiver / AE Sensor → BII Impedance Matching for Minimum Noise Factor NF → Preamp → Data Acquisition

BII7120 Series Omnidirectional Low Noise Hydrophone and BII7079 Directional Low Noise Hydrophone (Acoustic Sensor): Noise Level below Sea State Zero.

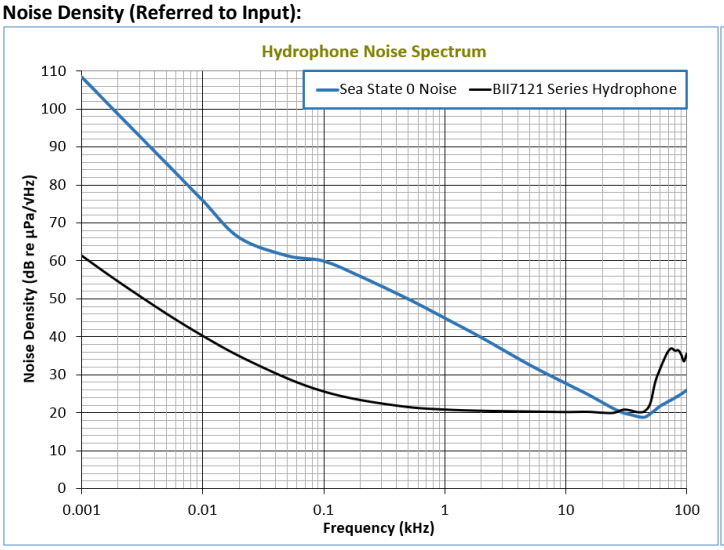
A low-noise acoustic sensor consists of an acoustic transducer and a low-noise preamp and filter. these low noise sensors are widely applied in sonic and ultrasonic engineering, electroacoustics, communication, bioacoustics, exploration seismology and seismic wave, physical acoustics, acoustical Imaging, and material study.

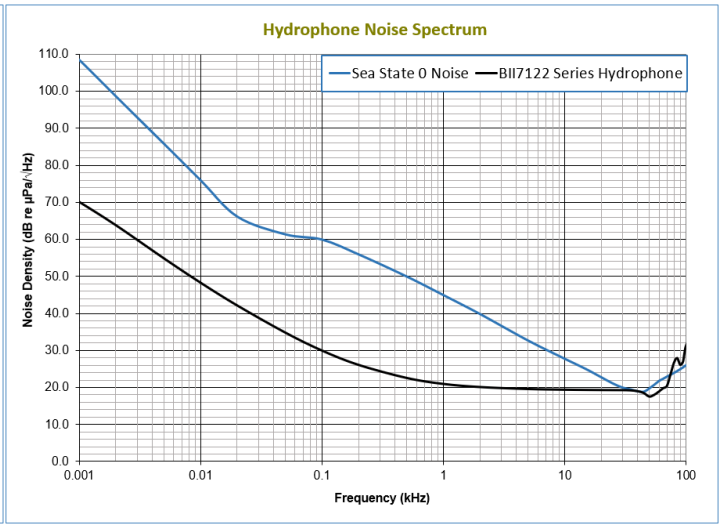
Approximately, electronic noise density of a preamp hooking up with a transducer: refer to input, RTI, $V_n^2 = e_n^2 + [\, i_n * \text{impedance of the transducer (or hydrophone)}]^2$.

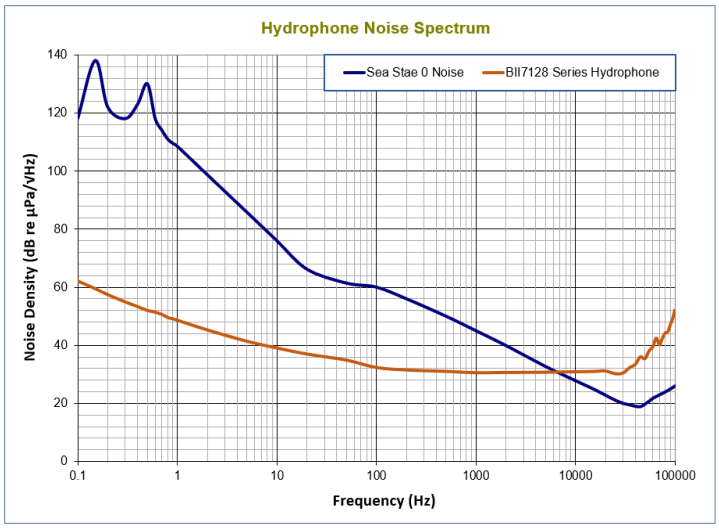
$e_n$: voltage noise density of the preamp, $i_n$: current noise density of the preamp.

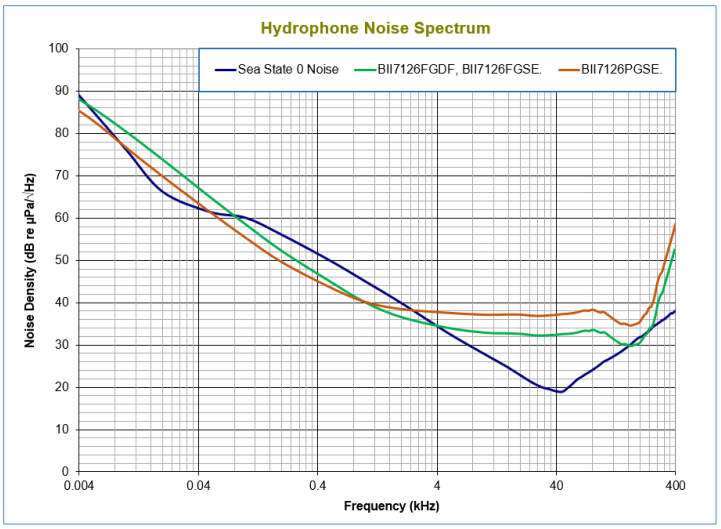
In high frequency range such as greater than 100 kHz, the pressure noise density of a acoustic sensor with low-noise preamp BII1051 ≈ 180 dB – FFVS of transducer, in dB µPa/√Hz. For example, a 1 MHz NDT transducer has FFVS of -197.6 dB V/µPa. Working with BII1051, the pressure noise density referring to input ≈ 17.6 dB µPa/√Hz.

**Noise Density (Referred to Input):**

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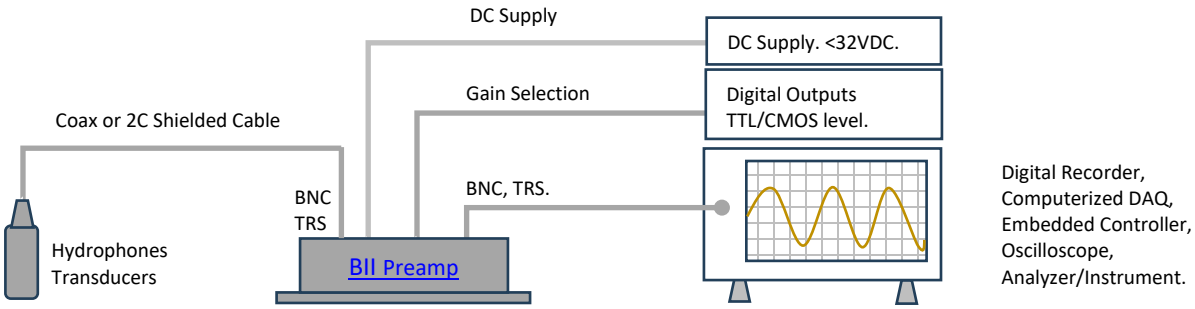
## Programmable Sensitivity Hydrophone: 60dB Selection Range

Sensitivity (FFVS) of a Programmable-sensitivity hydrophones (**PSH**) is digitally or manually selected with three lines (Two-bit Word, A0, A1 and Digital COMMON) or two lines (One-bit Word, A0 and Digital COMMON) or is continuously controlled by an analog voltage. The logic level of digital signal is CMOS/TTL-compatible and power supply rail-compatible. In applications of the active Sonar and sound-source tracking (marine animals, acoustic beacon, pingers, locator, acoustic tags...), the sound level at detection spot varies greater than 40dB (60 dB or higher) because of the variation of propagation loss, target strength, source level, etc. and the sound level could be too high or too weak for a sensitivity-fixed hydrophone. BII's programmable sensitivity hydrophone (**PSH**) is one of the solutions to solve the issue.
BII provide various PSH with different frequency ranges (0.1Hz to 10MHz) and different directivity patterns (Omnidirectional, Toroidal, Hemispherical, Conical, Fan-shaped, etc.)
**Nominal Sensitivities (FFVS) Variation**: 0 ~ 60/70 dB, 0/30 dB, 0/40 dB, 10/40 dB, 10/50, 20/50 dB, 20/60 dB, 30/70 dB, 0/20/40/60 dB, 20/40/60/80 dB.
**Related Preamps**: BII1090 PGA Amplifier and BII1030 VGA Amplifier.
**Applications:** Compensate Propagation Loss & Target Strength; SONAR; NDT; Detection of Acoustic Tag/Pinger/Locator/Marine Mammals; Passive Acoustic Monitoring.

**1. PSH: Standalone Hydrophones (AE Sensors, NDT Transducers) + Standalone PGA or VGA Preamp.**





**2. PSH: Piezoelectric Sensing Element + Built-in PGA and VGA amplifier.**
(1). Drive long cables up to 1000 m. (2). Refer to BII7000, BII7010, BII7070, BII7120, and BII7180.

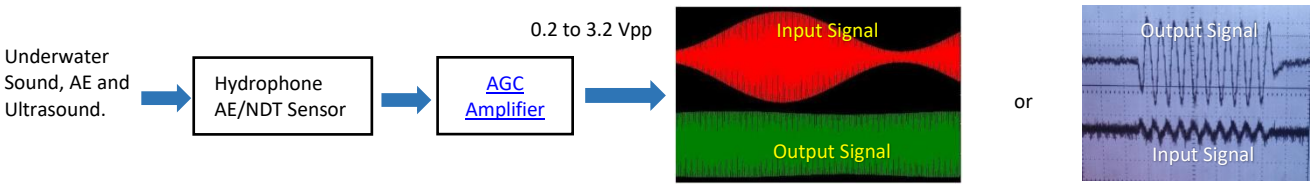
## Automatic Sensitivity Hydrophone (ASH) for SONAR and NDT: 80dB Range

An automatic Sensitivity Hydrophones (AE Sensors, NDT Transducers) (**ASH**) maintains suitable (or constant) voltage amplitude at output despite the variations of the detected sound pressures by automatically reducing its sensitivity when the sound is strong and raising it when sound is weak. It has 80dB dynamic range to equalize the differences in received sound intensities emitted by different sound sources, amplitude variations in a single sound source due to fading or reduced power, as well as varying echo levels caused by sound propagation loss in SONAR and ultrasonic testing. Besides, it is useful to detect the information being carried on by signal frequencies such as Doppler sonar for speed measurement, ASK and FSK digital communication, etc. The built-in bandpass filter allows the receiver to detect the sound of the interest and reject the sounds out of its bandwidth.
**Related Amplifiers**: BII2000 AGC Amplifier.

**Typical Applications**

| | | |
|---|---|---|
| Compensate Propagation Loss & Target Strength | Search of Acoustic Beacons: Tag, Pinger and Locator | Underwater Digital and Voice Communication |
| Passive Acoustic Monitoring (PAM System) | Doppler SONAR, Echo Sounding | Pulsing Ultrasonic Testing, Material Study. |

**1. ASH: Standalone Hydrophones (AE Sensors, NDT Transducers) + Standalone AGC Preamp.**




**Usable Frequency**: 100 Hz to 1 MHz, **Input Dynamic Range**: 80 dB, **Output Voltage Level**: 0.2 to 3.2 Vpp, **Sound Level Range $\Delta P_i$**: 80 dB µPa or $P_i$ = 110 to 190 dB µPa. **Note**: Minimum detection threshold is limited by noise levels in passband, which include electronic self-noise of the hydrophone and ambient sound noises if the ambient sound noises are not the measurand. The wider passband is, the higher the noise level is. **Pressure Noise (RTI) $P_n$**: $P_n \approx$ (-162 – Sensitivity of Sensing Element) at f ≥ 1 kHz, in dB µPa/√Hz. RTI: Refer to Input. (Most sensitive element is used in BII-7120 series low noise hydrophone and is around -182 dB V/µPa). **Output Type**: Single Ended or Differential, **Output Level Error**: < ± 2.0 dB, **Current (Quiescent)**: 17 mA @+24 VDC, DC Supply Voltage: +16 to +32 VDC.

**2. ASH: Piezoelectric Sensing Element + Built-in AGC Amplifier.**
(1). Drive long cables up to 1000 m. (2). Refer to BII7000, BII7010, BII7070, BII7120, and BII7180.

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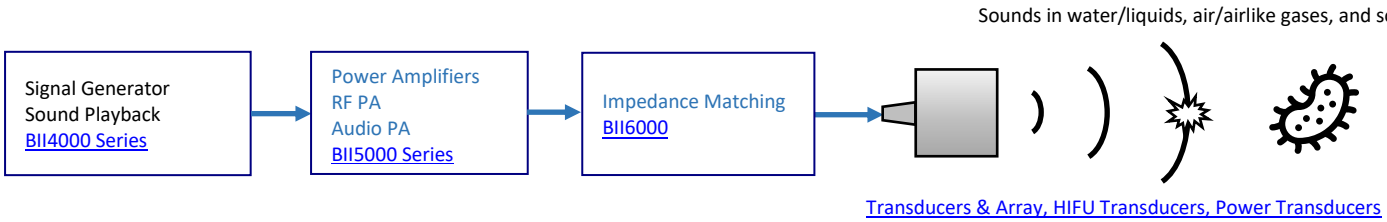
**Overall Conversion Efficiency from Electric Power to Sound Power**

Generally, field-deployed, hand-held, and portable **acoustical analytical instruments** (Hand-held Diver SONAR, Bottom-Moored Beacons/Transponders, Autonomous Underwater Vehicles, Echosounder, Sound Telemetry, NDT Flaw Tester, Material Study, etc....) use batteries (non-rechargeable or rechargeable) or a gasoline/propane portable generator as power sources which requires low-power components to extend service time.

**Sonic processing equipment** produces high sound intensity to modify the load medium, such as heating, surface cleaning, cavitation, degassing, emulsification, coagulation, destruction of bacteria, production of chemical reaction, etc... these devices operate in laboratories and factories.




**Overall Conversion Efficiency from Electric Power to Sound Power**

Efficiency of a System except Signal Generator = PA Efficiency * Impedance-Matching Efficiency * Transducer Efficiency.

**PA Efficiency**

BII manufacture two types of power amplifiers to drive transducers to produce sounds: Class AB (Linear Mode) and Class D (Switching Mode).
Efficiency of Class AB Linear PA η = 0.6 to 0.7.
Efficiency of Class D Switching Mode PA η = 0.91 to 0.985.

**Impedance-Matching Efficiency η** = 0.91 to 0.99 at 25 °C (77 °F). The efficiency increases with temperature increases till 100 °C (212 °F).

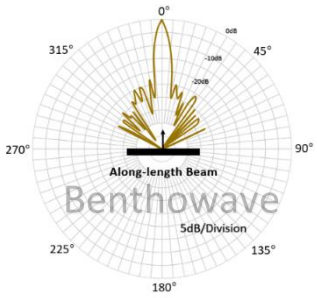
**Transducer Efficiency η** = 0.1 to 0.93. Generally, cylindrical, and spherical transducers possess highest efficiency. Broadband NDT transducers possess lowest efficiency. Other kind of disk-shape planar transducers possess median efficiency around 0.3 to 0.6 depending on their bandwidth.

**Directivity Patterns:**

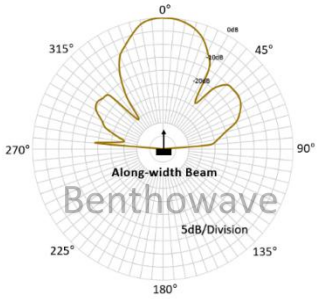
Following beam patterns are for illustration only. BII manufactures bespoke beam patterns for transducers (hydrophones and projectors) and arrays.

**Apertures of Line, Rectangular, Cylindrical Sector and Curved Surface.**

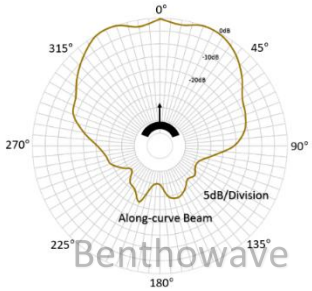
Along-length Beam Pattern



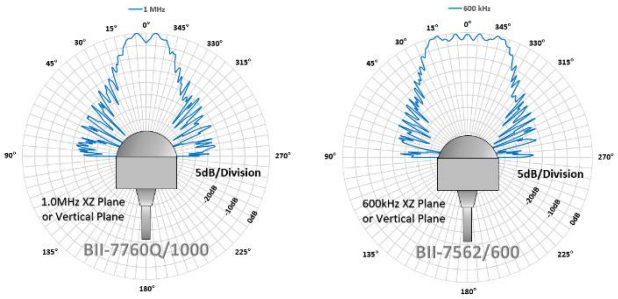

Along-width or Along-height Beam Pattern



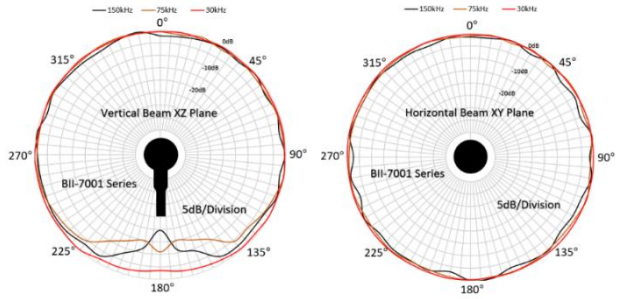

Along-curve Beam Pattern (Cylindrical Sector)



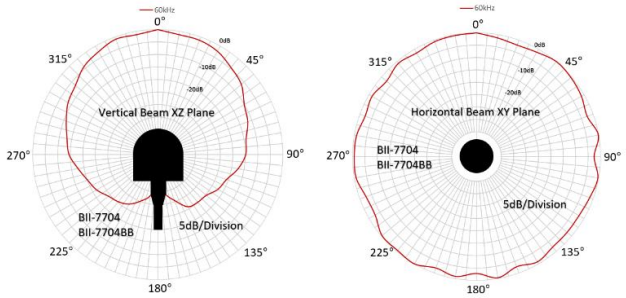

**Spherical Sector Directivity Pattern**



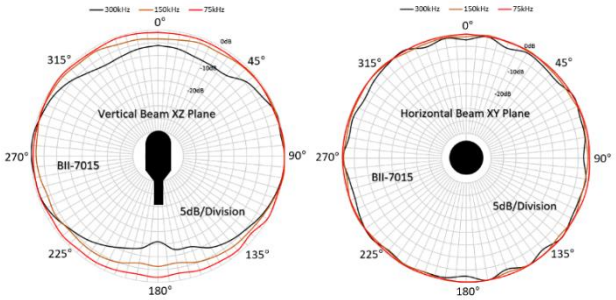

**Spherical Transducer (Hydrophones and Projectors)**



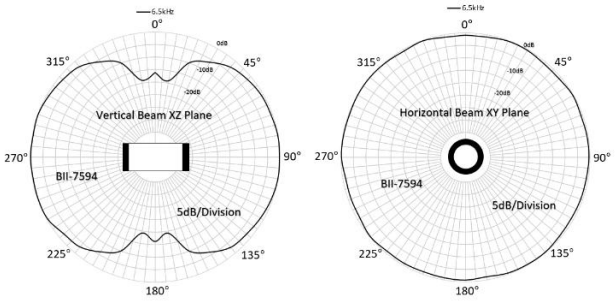

**Beam Patterns of Hemispheres and Spherical Domes**



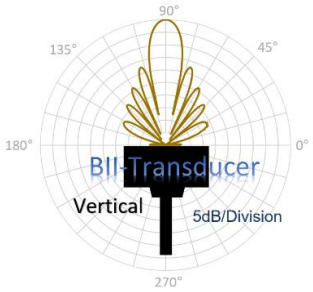

**Toroidal Beam Patterns**



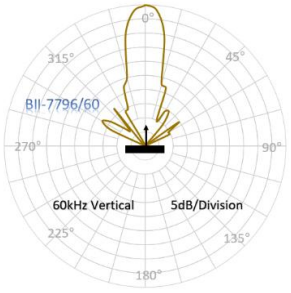

**Beam Patterns of Free Flooded Ring Transducer**



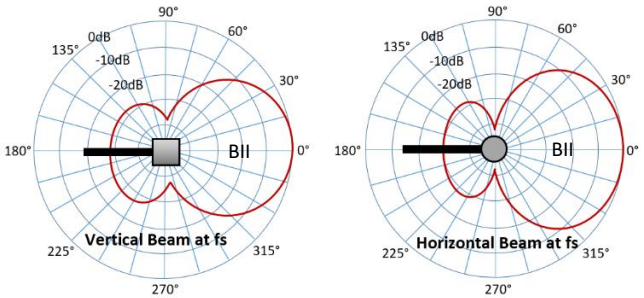

**Conical Beam without Shading**



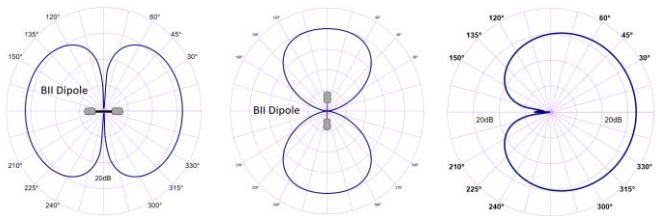

**Conical Beam with Shading**




**Beam Patterns of Low Frequency Directional Transducer**




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

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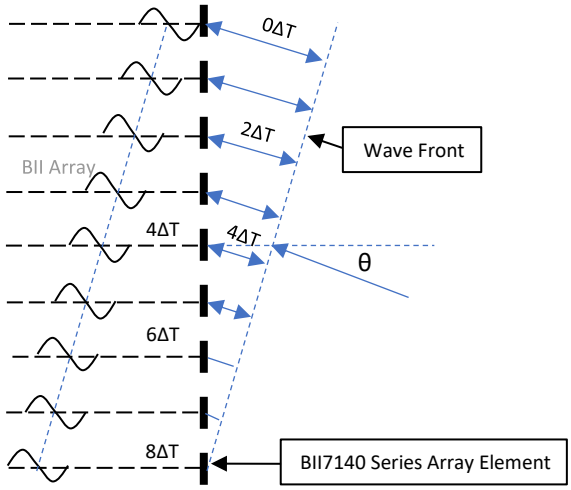
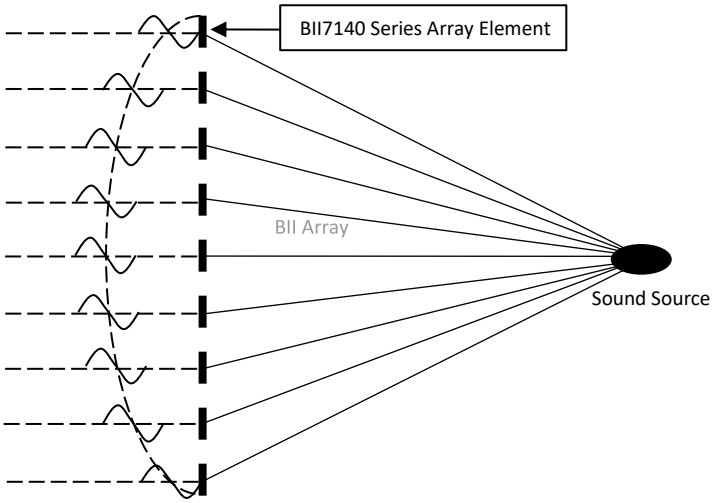
## Transducer and Hydrophone Array & Aperture Design - Spatial Filtering

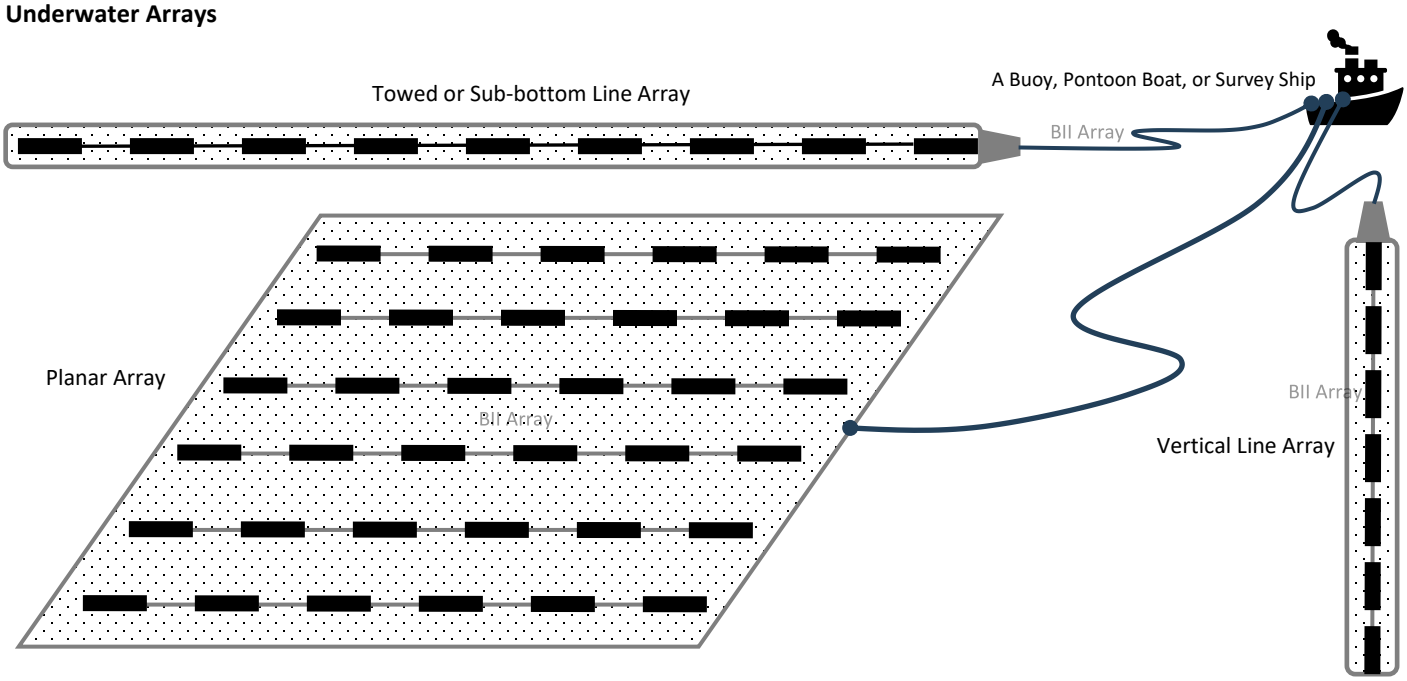
**Linear (Rectangular) Array Beam Steering**



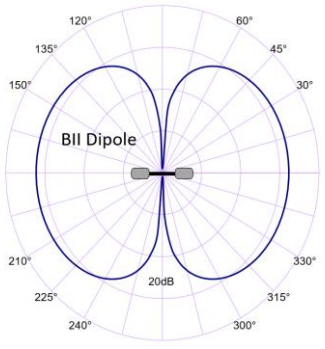

**Linear, Annular, and Planar Array Beam Focusing**

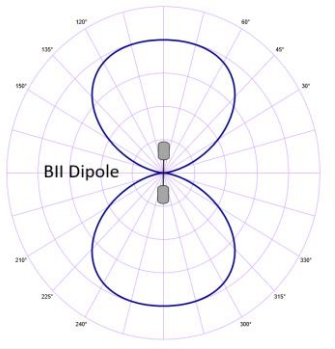



## Underwater Arrays

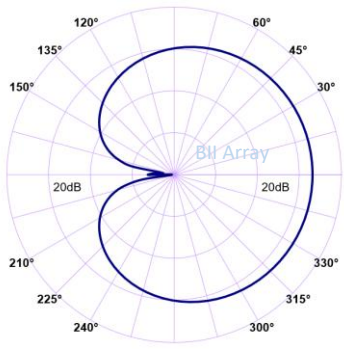



**"Figure 8" Pattern of a Dipole (Pressure-Gradient).**

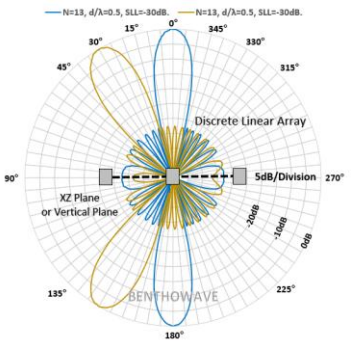



**Cardioid Pattern**




**Linear Array with BII Discrete Hydrophones**

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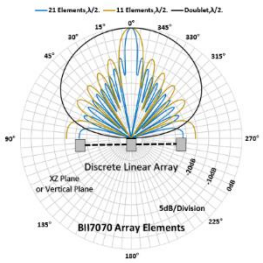
Benthowave's transducers and hydrophones can be used as array elements, which, depending on the operating frequency, can be simplified as Point, Line or Rectangle Aperture elements in Linear, Planar, Curved, and Conformal Array. Different mounting options are available from BII: Thru-hole/Hull, Bolt-fastening, End-face Mounting, Free Hanging, Flush Mounting and Flange Mounting. With the signals of array elements, tracking of sound source, beam-steering and sidelobe suppression can be done in signal processing. Standard dry and underwater mateable connectors are supported for quick interfacing among data acquisition devices.

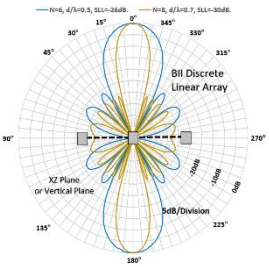
The performance of an array is determined by the performance of the elements, quantity of elements, spacing among elements and array pattern. Using an array of elements instead of single element underwater, the high array gain can be achieved, or the signal-to-noise ratio (SNR) can be improved.

With space-time signal processing, the -3dB beam width of the main lobe of the array can be controlled with weighting/shading techniques, and the beam of the main lobe can be steered to a specific direction with time-delay techniques. 2D or 3D images underwater can be captured with the arrays and the echo signal processing.

BII Bolt-fastening Mount is designed to be installed on portable-mounting apparatus for easy deployment and make configuration of the array pattern be easy, flexible and simple. Different array pattern can be set up quickly and easily in the field. Thru-hole Mount is designed to be installed on the wall/hull of underwater submersibles, pipes, tanks and vessels to detect or produce acoustic signals outside a submersible or inside a pipe, tank or vessel. Hull mounted array (such as linear, planar and cylindrical array) can be configured.

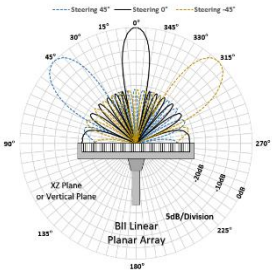

**How to use BII Transducer/Hydrophone as discrete array elements?** To achieve narrow beam width at a specific frequency and steer the beam to the direction of interest, multiple BII transducers or hydrophones shall be used to set up line array or planar array. For example, to detect 20kHz underwater sound, seven BII7070, BII7010 or BII7140 series hydrophones are used in half-wavelength spacing linear array to achieve beamwidth of 18° and suppressed sidelobe level of -30dB comparing to main lobe. Preamplifiers can also be integrated to drive long cable. Similarly, using the same array pattern, seven BII low-frequency acoustic transducers (projectors) can generate underwater sounds with a beamwidth of 18° and suppressed sidelobe level of -30dB.



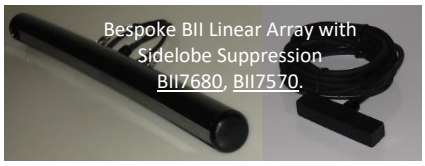

BII provide design service of Line (Linear) Array, Rectangular Planar Array, and Circular Planar Array: Side Lobe Level **SLL**, -3dB Beam Angle $\theta_{-3dB}$; Array Element Spacing d; Array Element Number N, Beam Steering, FFVS or TVR loss, and mutual effects among these parameters.

Please contact us for more info about Array Design Services.

**Related Products with Array Technology for Scanning SONAR: Imaging and long-range acoustic positioning, tracking, echo locating, navigation, communication, and artificial acoustic target in horizontal or vertical plane in the ocean, rivers, and lakes.**

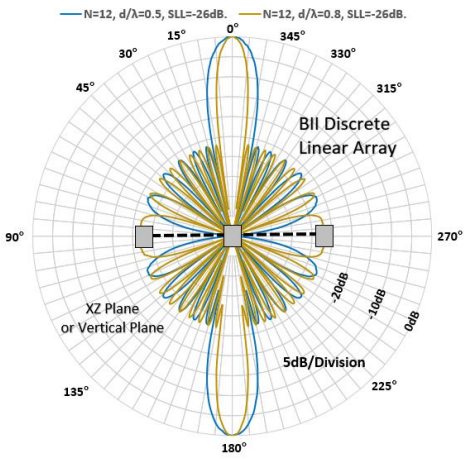


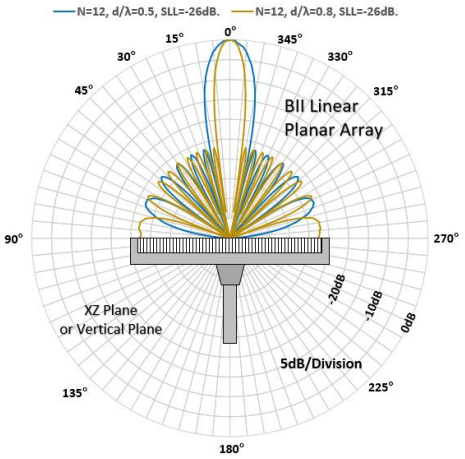

BII7630 Series Phased Array Transducer: Beamforming, Dynamic Focusing.
BII7660 Series Multibeam SONAR Transducers: 2D Imaging Sonar
BII7710 Series Scanning SONAR Transducer: 360° View Field in Horizontal Plane
BII7770 Series Underwater Mechanical Scanning Transducer
BII7740 Series Annular Array: Amplitude Shading, Array Focusing & Spreading

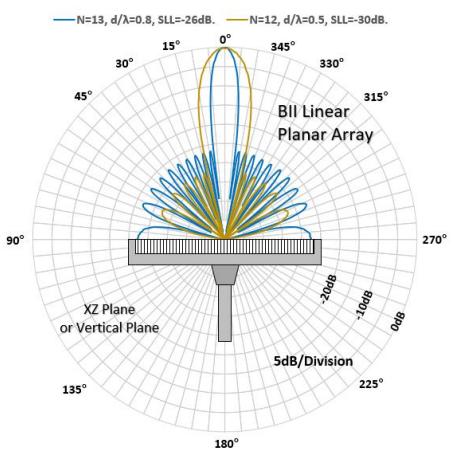



**Some Designs of Discrete Line Array and Linear Planar Array.**

N: Quantity of Array Elements, d: Element Spacing, λ: Wavelength, $\theta_{-3dB}$: Half Power Beamwidth, SLL: Sidelobe Level referring to Main Lobe.

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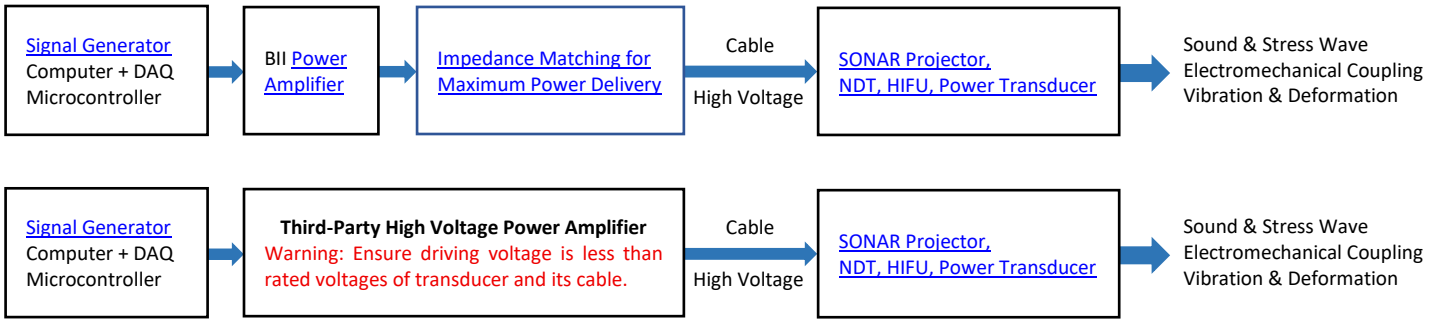
## How to Drive Transducers (Projector)

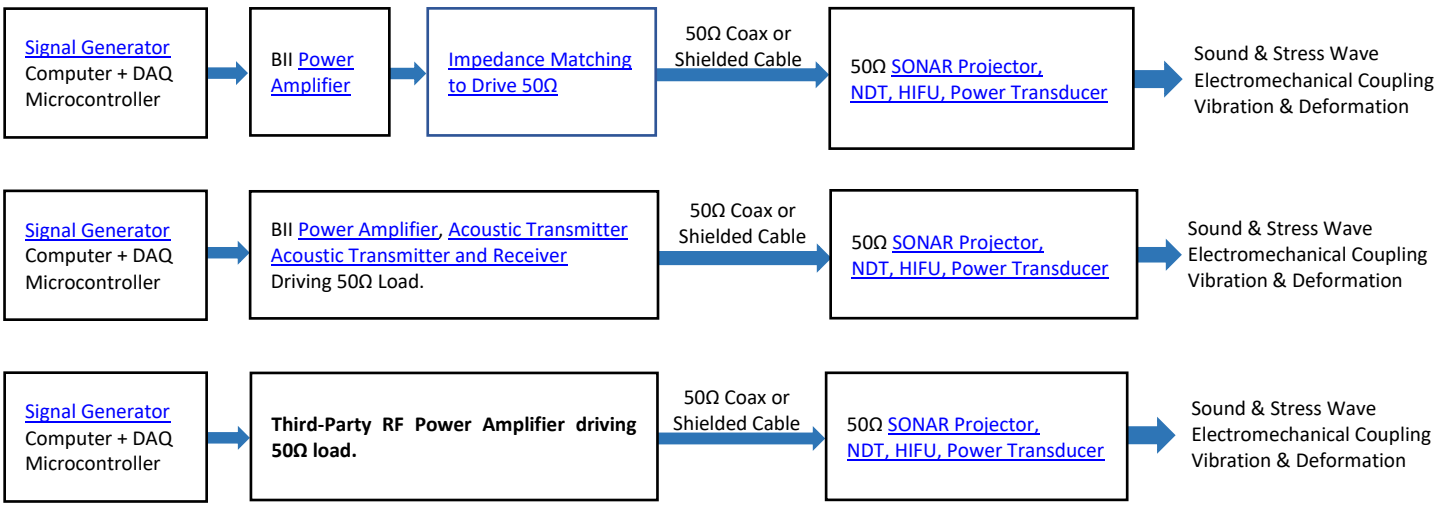
**Impedance Matching between Power amplifiers and Transducers.**
The cable has adverse effect on power transmission between the power amplifier and the transducer caused by cable's resistive, capacitive, and inductive performance in different frequency range. Transducer itself is resistive, capacitive, and inductive load at different frequency range. Therefore, an impedance matching unit is a necessary part between power amplifier and transducer for maximum power transmission and the best power factor.

**(1). Transducers without Built-in Impedance Matching**




a. **Driving voltage of transducer** is limited by voltage ratings of both cables and transducers.
b. **Grounding** are necessary for operating safety.
c. **Impedance mismatch** exists between cable and transducer. The mismatch can be ignored in low frequency range when cable length is much less than electromagnetic wavelength.
d. **This setup is favorable to hull-mounted or wall-mounted transducers**. The cables and/or wires are short among transducers and electronic driving circuits. In low frequency range, "Short Cable" means the adverse effects of its capacitance, resistance, and inductance on power transmission are little and can be ignored.
e. **Exchangeability among parts is poor**. Each transducer needs a bespoke impedance matching device to match its impedance to the one of a power amplifier.

**(2). 50Ω Impedance Matching**




**Advantage: The exchangeability among parts is excellent for easy maintenance, fast system recovery, lower cost, etc.**
BII transducers with built-in impedance matching are available in the product numbers IM (impedance equipped with the default 50Ω) or -IM50Ω (50Ω impedance matching). 50Ω is the most used impedance matching and is convenient for use with 50Ω coaxial cable.
According to the customer's specific power amplifier load requirements, customers can also customize transducers with other resistance values, such as IM2Ω, IM3Ω, IM5Ω, IM8Ω, IM16Ω, IM75Ω, IM100Ω, etc. When the cable characteristic impedance value, transducer impedance value and power amplifier load requirements are different, short cables must be used between the power amplifier and transducer to prevent the adverse effects of the cable on power transmission.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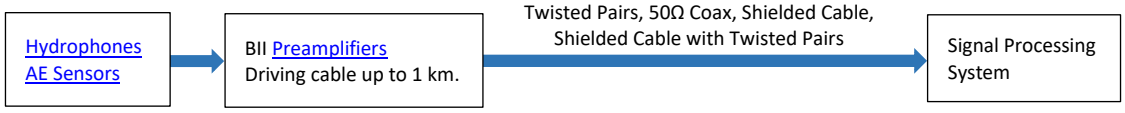
## How to Choose Components for Long Cable Deployment



Much information carried by underwater sounds, ultrasounds, vibrations, stress and shock waves is far from the sites where operators or recording and signal processing systems stand, or, the subjects under investigation or test are dangerous to human being or far from the central operating systems. These field applications are characterized by remote signal (or energy) detection, monitoring, transmitting, and control. As the distance increases between a transducer (hydrophone and projector) and its signal process system, a special set of instrumentation problems is encountered such as EMI noise pickup, signal attenuation over cable, cable cost, voltage potential differences among “grounds”, etc.

### Sound Detection




BII preamps provide flexible and bespoke cable driving solutions with current, single-ended voltage, or differential voltage to drive Twisted Pairs, 50Ω Coax, Shielded Cable, Shielded Cable with Twisted Pairs.

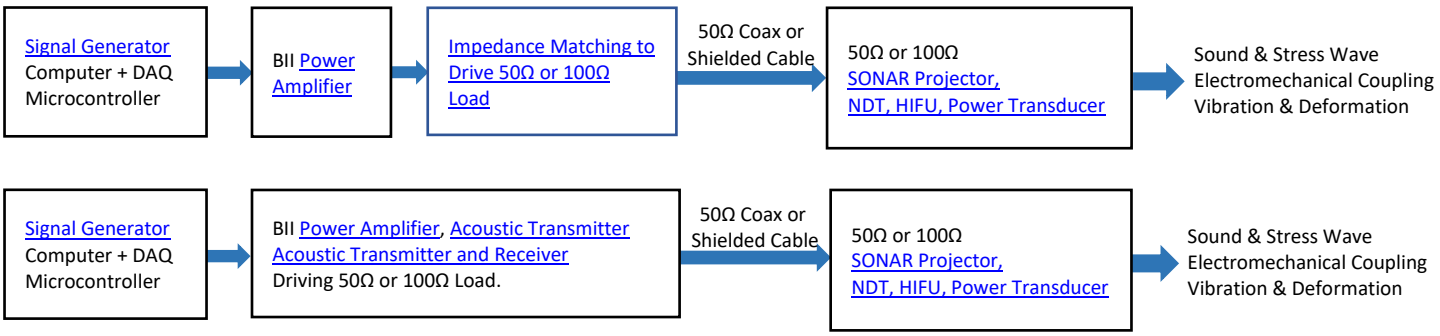
**A Twisted Pair** is best for lowest cost wiring solutions in low frequency range. Signals in current form is immune to voltage noise pickup, so shielding is not needed. The conductor resistance does not reduce signal current, so small gauge wire can be used. Buyer may make twisted pairs with single wire for special applications such as towed array wirings inside a streamer housing or conduit. BII differential preamp drives a twisted pair.

**A Shielded Cable with Twisted Pairs** is best for EMI rejection for low frequency voltage or current signal transmission over long cable, but generally it is much more expensive than other cables. BII stocks shielded cable with a twisted pair and PUR or PVC jacket.

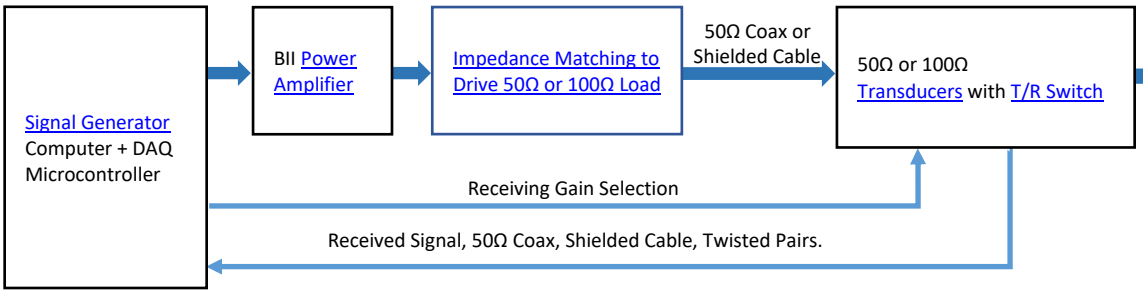
**A Shielded Cable with Multiple Conductors** is for single-ended and differential voltage signal transmission. Differential signal is superior to single ended signal with cancellation of common-mode noise voltage from magnetic induction, capacitive coupling, and ground potential differences or loops, etc. BII preamps drive shielded cable up to 1 km.

**A Coax Cable** such as RG58, RG174, RG178, or RG316 is for high frequency signal transmission. The coax shield provides adequate rejection to high frequency EMI. BII1040 and BII1090 series preamps achieve 20 MHz bandwidth.

### Sound Radiation




### Sound Radiation and Detection: SONAR and NDT





1. The shielded cable or coax provide means for grounding which is critical to operating safety.
2. EMI generated by conductors is reduced by grounded shielding.
3. Magnetic flux generated by a twisted pair will cancel each other.
4. Maximum transmitting power is limited by voltage and current ratings of the cables besides the power rating of the power amplifier.
5. In low frequency range such as 0.1 to 10 kHz, the high-power impedance matching unit is bulky and may not be suitable to be integrated into transducer housing.

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## How to determine pulse width, duty cycle and off-time with input pulse power (peak power)

This document is exclusively for choosing BII transducers and related BII products.
Refer to Typical Signals for Active SONAR, Ultrasound, HIFU (High Intensity Focused Ultrasound) and Communication for more information.

**$f_s$:** Series (Motional) Resonance Frequency. Generally, TVR and efficiency η of a transducer reach maximum values at $f_s$ and the transducer (projector) operates at $f_s$ to produce sound. **SL:** Source Level, in dB μPa*m; **T:** Temperature of the loading medium such as sea water, in °C, [(°C × 9/5) + 32 =°F]; **TVR**: Transmitting Voltage Response, in dB μPa*m/V; **$G_p$**: Equivalent Parallel Conductance of the Transducer, in Siemens S (or $\Omega^{-1}$). $G_p = G_{max}$ at $f_s$. $\boldsymbol{R_{TL}}$: normalized Load Resistance of the transducer such as a 50Ω transducer which, generally, has a built-in impedance matching network.
**IPP**: Input pulse power (peak power) driving a transducer, in RMS Watt; **MIPP**: Maximum Input Pulse Power of a transducer at $f_s$, in RMS Watt; **MCIP**: Maximum Continuous Input Power at $f_s$, in RMS Watt; **MPW**: Maximum Pulse Width at MIPP and at $f_s$, in Second; **PW**: Pulse Width (or Pulse Duration), in Second; **D**: Duty Cycle; **$t_{off}$**: Off-time. During off-time, the transducer stops energy conversion from electrical to mechanical and cools down in water.
Note: **MIPP, MCIP and MPW** are maximum values allowable to drive a transducer without over-heating and over-voltage.

1. Determine SL or RMS drive voltage $V_{rms}$ required by the application and obtain the temperature T of the loading medium in field.

2. Calculate IPP (input pulse power):

$$10 * logIPP = SL + 10 * logG_p - TVR, \qquad IPP = V_{rms}^2 * G_p, \qquad or, \ IPP = \frac{V_{rms}^2}{R_{TL}}$$

If $G_p$ and TVR of a transducer are not published online, please contact BII for the information.
If Impedance of the transducer ((Z, θ), or (R, X)) are published, $G_p$ can be deduced from impedance.

$$G_p = \frac{cos\theta}{Z} = \frac{R}{R^2 + X^2}$$

Generally, the voltage and current rating of a transducer cable is 600 $V_{rms}$ and 4 A or 10 A.
If the driving voltage required to achieve the SL is greater than 600 $V_{rms}$ or the voltage rating of the transducer cable, a built-in impedance matching network should be used to boost driving voltage for achieving greater output acoustic power (or SL).

3. Choose suitable transducers with IPP and MIPP at $f_s$.
Transducers with MIPP greater than IPP are suitable for the application. Warning: if IPP > MIPP at fs, the transducer would be damaged beyond repair with over-heat or over-voltage.
For example, an application needs IPP of 500 W to achieve required sound level, and we choose a BII transducer with MIPP of 1000 Watt, MPW of 1 Second, and MCIP of 10 Watt, at $f_s$. Loading medium is sea water, and its temperature is 17°C.

4. $PW \leq \frac{MIPP * MPW * \left(\frac{120℃ - T}{103℃}\right)}{IPP}$

PW ≤ 1000*1*1/500 = 2 (Seconds). That is, pulse width (duration) of 500W driving signal at 17°C sea water must be less than 2 seconds.

5. $D \leq \frac{MCIP * \left(\frac{120℃ - T}{103℃}\right)}{IPP}$

D ≤ 10*1/500 = 2%. That is, duty cycle of 500W driving signal at 17°C sea water must be less than 2%.

6. Off-time **$t_{off}$** ≥ Pulse Width*(1-D)/D.

**$t_{off}$** ≥ 98 Seconds, when PW=2 seconds.
**$t_{off}$** ≥ 49 Seconds, when PW=1 second.
**$t_{off}$** ≥ 4.9 Seconds, when PW=100 ms.
**$t_{off}$** ≥ 490 ms , when PW=10 ms.
**$t_{off}$** ≥ 49 ms , when PW=1 ms.
etc. …

After driving the transducer for 2s at 500W, the transducer must be off and allow it to cool down in the 17°C water for 98 seconds at least before driving it again.
…
After driving the transducer for 1ms at 500W, the transducer must be off and allow it to cool down in the 17°C water for 49 milliseconds at least before driving it again.

7. If calculated PW and D do not meet the requirements of the application, please choose another transducer and re-evaluate it by repeating step 2 to step 6 listed above; or consider using an array. **For a planar array of N element parallel-mounted transducers, the sound level of the array will increase by 20*log$_{10}$N and the narrower beam width will be achieved by comparing the sound level and beam width of the single element.**

8. After a suitable transducer is chosen, and IPP, PW and D are checked out completely, it is time to choose power amplifier and impedance matching network.
a. Choose the power amplifier which can be used with the IPP, PW and D.
Note: power amplifiers with maximum power rating less than transducers' MIPP are recommended to use. This can reduce the possibility of damaging transducers with over-power (or over-voltage) by accident.
b. Find out the load requirements from the specification of the power amplifier.
Most RF power amplifiers drive 50Ω load, and most audio power amplifiers drive 2 Ω to 32Ω.
BII power amplifiers drive 2 Ω to 32Ω from 20Hz to 3MHz, and BII's bespoke power amplifier drive 50Ω up to 10MHz.
c. BII's BII6000 series provide impedance matching between transducers and power amplifiers at specified operating frequency (generally, at fs). There are two packages available: an impedance matching unit is built inside transducer housing or is manufactured inside a separate housing as a standalone unit.

9. Contact BII about your request on transducers and impedance matching units.

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## Useful Acoustic Formulae of Transducers (Projectors and Hydrophones)

**Unit Conversion**

**Free-field Voltage Sensitivity FFVS:** -180 **dB V/μPa** = $10^{-180/20}$ V/μPa = $10^{-9}$ V/μPa = $10^{-3}$ V/Pa = 1 mV/Pa = $10^{-3-6}$ V/μPa = 20*$Log_{10}(10^{-9})$ dB V/μPa = -180 **dB V/μPa.**

**Transmitting Voltage Response TVR:** 180 **dB μPa/V at 1m** = $10^{180/20}$ μPa/V@1m = $10^{9}$ μPa/V@1m = $10^{3}$ Pa/V@1m = 20*$\log_{10}10^{3+6}$ dB μPa/V@1m = 180 **dB μPa/V at 1m**.

**Impedance Z and Admittance Y.**

$Z = R + jX = \frac{G}{G^2+B^2} - \frac{jB}{G^2+B^2}$; $Y = G + jB = \frac{R}{R^2+X^2} + \frac{jX}{R^2+X^2}$. $|Z| = \frac{1}{|Y|} = \sqrt{R^2+X^2} = \frac{1}{\sqrt{G^2+B^2}}$; $Impedance\ Phase\ \theta = \tan^{-1}\frac{X}{R} = -\tan^{-1}\frac{B}{G}$.

R: Resistance, X: Reactance, G: Conductance, B: Susceptance.

**Bandwidth or Quality Factor $Q_e$ and $Q_m$.**

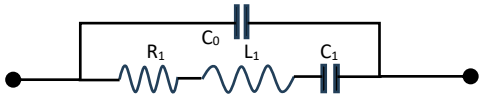
**Untuned Transducer**: Electrical $Q_e$ at $f_s$ = $\omega_s C_0 * R_1$ = $B_0/G_{max}$; Mechanical $Q_m$ at $f_s$= $1/(\omega_s C_1 * R_1)$ = $G_{max}/B_1$.

**Tuned Transducer** ($C_0$ is cancelled out by Inductance) -3dB Bandwidth at fs = $f_s/Q_m$ = $f_s * B_1/G_{max}$.

Parallel Resonance Frequency $f_p = f_s\sqrt{1 + C_1/C_0}$, which **maximum FFVS** is achieved at.

fs: Mechanical Resonance Frequency or Series resonance frequency which **maximum TVR** is achieved at.

The info above-mentioned is useful to choose transducers (hydrophone, projector, and T/R Transducers.).



Equivalent Circuit of BII Transducer around Resonance

Parameters of a Broadband (Low Q) Transducer (300kHz, Φ18mm Planar Aperture): $C_0$ = 0.568 nF, $C_1$ = 0.517 nF, $L_1$ = 0.611 mH, $R_1$ (Material Loss and Radiation Resistance) = 260 Ω.

**Useful Acoustic Formulae**:

| | | | |
|---|---|---|---|
| **Directivity, Main Lobe Width:** | Linear Transducer: $\theta_{-3dB}$ (°) = 50.8*λ/L at L > λ, λ: Wavelength, L: Length. | | |
| | Disk Transducer: $\theta_{-3dB}$ (°) = 58.9*λ/D at D > λ, λ: Wavelength, D: Disk Diameter. | | |
| **Transducer SL (Source Level):** | SL = TVR + 20*log ($V_{rms}$), dB re μPa @ 1m.<br>TVR: Transmitting Voltage Response. $V_{rms}$: (Root Mean Square) Driving Voltage of Transducers. | | |
| **Transducer SL (Source Level):** | SL = 10*log($P_{in}$) + 10*log(η) + DI + 170.8, dB re μPa@1m.<br>$P_{in}$: Input Electrical Power. η: Electroacoustic Efficiency. DI: Directivity Index. | | |
| **Input Power:** | $P_{in} = V_{rms}^2 * G$. G: Parallel Conductance of Transducer. | | |
| **Distance d of Acoustic Far Field of a Transducer:** | **Planar Transducer**: d ≥ Radiation Area/λ.<br>**Line (linear) or Thin Cylinder:** d ≥ (Length*Length)/λ and d ≥ Length. | | |
| **Hydrophone/Acoustic Sensor $V_{rms}$:** | $V_{rms}$ = SPL + FFVS, dBV. SPL: Sound Pressure Level (dB re μPa). FFVS: Free Field Voltage Sensitivity (dB re V/uPa). dBV = 20*log(Voltage). | | |
| **Transducer as a High Pass Filter:** | A transducer or hydrophone (no preamp) with a parallel resistor is a high pass filter: $f_{-3dB} = 1/(2\pi R_i C_h)$.<br>$R_i$: Input Resistance or Impedance of a Preamp or A/D Converter.<br>$C_h$: Capacitance of a Transducer or Hydrophone at 1 kHz or $f_s$. | | |
| **Signal Loss Over Extension Cable or a Capacitor:** | 20*log[$C_h/(C_h+C_c)$], dB.<br>$C_h$: Hydrophone Capacitance. $C_c$: Capacitance of Extension Cables or Capacitors in Parallel. | | |
| **Underwater Sound Transmission Loss:** | Spherical Spreading: TL = 20 * log R. R – Range, m.<br>Absorption Coefficient (≤50 kHz): α (dB/km)) = 1.0936 [$0.1*f^2/(1+f^2) + 40*f^2/(4100+f^2)$]. f: frequency (kHz). | | |
| **Attenuation/Absorption Coefficient of Sediments:** | around 0.06f to 0.6f (dB/(m*kHz)). | | |
| **Electrical Power Loss over Cable:** | Power Loss over cable = $2*I_{rms}^2*R*L$.<br>$I_{rms}$: RMS Cable Current. R: Nominal Conductor Resistance, about 0.035 Ω/meter. L: Cable Length (meter). | | |
| **Signal Detection:** | C = B*log(1+SNR)/log2. SNR = SL – TL – NL - DI, or SNR = SL - 2TL + TS – NL + AG.<br>C: Channel Capacity. B: Channel Bandwidth. SNR: Signal-to-Noise Ratio. | | |
| **Constants:** | Free Dielectric $\varepsilon_o$ = 8.842 x $10^{-12}$ C/mV.<br>Sound Speed in Sea Water: C = 1449.2+4.6T-0.055$T^2$+0.00029$T^3$+(1.34-0.010T)*(S-35)+0.012z (m/s).<br>T: Temperature, °C. S: Salinity, parts per thousand of dissolved weight of salts. z: Depth, meter.<br>Sound Speed in Fresh Water: C = 1481 m/s. Density of Sea Water: 1026 kg/$m^3$. Fresh Water: ρ = 998 kg/$m^3$. | | |
| **Ocean Sound Sources** | **Frequency Range** | **Ocean Sound Sources** | **Frequency Range** |
| Vessel Traffic: | 5 to 500 Hz | Drill Ship: | 10 to 20,000 Hz |
| Airgun (Seismic Reflection Profiling): | 5 to 1,000 Hz | Ice: | 10 to 1,000 Hz |
| Earthquake: | Up to 100 Hz | Ocean Surfaces: | 1 to 50,000 Hz |
| Biologic (Sea Animal) Sounds: | Several Hz to 150 kHz | Turbulent Pressure Fluctuation: | 1 to 100 Hz |

| **Absorption of Sound in Air at 20°C (68°F), Relative Humidity: 10%, 1 atm.** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Frequency (kHz) | 30 | 40 | 50 | 70 | 100 | 120 | 150 | 200 | 250 | 300 | 500 | 1000 |
| Absorption (dB/m) | 0.3 | 0.4 | 0.5 | 0.7 | 1.8 | 2.5 | 4.0 | 6.5 | 10 | 16 | 43 | 200 |

| **Planar Transducer:** | 33 kHz | 50 kHz | 70 kHz | 120 kHz | 200 kHz | 300 kHz | 420 kHz | 600 kHz |
|---|---|---|---|---|---|---|---|---|
| **Cavitation Threshold: at Sea Surface, (dB μPa)** | 203 | 206 | 209 | 214 | 214 | 217.5 | 220 | 223 |

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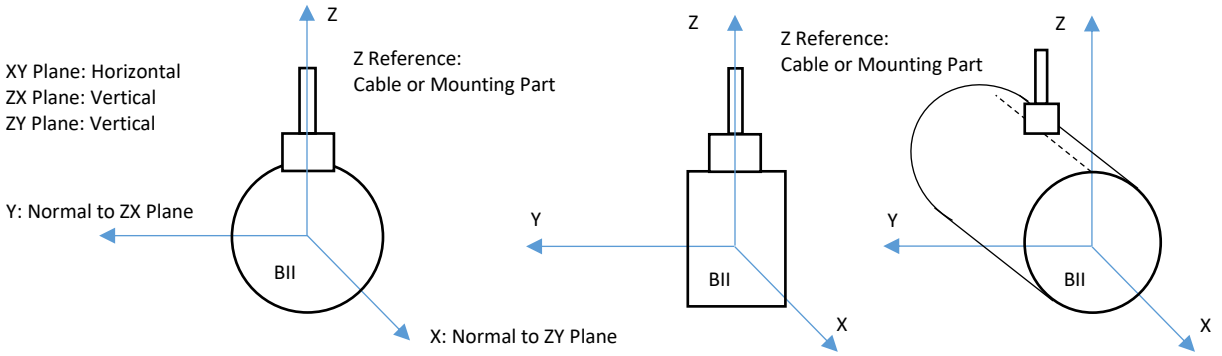
## Testing and Calibration

**Underwater Electroacoustic Measurements**

**FFVS** (Free-field Voltage Response) or **RVR** (Receiving Voltage Response), **TVR** (Transmitting Voltage Response), **Directivity Pattern** (Beam Pattern).
**Impedance Measurement**: Z-Θ, R-X, G-B, Equivalent Circuit Model.
**Power**: Efficiency, Power Factor, Quality Factor (Bandwidth).
**Environmental Testing**: Pressure, Thermal (Temperature), Electric Field (or Voltage Rating).
**Calibration Methods**: BII uses primary methods (or reciprocal calibration) and secondary method (or comparison calibration) from 26 Hz to 10 MHz.

**Hydrophone and Transducer (Projector) Orientation**




**BII's TVR and FFVS Testing:**

Spherical and cylindrical hydrophones/transducers: in XY plane
Hemispherical hydrophones/transducers: on acoustic axis normal to the hemispherical face.
Curved/sector hydrophones/transducers: on acoustic axis normal to the curved face.
Circular planar hydrophones/transducers: on acoustic axis normal to the receiving or transmitting face.
Rectangular planar hydrophones/transducers: on acoustic axis normal to the receiving or transmitting face.
Note: Acoustic axis is perpendicular to the transmitting/receiving face and passes through the geometry center of the face.


**Signal Level is too weak:**

If the signal level generated from transducers or hydrophones is much less than the expected. The major reasons are followings:
1. Spot of signal detection is NOT on the acoustic axis of maximum response. Make sure the detection spot is on acoustical axis of directional transducers or hydrophones.
2. Standing waves or echo interferences in small body of water. Use larger body of water to reduce reflection from boundaries.

**Tolerance and Accuracy of Electroacoustic Measurement**

| **Ambient Temperature:** | 23 ± 2 °C | | |
|---|---|---|---|
| **Transducer Parameters** | **Tolerance** [1] | **Accuracy** | **Note** |
| **Resonant Frequency in water:** | Nominal ±10% | 7 ppm ±1 mHz (at 5 to 40 °C, typical) [2] | Loaded with Water |
| **Capacitance in water:** | Nominal ±10% | ±0.08% (±0.045% typical) [2] | Test with Low Electrical Field at 1 kHz |
| **Impedance/Admittance in water:** | Nominal ±10% | ±0.08% (±0.045% typical) [2] | G-B, Z-θ, or R-X |
| **-3 dB Beam width (°):** | Nominal ±2° | ±0.3° (±0.1° to ±0.2° typical) [2] | -3 dB Angle of Main Lobe |
| **TVR (dB µPa/V@1m):** | Nominal ±3 dB | ±1.0 dB (±0.5 dB typical) [3] | Transmitting Voltage Response |
| **FFVS or RVR (dB V/µPa):** | Nominal ±3 dB | ±1.0 dB (±0.5 dB typical) [3] | Receiving Sensitivity |

Note:
1. The tolerance is the variation from the nominal value stated in datasheet and is caused by repeatability of manufacturing processes and parameter variations of raw materials from batch to batch.
2. These values of accuracies are from third-party's measuring instrument.
3. Theoretical calculation from specifications of third parties' measuring instruments of Voltage, Frequency, Time, Impedance and Dimension. Handbook values of densities are used. Sound velocities measured at BII are used.

**How Often Should the Transducer (Projector and Hydrophone) be Recalibrated?**

If a major disturbance (a field parameter exceeds the maximum value stated in datasheet) such as a high temperature, high driving voltage or a high pressure is applied to a transducer, the transducer needs to be recalibrated.
Piezoelectric materials used in BII standard transducers (Projector and Hydrophone) have average ageing time of 1 to 3 years. BII carefully manages the material inventory to allow enough ageing time to stabilize piezoelectric materials. FFVS variation of a BII reference hydrophone used in comparison calibration ΔFFVS ≤ ± 0.2 dB at 1kHz in five years. BII does not have suggestions on recalibration of these standard/reference transducers. The recalibration shall reference to the metrology policies or regulations of end user's country.
Average ageing time of customized new transducers is one month. It is suggested to recalibrate these transducers in field after one-year field use.

**Does BII Provide Calibration Service?**

Yes, BII provides calibration services to BII transducers with reasonable fees and different calibration packages to suit end users' different requirements.

**Certified Underwater Sound Measurements**

The Institute for National Measurement Standards is a country's national metrology institute responsible for evaluation of standards and methods of measurement. Its Calibration Laboratory Assessment Service provides quality system, technical assessment services and certification of specific measurement capabilities of calibration laboratories.
BII's Underwater Electroacoustic Measurement Laboratory is NOT certified by National Metrology Institute in Canada. If a buyer needs measurement certified by National Metrology Institute, the buyer should have BII's products calibrated by certified calibration laboratories at buyer's cost in buyer's country. The national acoustic and naval laboratories in most countries provide certified underwater sound calibration services.

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## Measurements of Ferroelectric and Piezoelectric Materials

**Ferroelectric and Piezoelectric Material Test:**

D-E or P-E Hysteresis Loop. Dielectric Constant and Loss in low and high filed (Electric Field, Stress and Temperature). Piezoelectric Constants: d and g constants.

The Equations of state of piezoelectric effect: $\boldsymbol{D = dT + \varepsilon^T E \ and \ S = s^E T + dE}$

Thermodynamics of Ferroelectric/Piezoelectric Medium: Gibbs Functions G = U – S*T – E*D – H*B – σ*θ.

Energy Loss Density per Hysteresis Loop of Ferroelectric/Piezoelectric Materials = ∫DdE.

Piezoelectric Strain Constant d, Polarization P, Dielectric Constant ε and Electrostrictive Constant q: d ≈ 2q*ε*P.

Dielectric Susceptibility χ, Internal Field Constant γ, Polarizability α, Entity Density N: χ = N*α/(ε₀*(1-N*α*γ)).

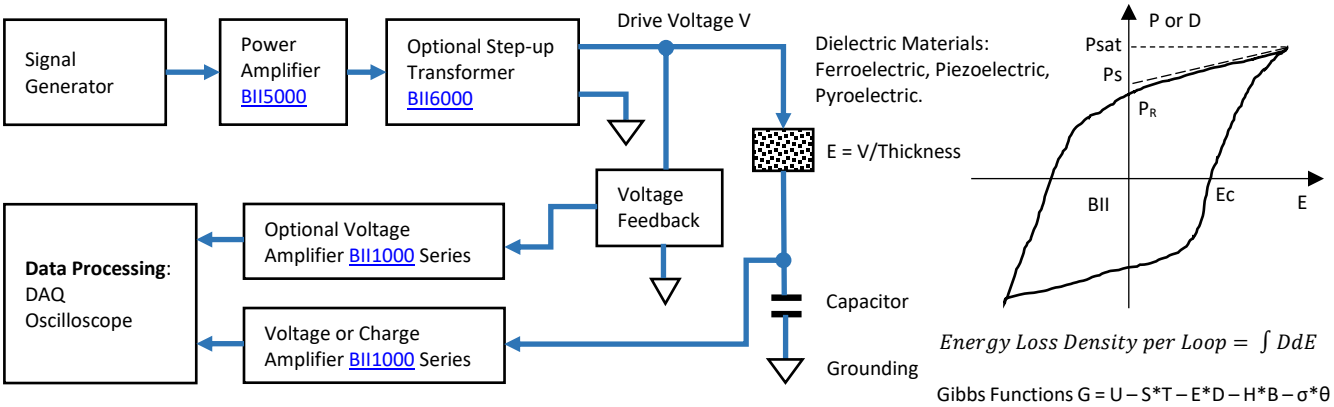
Debye Equation: $\varepsilon_r^* = \varepsilon_{r\infty}' + (\varepsilon_{rs}' - \varepsilon_{r\infty}')/(1 + j\omega/\omega_r)$. $\omega_r$: Relaxation Frequency.

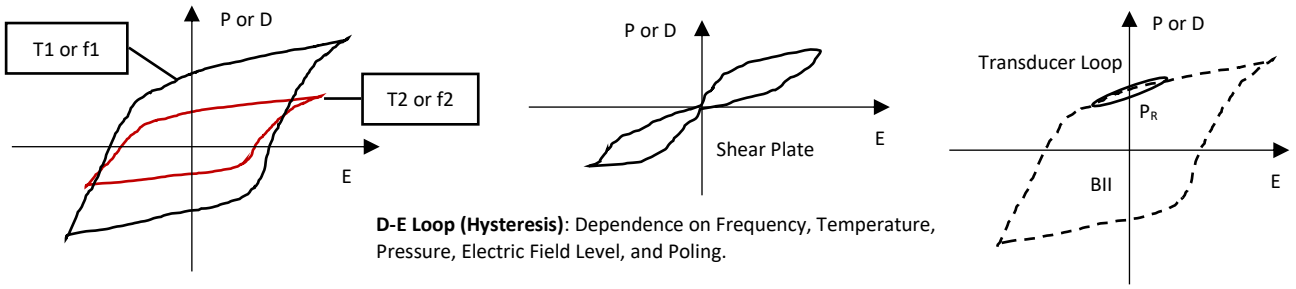
Note: 1. BII electronic components are custom fit to a specific measurement system. Please contact and discuss with BII about your specs.

2. The block diagrams are for illustration ONLY, some parts are not shown such as DC power suppliers.

**Studies of Ferroelectric and Piezoelectric Materials**. BII manufactures electronic components measuring properties of dielectrics (pyroelectric, ferroelectric and piezoelectric materials) from 30 Hz to 10 MHz: Power Amplifiers, Voltage Step-up Transformers, Charge and Voltage Amplifiers. BII power amplifiers can drive the materials directly down to 1 Hz if transformers are not used to step up voltage. Parameters and performances of the material are measured at working conditions. Therefore, the performance prediction of transducers is accurate in the design phase with these material data.

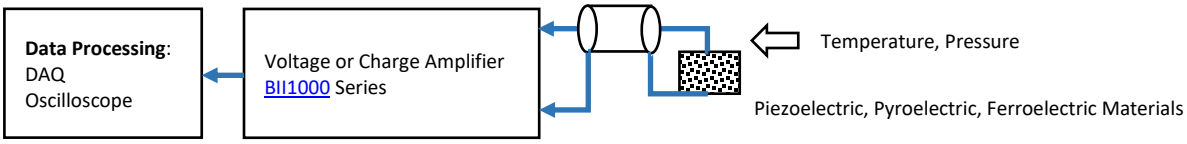
**D-E or P-E Hysteresis Loop and S-E**. A wideband measurement system of high electric field and/or low electric field can be set up with these components to test P-E (or D-E ) hysteresis (Sawyer-Tower Circuit), Strain-Electric Field, dielectric constant, energy loss (dissipation factor or loss tangent tanδ), and their dependence on driving field, frequency, temperature and pressure (axial or hydrostatic).




**D-E Loop (Hysteresis)**: Dependence on Frequency, Temperature, Pressure, Electric Field Level, and Poling.

**Direct Measurement of Piezoelectric Constants.** With standard test weights and BII amplifiers, a low-cost simple quasi-static absolute measurement system can be set up to measure piezoelectric strain and/or voltage constants with reasonable accuracy: $d_{31}$, $d_{33}$, $d_h$, $g_{31}$, $g_{33}$ and $g_h$. The direct method has no limitation on material sizes and shape comparing to the resonance method and does not require a piezoelectric reference material comparing to the comparison method. To maintain high measurement accuracy, the amplifiers can be calibrated whenever needed with standard laboratory electronic instruments such as signal generators and oscilloscopes, etc... Thanks to the high gain of the operational amplifier, the capacitances of the material under test and the cable have little effect on the charge measurement, or BII's charge amplifiers provide "**short circuit" condition or constant E for d constant measurement**. BII's high impedance voltage amplifiers provide **"open circuit" condition or constant D for g constant measurement**. Besides, the amplifiers can also be used to measure the effects of thermal/temperature, pressure, electrical field on Ferroelectric and Piezoelectric materials such as thermal and pressure depoling.




**Impedance Spectroscopy.** A customized impedance measurement system can be configured with BII's electronic components to study the material response to the applied electric field from 1 Hz to 10 MHz. The impedance of a material is computed over a range of frequencies with measured V and I. Material properties such as energy storage, dissipation, relaxation and polarization are revealed from the impedance.

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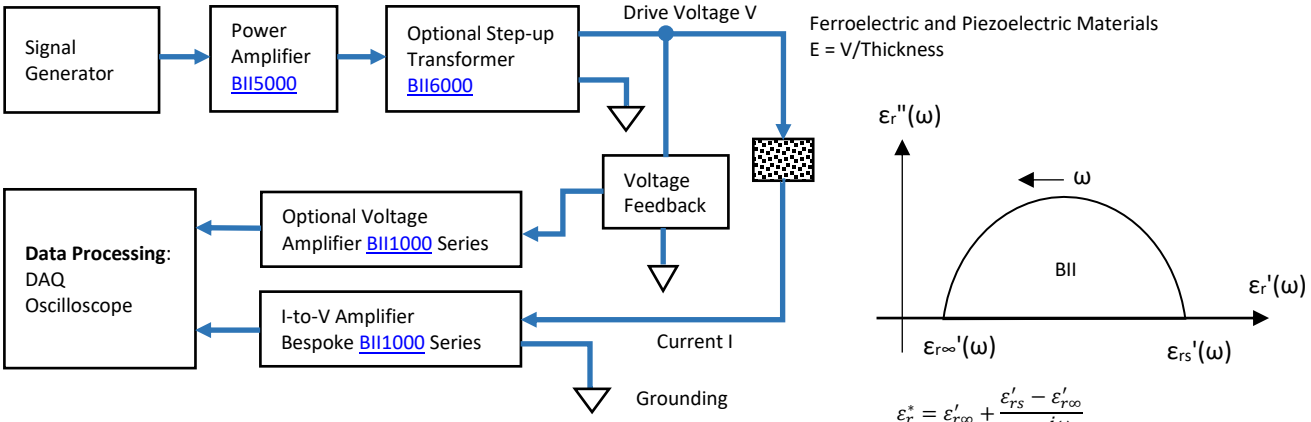


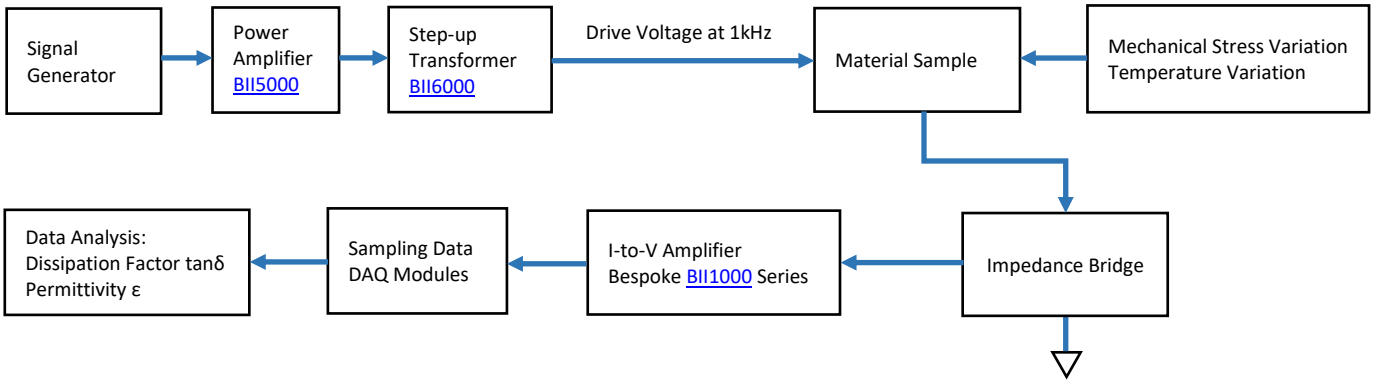

$$\varepsilon_r^* = \varepsilon'_{r\infty} + \frac{\varepsilon'_{rs} - \varepsilon'_{r\infty}}{1 + \frac{j\omega}{\omega_r}}$$

$\omega_r$: *Relaxation Frequency*

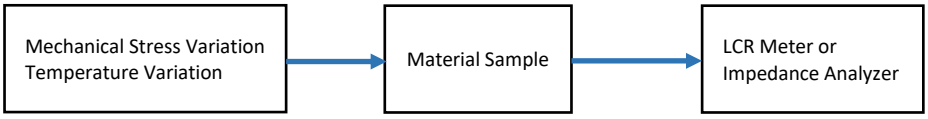
Impedance = V/I = Z*cosθ + jZ*sinθ. Dissipation Factor D = Loss Tangent tanδ = cotθ.
Quality Factor Q = tanθ. I = (jωε' + ωε")*$C_0/\varepsilon_0$*V. tanδ = ε"/ε'. Power Factor = cosθ.

**Large Signal Piezoelectric Properties.** High driving electrical field increases dielectric constant and loss factor of the piezoelectric material. The piezoelectric constants d and k are functions of dielectric constants. The increase of tanδ dissipation factor results in higher temperature which may destroy the piezoelectric transducer. Dielectric constants and loss factors of the materials for high power operation may be measured at various field levels (up to 600 Vrms/mm) at 1 kHz under isothermal conditions. Effects of mechanical stress (pressure) and/or temperature on piezoelectric properties need to be measured as well.

**High Field Measurement:**




**Low Field and Ageing Measurement:**

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## Electronic Performance Test

**Parameter Measurements of Preamplifiers, Power Amplifiers, Impedance Matching Unit and T/R Switches**

Beside standard tests such as Gain vs Frequency, -3dB cut-off frequencies, power consumption, etc.., following performance tests are available up to 1.5MHz upon request when ordering:

1. THD+N ratio and THD+N level measurements

$$THD + N\ ratio = 20log_{10}\left(\frac{rms\ value\ of\ noise\ and\ distortion}{rms\ value\ of\ signal, noise, and\ distortion}\right)$$

2. SINAD measurement

$$SINAD = 20log_{10}\left(\frac{rms\ value\ of\ signal, noise, and\ distortion}{rms\ value\ of\ noise\ and\ distortion}\right)$$

3. THD ratio and THD level measurements

$$THD\ ratio\ = 20log_{10}\left(\frac{rms\ value\ of\ distortion}{rms\ value\ of\ signal\ and\ distortion}\right)$$

4. SMPTE IMD measurements

The SMPTE IMD function provides a measure of the second and third order intermodulation distortion introduced by the DUT by injecting two pure tones (tone 1 and tone 2, where tone 1 is at a much lower frequency than tone 2, for example, 20 Hz and 3.5 kHz respectively) into the DUT. SMPTE IMD is expressed in dB (default) or as a percentage.

If tone 1 = f1 and tone 2 = f2, the following harmonics are considered.

– f2 – f1
– f2 + f1
– f2 – 2f1
– f2 + 2f1

The SMPTE IMD value is computed as the ratio of the sum of the intermodulation harmonics amplitude to the upper frequency tone amplitude.

5. DFD measurements

The DFD measurement is similar to SMPTE IMD, except that the two tones in the stimulus signal are of equal amplitude and are spaced closer to each other (typically 28 kHz and 30 kHz).

6. SNR measurement

$$SNR\ = 20log_{10}\left(\frac{rms\ value\ of\ signal}{rms\ value\ of\ noise}\right)$$

7. Phase Measurement

Phase measurements are used to describe the positive or negative time offset in a periodic waveform cycle (such as a sine waveform), measured from a reference waveform. Phase is expressed in degrees (°) and varies with frequency.

8. Crosstalk Measurement

In Sonar systems with more than one channel such as an array with beam steering and/or amplitude shading, it is common for a signal in one channel to appear at the output of another channel at a reduced level. Crosstalk refers to this signal leakage across channels, and it is expressed in dB (default) or as a percentage. Crosstalk is a measurement of the ratio of the signal amplitude in an unused channel relative to that of a channel driven with a signal. Crosstalk is largely due to capacitive coupling between the channel conductors in the device and generally varies with frequency. Crosstalk can be computed as follows.

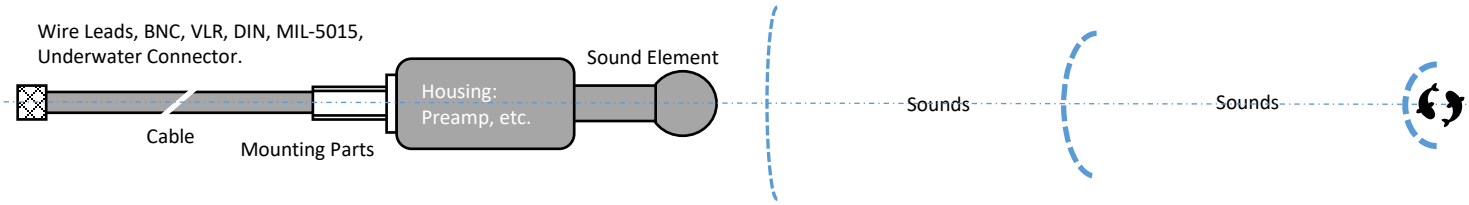
$$Crosstalk\ = 20log_{10}\left(\frac{rms\ value\ of\ signal\ measured}{rms\ value\ of\ signal\ driven}\right)$$

## Ordering Information

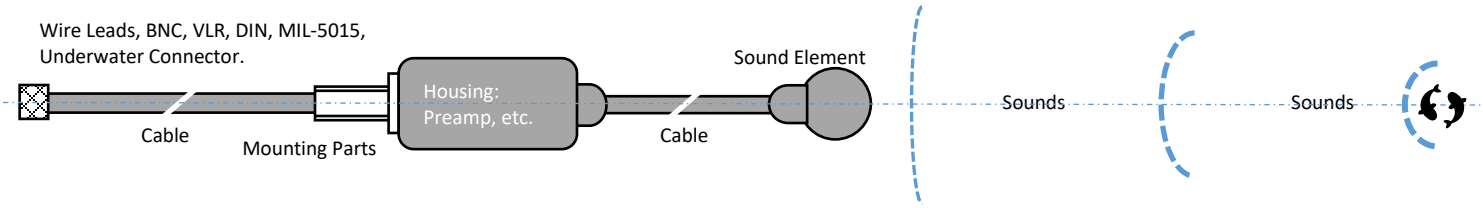
## How to Order Hydrophones, AE Sensors, Ultrasonic Receivers, and Wave Height Sensors

**Transducer Structure with Electronic Module (Preamp, Filters, AGC Amp, etc.) and Sound Element.**

1. **Default Transducer Structure**: Sound Element is potted in Housing of Electronics.



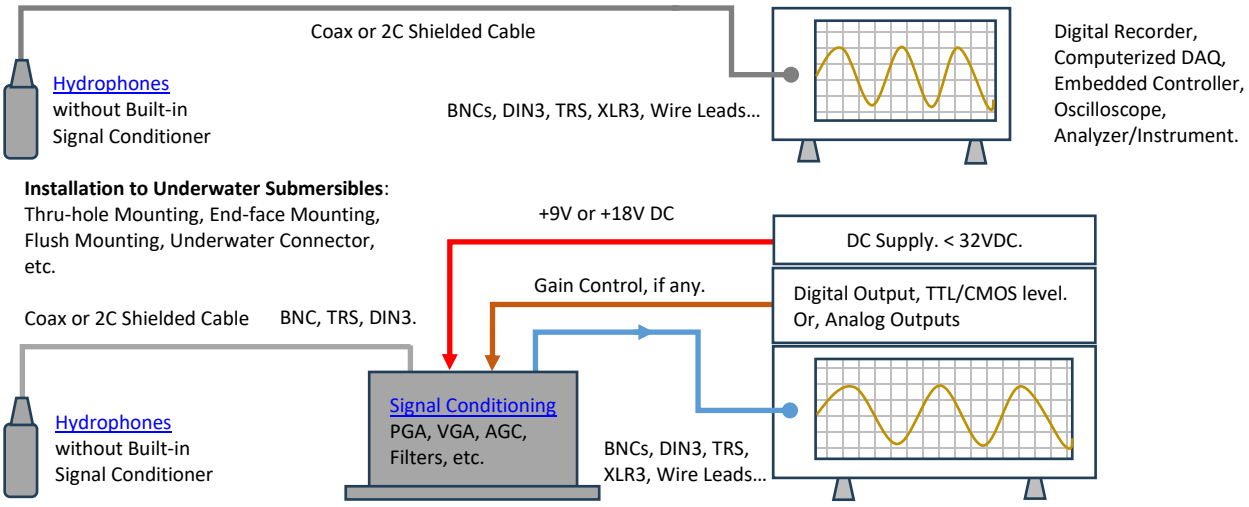

2. **Bespoke Transducer Structure**: Sound Element is separated from Housing of Electronics with cable of bespoke length.




**How to Order Sound Receiving Devices Which Do NOT Have Built-in Preamp and Filters**

| **Hydrophone Part Number** | **-Mounting Part** | **-Cable Length** | **-Cable Type** | **-Connector Type** |
|---|---|---|---|---|
| BII7xxx | Mounting Options. | in meter. | Cable Options. | Connector Options. |
| **Example:** | **Description** | | | |
| BII7xxx-FH-6m-RG174-BNC | BII7xxx Hydrophone, Free Hanging, 6m RG174 Coax, BNC Male. | | | |
| BII7xxx-BFMP-NPT3/8"-6m-RG174-BNC | BII7xxx Hydrophone, Bolt-fastening Mounting: BFMP-NPT3/8", 6m RG174 Coax, BNC Male. | | | |
| BII7xxxDW-THM-7/16"-0.6m-SC36-WL | BII7xxxDW Hydrophone, Thru-hole Mounting THM-7/16", 0.6m Shielded Cable SC36, Wire Leads. | | | |
| BII7xxx-HT-FH-6m-RG178-BNC | BII7xxx Hydrophone, Service Temperature: -10 °C to 120 °C (14 °F to 248 °F). Free Hanging, 6m RG178 Coax, BNC Male. | | | |
| BII7xxxDF-FH-0.6m-SC65-UMC3P | BII7xxxDF Hydrophone, Free Hanging, 0.6m Shielded Cable **SC65**, 3-pin Underwater Mateable Connector. | | | |

**System Configuration of Receiving Sounds and Waves.**





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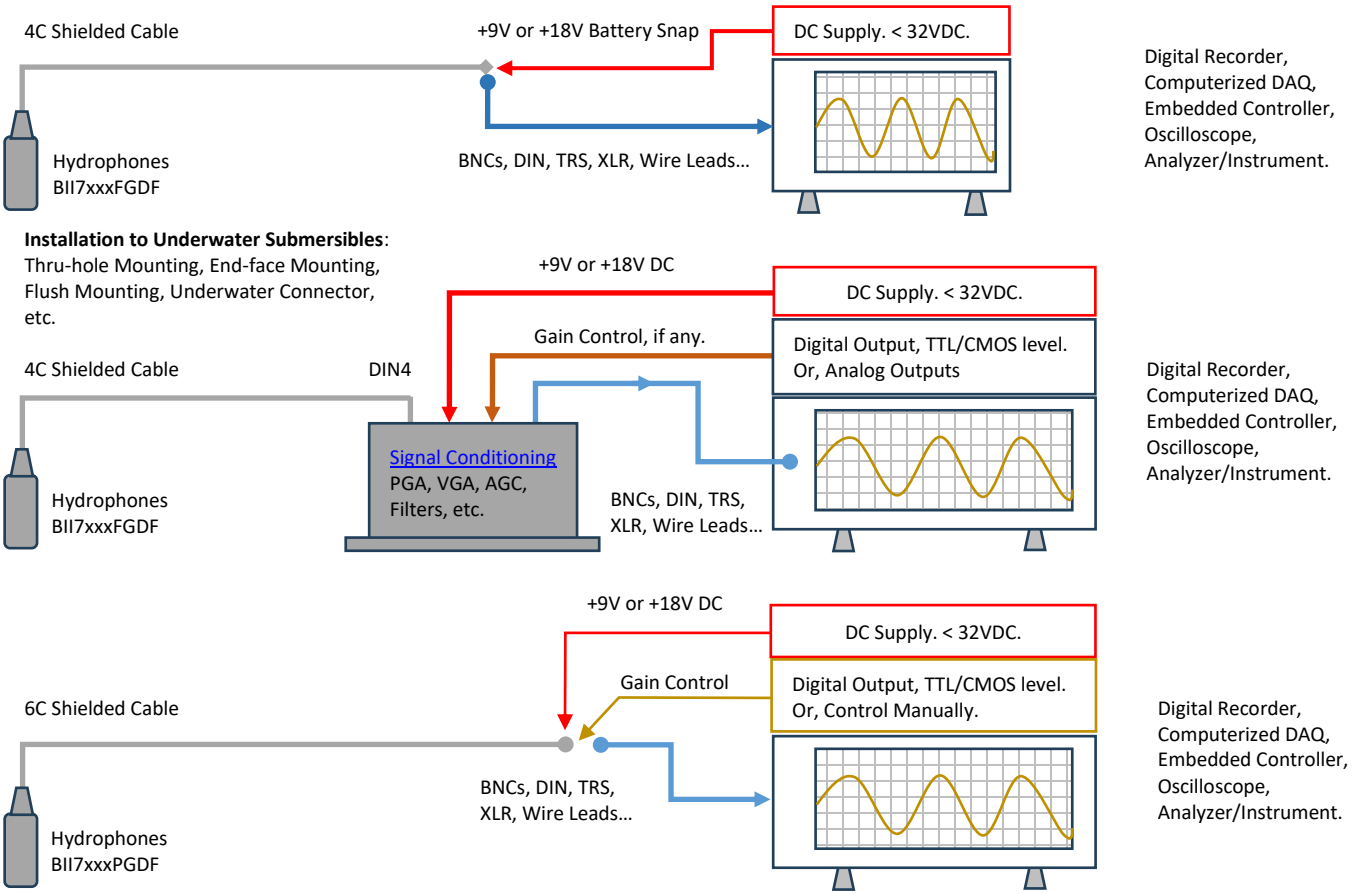
**How to Order Sound Receiving Devices Which Have Built-in Preamp and Filters**

| **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** | **-Preamp Gain** | **-HPF or HPF/LPF** | **-Mounting** | **- Cable Length** | **-Connectors for Signal/Gain Selection/DC Supply** |
| BII7XXXFGDF<br>BII7XXXPGDF | Fixed, in dB.<br>Gain Options. | -3dB Filter frequencies | Mounting Options. | in meter.<br>Up to 305m (1000 ft). | Connector for Signals, Gain Selection (if any), and DC Supply. |
| **Example of Part Number:** | | | **Description** | | |
| BII7XXXFGDF-26dB-10Hz-BFM-7/16”-100m-DIN3/BS | | | BII7XXXFGDF Hydrophone, Gain: 26dB, High Pass Filter: 10Hz, Bolt Fastening Mounting BFM-7/16”, 100m Shielded Cable, Connector: 3-pin DIN for Signals and Battery Snap for +9VDC Batteries. | | |
| BII7XXXFGDF-26dB-10Hz-BFM-7/16”-100m-XLR3/BS | | | BII7XXXFGDF Hydrophone, Gain: 26dB, High Pass Filter: 10Hz, Bolt Fastening Mounting BFM-7/16”, 100m Shielded Cable, Connector: 3-pin XLR for Signals and Battery Snap for +9VDC Batteries. | | |
| BII7XXXFGDF-26dB-10Hz-BFM-7/16”-100m-DIN4 | | | BII7XXXFGDF Hydrophone, Gain: 26dB, High Pass Filter: 10Hz, Bolt Fastening Mounting BFM-7/16”, 100m Shielded Cable, Connector: 4-pin DIN for Signals and DC Power Supply. | | |
| BII7XXXFGDF-26dB-10Hz-FH-0.6m-UMC4P | | | BII7XXXFGDF Hydrophone, Gain: 26dB, High Pass Filter: 10Hz, Free Hanging, 0.6m Shielded Cable, Connector: 4-pin Underwater Mateable Connector for Signals and DC Power Supply. | | |
| BII7XXXPGDF-10/50dB-10Hz-BFM-7/16”-100m-DIN3/WL/BS | | | BII7XXXPGDF Hydrophone, Gain: 10 & 50dB, High Pass Filter: 10Hz, Bolt Fastening Mounting BFM-7/16”, 100m Shielded Cable, Connector: 3-pin DIN for Signals, Wire leads for Gain Selection, and Battery Snap for +9VDC Batteries. | | |
| BII7XXXPGDF-20/50dB-10Hz/300kHz-BFM-7/16”-100m-XLR3/WL/BS | | | BII7XXXPGDF Hydrophone, Gain: 20 & 50dB, Bandpass Filter: 10Hz to 300kHz, Bolt Fastening Mounting BFM-7/16”, 100m Shielded Cable, Connector: 3-pin XLR for Signals, Wire leads for Gain Selection, and Battery Snap for +9VDC Batteries. | | |

**System Configuration of Receiving Sounds and Waves.**

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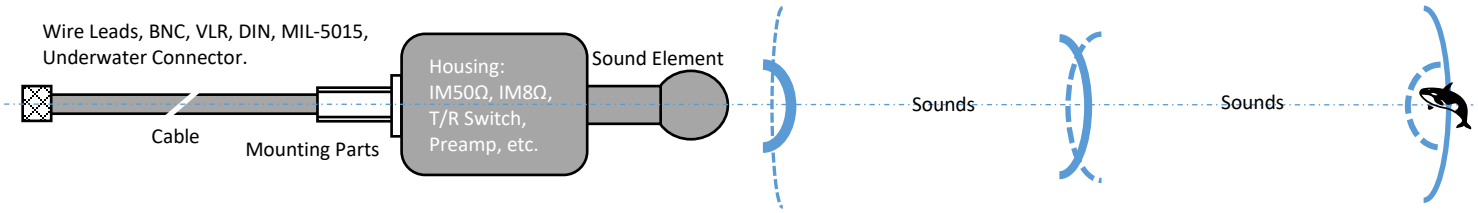
## How to Order Underwater Transducer (Projector), HIFU Transducer, and Ultrasonic Power Transducer

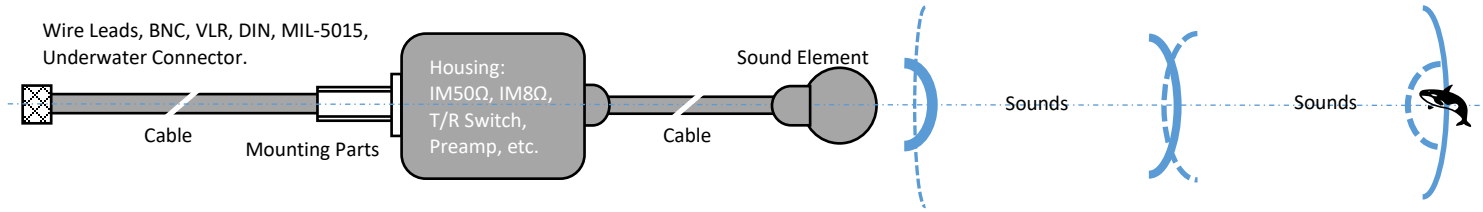
If a hydrophone or transducer does not support a specific parameter, or the default parameter stated in the specification is to be ordered, please ignore that parameter or use blank. If your applications have requirements about physical size, operating depth, service temperature, special regulations, ..., please contact us for custom-fit products.

**Transducer Structure with Electronic Module (Impedance Matching Network and Transmit/Receive Switch, Preamp, etc.) and Sound Element.**

1. **Default Transducer Structure**: Sound Element is potted in Housing of Electronics.

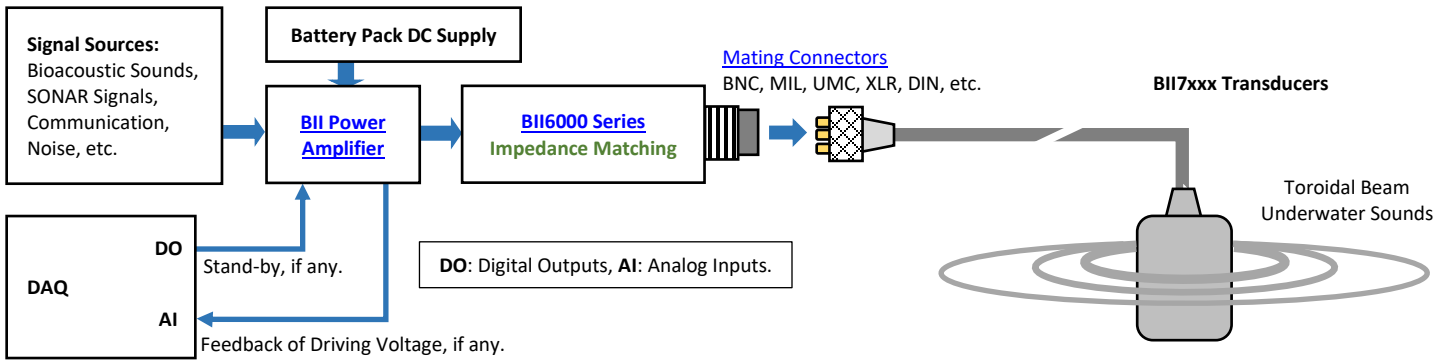


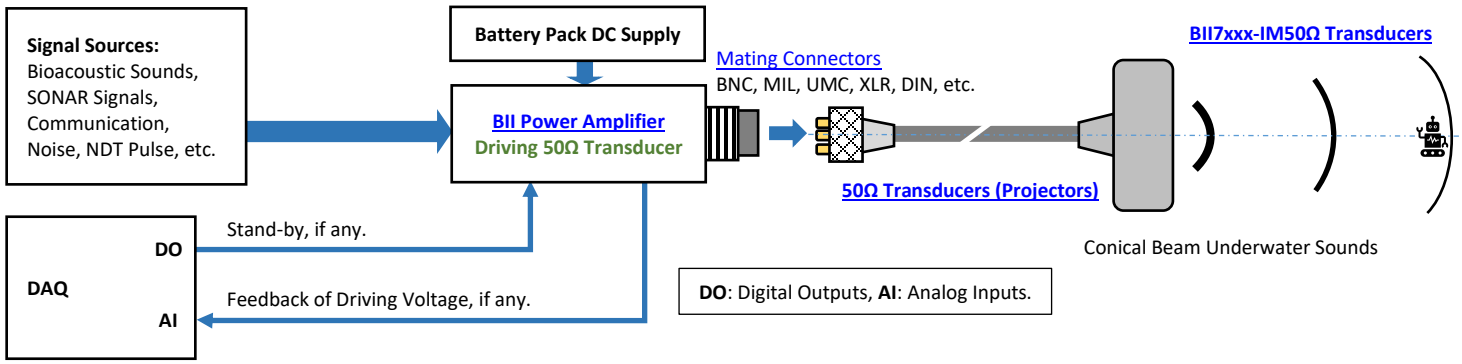

2. **Bespoke Transducer Structure**: Sound Element is separated from Housing of Electronics with cable of bespoke length.




**System Block Diagram of Generate Sounds**

This setup is a compact and low-cost solution for end users' acoustic system by integrating BII's Power amplifier (PCB form factor) and Impedance Matching device (PCB or small-enclosure form factor) into end users' grounded enclosures.




**How to Order Transducers Generating Sounds.** The default options are for stock items which are regularly available.

| **FH**: Free Hanging. **SC for Transmit**: Shielded Cable (Rubber Jacket, 600V) with 2 conductors. **Coax**: 50 Ω Coaxial Cable. **WL**: Wire Leads. | | | | | |
|---|---|---|---|---|---|
| **Underwater Mateable Connector UMC2P is fixed with 0.6m unshielded cable (USC).** | | | | | |
| **Part Number** | **-Appendage** | **-Mounting** | **-Cable Length** | **-Cable Type** | **-Connector for signals of Transmit and Temperature Sensor** |
| BII75xx<br>BII75XX-IM50Ω | Default:<br>**None**. | Default:<br>**BFM-FH-M8**, or<br>**BFM-FH-3/8**". | Default:<br>**15m or 0.6m**. | **SC** for low frequency signal.<br>**USC** for UMC2P Connector.<br>**Coax** for high frequency signal. | Default: **WL**. |
| **Example:** | | **Description** | | | |

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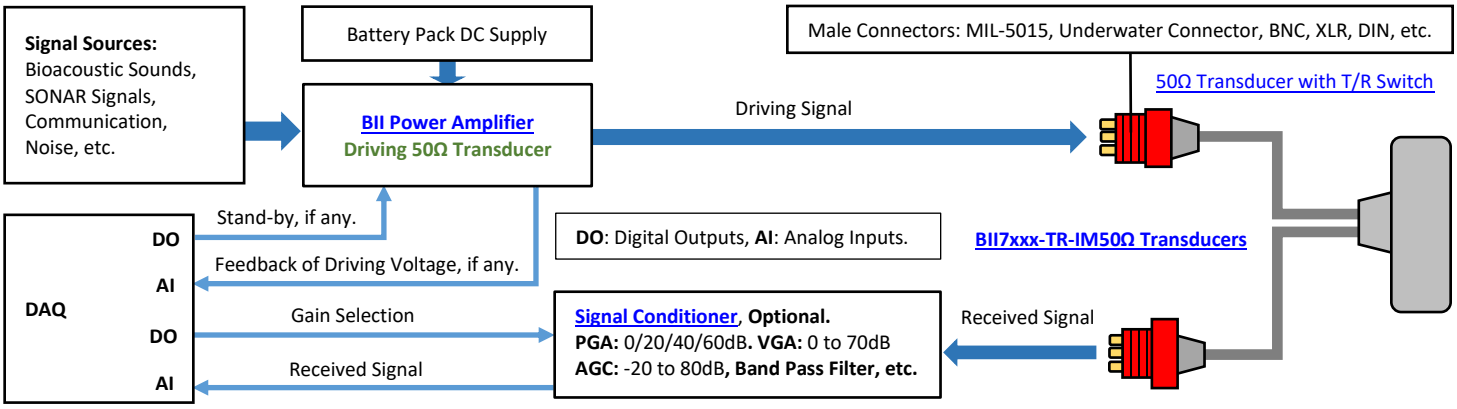
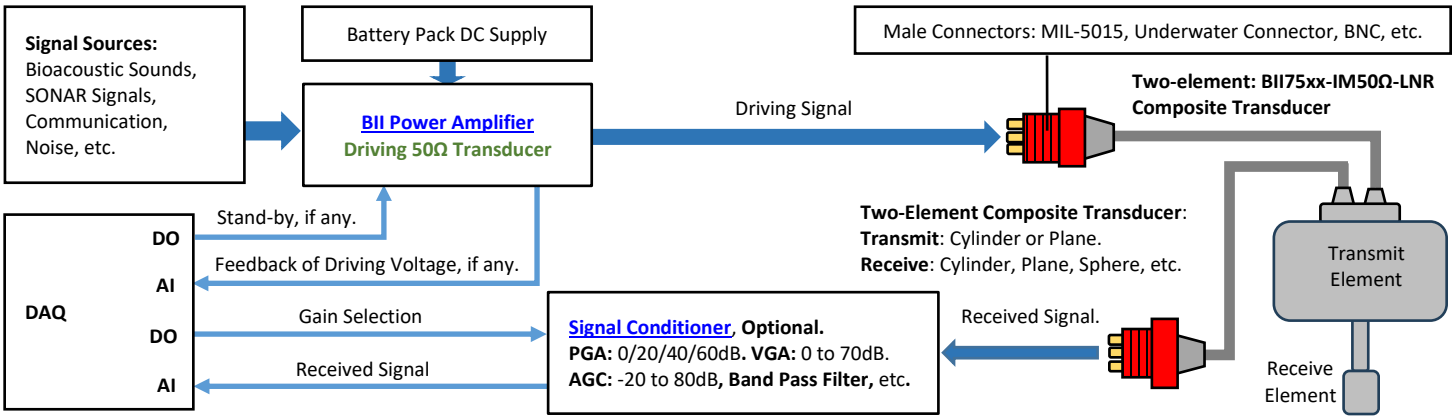
| | |
|---|---|
| **BII75xx-BFM-FH-15m-SC-WL** | **BII75XX Transducer, Bolt-Fastening Mounting with Free Hanging: BFM-FH, 15m Shielded Cable, Wire Leads.** |
| BII75xx-BFM-FH-M8-0.6m-USC-UMC2P | BII75XX Transducer, Bolt Fastening Mounting with Free Hanging: BFM-FH-M8, 0.6m Unshielded Cable, Male Underwater Mateable Connector with Locking Sleeve: DLSA-M. |
| BII75XX-HT-FH-6m-RG178-BNC | BII75XX Transducer, Service Temperature: -10 °C to 120 °C, or 14 °F to 248 °F. Free Hanging, 6m RG178 Coax, BNC Male. |
| BII75XX-IM50Ω-FH-20m-RG58-BNC | BII75XX Transducer, Built-in Impedance Matching Network as 50Ω load at fs, Free Hanging, 20m RG58 Coax, Male BNC. |
| BII75XX-IM8Ω-FH-15m-SC-XLR3P | BII75XX Transducer, Built-in Impedance Matching Network as 8Ω load at fs, Free Hanging, 15m Shielded Cable, XLR Plug. |

**System Setup of Transmitting and Receiving Sounds.**




**How to Order Transmitting and Receiving Transducers.** The default options are for stock items which are regularly available.

| | | | | | | |
|---|---|---|---|---|---|---|
| **FH**: Free Hanging. **SC for Low Frequency Transmit**: Shielded Cable (Rubber Jacket, 600V) with 2 conductors. **Coax for High Frequency Transmit:** 50 Ω Coaxial Cable. **SC for Low Frequency Receive**: Shielded Cable with 4 conductors. **Coax for High Frequency Receive:** 50 Ω Coaxial Cable. **WL**: Wire Leads. **HPF**: -3dB High Pass Filter Frequency. **LPF**: -3dB Low Pass Filter Frequency. **Cable of Temperature sensor** is two-conductor shielded cable. **Cable of DC Supply** is two-conductor shielded cable in case that receive cable is coax. | | | | | | |
| **Receiving Cable is fixed to be four-conductor Shielded cable. Transmitting cable can be customized to be Coax or two-conductor shielded cable.** | | | | | | |
| **Length of Transmitting and receiving cables are same in default.** | | | | | | |
| **Undewater Mateable Connector UMC2P and UMC4P are fixed with 0.6m unshielded cables.** | | | | | | |
| **Part Number** | **-Preamp Gain** | **-HPF/LPF** | **-Mounting** | **-Cable Length** | **-Transmit Cable** | **-Connector for signals of Transmit/ Receive/DC Supply/Temperature** |
| **BII75xx-TR-IM50Ω**<br>**BII75xx-IM50Ω-LNR** | Default: **xxdB** | -3dB Receive bandpass Frequencies. Default: **2kHz to xxxkHz** | Default: **BFM-FH-M8, or, BFM-FH-3/8".** | Default: **15m.** | **SC or Coax.** Default: **SC.** | Default: **WL.** |

| **Example:** | **Description** |
|---|---|
| **BII75xx-TR-IM50Ω-xxdB-2kHz/xxxkHz-BFM-FH-M8-15m-SC-WL** | **BII75xx Transducer, Built-in T/R Switch, Built-in Impedance Matching Network as 50Ω load at fs, Receive Gain: xxdB, Receive Bandpass Filter: 2kHz to xxxkHz. Bolt-Fastening Mounting with Free Hanging: BFM-FH-M8, 2 x 15m cables, Transmitting Cable: Shielded Cable, Wire Leads.** |
| **BII75xx-IM50Ω-LNR-xxdB-2kHz/xxxkHz-BFM-FH-M8-15m-SC-WL** | **BII75xx Transducer, Built-in Impedance Matching Network as 50Ω load at fs, Built-in Low Noise Receiver, Receive Gain: xxdB, Receive Bandpass Filter: 2kHz to xxxkHz. Bolt-Fastening Mounting with Free Hanging: BFM-FH-M8, 2 x 15m cables, Transmitting Cable: Shielded Cable, Wire Leads.** |
| BII75xx-TR-IM50Ω-xxdB-2kHz/xxxkHz-BFM-FH-M8-15m-SC-MIL3P/XLR4P/BS | BII75xx Transducer, Built-in T/R Switch, Built-in Impedance Matching Network as 50Ω load at fs, Receive Gain: xxdB, Receive Bandpass Filter: 2kHz to xxxkHz. Bolt-Fastening Mounting with Free Hanging: BFM-FH-M8, 2 x 15m cables, Transmitting Cable: Shielded Cable, 3 Pin MIL-5015 Connector for Transmit Signal, 4 Pin XLR for Receive Signal, 9V Battery Snap for DC Supply. |
| BII75xx-TR-IM50Ω-xxdB-2kHz/xxxkHz-FH-15m-RG58-BNC/BNC/BS/TRS | BII75xx Transducer, Built-in T/R Switch, Built-in Impedance Matching Network as 50Ω load at fs, Receive Gain: xxdB, Receive Bandpass Filter: 2kHz to xxxkHz. Free Hanging, 2 x 15m cables, Transmitting Cable: RG58 Coax, BNC Male Connector for Transmit Signal, BNC Male for Receive Signal, 9V Battery Snap for DC Supply, TRS for Temperature Signal. |

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**Cable and Connector Information for Signals of Hydrophones and Power Transducers (Projectors). Non-UL Uses.**

| | **Wire and Cable Types** | **Ratings of Voltage, Current or Power, and Temperature.** |
|---|---|---|
| **Cables**: | AWG18 Wires (**WR**) | 3000 $V_{rms}$, 10 $A_{rms}$. |
| | Two Conductor Unshielded Cable (**USC**). AWG18 Conductors. | 600 $V_{rms}$, 10 $A_{rms}$. -40°C To +90°C, or -40°F to 194°F. |
| | Two Conductor Shielded Cable (**SC**). AWG20 Conductors. | 600 $V_{rms}$, 4 $A_{rms}$. -50°C To +90°C, or -58°F to 194°F. |
| | Two Two-conductor Shielded Cable Bundle (**2SC**). AWG20 Conductors. | 600 $V_{rms}$, 10 $A_{rms}$. -50°C To +90°C, or -58°F to 194°F. |
| | Two, Four or Six Conductor Shielded Cable (**SCxx**). AWG20, AWG24, AWG26, AWG28 Conductors. | 60 to 300 $V_{rms}$, 0.2 $A_{rms}$ to 10A, for Hydrophone Use ONLY. -40°C to +80°C or -40°F to 176°F. |
| | High Temperature Twisted Pair Shielded Cable (**HTTPSC40**). | 600 $V_{rms}$, 5.0/10 $A_{rms}$, up to +200°C or 392°F, Non-waterproof. |
| | High Temperature Twisted Pair Shielded Cable (**HTTPSC36**). | 600 $V_{rms}$, 2.1/3.5 $A_{rms}$, up to +200°C or 392°F, Non-waterproof. |
| | High Temperature Twisted Pair Shielded Cable (**HTTPSC32**). | 600 $V_{rms}$, 1.2/2.2 $A_{rms}$, up to +200°C or 392°F, Non-waterproof. |
| | High Temperature Twisted Pair Shielded Cable (**HTTPSC125**). | 300 $V_{rms}$, 0.92 Arms, -50°C to +125°C or -58°F to 257°F. |
| | High Temperature Shielded Cable (**HTSC150**). | 600 $V_{rms}$, 2.8 Arms, -70°C to +150°C or -94°F to 302°F. |
| | Coax RG58 (50Ω) (**RG58**) | 1400 $V_{rms}$, 4 $A_{rms}$. -40°C To +80°C or -40°F to 176°F. |
| | Coax RG174/U (50Ω) (**RG174**) | 1100 $V_{rms}$, 1.6 $A_{rms}$. -40°C To +75°C or -40°F to 167°F. |
| | Coax RG316/U (50Ω) (**RG316**) | 900 $V_{rms}$, 2.0 $A_{rms}$, -50°C To +200°C or -58°F to 392°F. |
| | Coax RG178B/U (50Ω) (**RG178**) | 750 $V_{rms}$, 0.86 $A_{rms}$, -70°C To +200°C or -94°F to 392°F. |
| Connectors: | **Connector Type** | **Ratings of Voltage, Current or Power, and Temperature.** |
| | 1. Wire Leads (**WL**) | Used for Cables or Wires. |
| | 2. 50Ω BNC (**BNC**), Bayonet Lock. Panel Mount or In-line. In-line BNC: Input uses Pin, output uses Socket. Panel Mount BNC: Both Input and Output use BNC Jacks. | 500 $V_{rms}$, 100 ~ 316 W, 1 $A_{rms}$ Continuously. Pulse Current: 5 ~ 10 $A_{peak}$ at range of µS to mS, D ≤ 1%. 10 ~ 20 $A_{peak}$ at range of nS to µS, D ≤ 1%. Used for Grounded Signal with Metal Enclosures or Coax Cables. |
| | 3. MIL-5015 Type Connector (**MIL**), Thread Fastening. Panel Mount or In-line. Input uses Pin, output uses Socket. | 500 $V_{rms}$, 13 A; Up to +125°C or 257°F, or, 900 $V_{rms}$, 13 A; Up to +125°C or 257°F. Used for Metal Enclosures or Shielded Cables. |
| | 4. Circular Connector DIN EN (**DIN**), Thread Fastening. Panel Mount or In-line. Input uses Pin, Output uses Socket. | 250 $V_{rms}$, 10 A; -40°C to +100°C or -40°F to 212°F. Used for Metal Enclosures or Shielded Cables. |
| | 5. XLR Connector (**XLR**), Positive Latchlock. Panel Mount or In-line. Input uses Pin, Output uses Socket. | 133 $V_{rms}$, 15 A; -25°C to +75°C or -13°F to +167°F. Used for Metal Enclosures or Shielded Cables. |
| | 6. 3.5mm or 1/8" TRS (**TRS35**), Panel Mount with Jack, In-line with Plug, for analog audio signals. | 30 Vrms, 0.3A; -25°C to +75°C or -13°F to +167°F. Used for Metal Enclosures or Shielded Cables. |
| | 7. Underwater Mateable Connector (**UMC**), Thread Fastening DLSA-F or DLSA-M. Panel Mount or In-line. Input uses Pin, Output uses Socket. | 600 $V_{rms}$, 10 A. Waterproof, IP68. Max. Diameter Φ35.5mm. Used for Metal Enclosures or Transducers (Projectors). |
| | 8. Underwater Mateable Connector (**UMC**), Thread Fastening MCDLS-F or MCDLS-M. Panel Mount or In-line. Input uses Pin, Output uses Socket. | 300 $V_{rms}$, 10 A. Waterproof, IP68. Max. Diameter Φ22mm. Used for Metal Enclosures or Hydrophones. |
| | ~~9. Sheathed Banana Jack. Panel Mount or In-line.~~ | ~~1000V CAT III/600V CAT IV, 25A. IEC61010-031 rated. **NOT USED in this device.**~~ |
| | ~~10. SMA (Plug, Male Pin) (**SMA**). Thread Fastening. In-line.~~ | ~~Voltage Rating: 335 $V_{RMS}$ Continuous. (Max. Diameter Φ9.24 mm). Up to 155°C or 311°F.~~ |
| | ~~11. SMC (Plug, Female Socket) (**SMC**). Thread Fastening. In-line.~~ | ~~Voltage Rating: 335 $V_{RMS}$ Continuous. (Max. Diameter Φ6.4 mm). Up to 155°C or 311°F.~~ |
| | ~~12. LEMO (Plug Male Pins) (**LEMO**). Push-Pull Fastening. Panel Mount or In-line.~~ | ~~900 V (AC), 1270 V (DC), 8A, (Max. Diameter Φ9.5 mm with 3 contacts). Temp (min / max) -55°C / +250°C.~~ |

How to choose cable and connector for BII devices: Driving Voltage $V_{drive}$ ($V_{rms}$) = $\sqrt{RMS\ Power * \frac{G}{G^2+B^2}}$.

BII lists G-B data at fs and/or the graph of G-B vs Frequency in online datasheet.

**Case 1.** Deliver 1000 $W_{rms}$ to 3 kΩ transducers at $f_s$. Note: $G/(G^2+B^2)$ = 3 kΩ is the resistive load of the transducer in load medium at $f_s$.
Driving voltage to transducer $V_{drive} = \sqrt{1000 * 3000}$ = 1732 $V_{rms}$. The current to 3 kΩ transducer $I_{drive} = V_{drive}/R_L$ = 1732$V_{rms}$/3000Ω = 0.57733 $A_{rms}$.
Therefore, AWG18 Wire and Wire leads are suitable.

**Case 2.** Deliver 500 $W_{rms}$ to 300 Ω transducers at $f_s$. Note: $G/(G^2+B^2)$ = 300 Ω is the resistive load of the transducer in load medium at $f_s$.
Driving voltage to transducer $V_{drive} = \sqrt{500 * 300}$ = 387.3 $V_{rms}$. The current to 300 Ω transducer $I_{drive} = V_{drive}/R_L$ = 387.3$V_{rms}$/300Ω = 1.291 $A_{rms}$.
Therefore, Two Conductor Shielded Cable and MIL-5015 Type Connector or Underwater Mateable Connector (UMC) are suitable.

**Case 3.** Deliver 300 $W_{rms}$ to 50 Ω transducers at $f_s$.
Driving voltage to transducer $V_{drive} = \sqrt{300 * 50}$ = 122.5 $V_{rms}$. The current to 50 Ω transducer $I_{drive} = V_{drive}/R_L$ = 122.5$V_{rms}$/50Ω = 2.45$A_{rms}$.
Therefore, 50Ω RG58 Coax and BNC are suitable.

Please contact us for bespoke wirings of differential transducers such as dipole, quadrupole, multimode rings, and flextensional sources.

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## Abbreviation List for Ordering

| **Principal Parameters** | | |
|---|---|---|
| **DR**x: Depth Rating x meters | **SL:** Source Level, in dB re µPa*m | **$Q_m$**: Quality factor, -3dB Bandwidth = fs/$Q_m$ |
| **fs**: Resonance Frequency in kHz | **PW**: Pulse Width | **D**: Duty Cycle |
| **CW:** Continuous Wave (Operating) | **$f_{im}$:** Impedance Matching Frequency in kHz. $f_{im}$ = fs by default. | |
| **BW:** -3dB Beam Width | **SLL:** Side Lobe Level in dB, Nominal to Main lobe. | **TS**: Built-in Temperature Sensor (NTC thermistor) |

| **Built-in Impedance Matching and T/R Switch** | | |
|---|---|---|
| **IM**: Impedance Matching | **TR**: Transmit & Receive Switch | **TRIM**: T/R Switch and Impedance Matching |

| **Beam Pattern** | |
|---|---|
| **SPH:** | Beam generated by spherical transducer. Generally, -3dB Beam Width at fr: 360° x 250° in XY and ZX plane, frequency dependent. |
| **HSPH:** | Beam generated by hemispherical transducer. Generally, -3dB Beam Width at fr: 360° x 70° in XY and ZX plane, frequency dependent. |
| **CLD:** | Beam generated by cylindrical transducer. Generally, -3dB Beam Width at fr: 360° x (40°~80°) in XY and ZX plane, frequency dependent. |
| **BW or $\Delta\boldsymbol{\theta}$:** | -3dB conical Beam Width Δθ in ZX and ZY plane, in °, generated by transducers of circular plate or convex shell. |
| $\Delta\boldsymbol{\theta_H} \times \Delta\boldsymbol{\theta_V}$: (Planar) | -3dB fan-shaped Beam Width, generated by transducers with rectangular (or square) apertures. $\Delta\boldsymbol{\theta_H}$ is in ZX plane (Along-track, Along-length or Horizontal Plane) and $\Delta\boldsymbol{\theta_V}$ is in ZY plane (Cross-track, Cross-length or Vertical Plane), such as -3dB Along-Length x Cross-Length Beam Width = 5° x 50°. |
| $\Delta\boldsymbol{\theta_H} \times \Delta\boldsymbol{\theta_V}$: (Curved) | -3dB fan-shaped Beam Width, generated by transducers with cylindrical curve apertures. $\Delta\boldsymbol{\theta_H}$ is in ZX plane (Along-curve or Horizontal Plane) and $\Delta\boldsymbol{\theta_V}$ is in ZY plane (Cross-curve or Vertical Plane), such as -3dB Along-curve x Cross-curve Beam Width = 120° x 20°. |

| **Signal Conditioning of Received Signals** | | | | |
|---|---|---|---|---|
| **SE**: Single Ended Signal/Unbalanced | **DF**: Differential Signal/Balanced | **HPF**: High Pass Filter | **LPF**: Low Pass Filter | **BPF**: Band Pass Filter |
| **AGC**: Automatic Gain Control Amplifier | **VGA**: Variable Gain Amplifier | **PG:** Programmable Gain Preamp | **FG:** Fixed Gain Preamp | Reserved |

**Mounting Parts:** Detail information at Mounting Parts.

**Wires and Cables with Service Temperature < 120 °C. Cable Jacket: PVC, Polyurethane, EPDM rubber, etc., 1/2/4/6 Conductors are in stock.**

| | | |
|---|---|---|
| **WR**: Wires | **WRB**: Wires Bundle | **SCB**: Shielded Cable Bundle |

**MiniCoax**: Coax, ΦD=1.4mm, -30°C To +105°C.

**RG174**: RG174/U 50Ω Coax, ΦD = 2.8mm, -30°C to +75°C.

**RG58**: RG58 50Ω Coax, ΦD = 4.9mm, -40°C to +80°C, see Note 1.

**MiniSC:** Miniature Shielded Cable, ΦD=2.438 mm. -20°C to +105°C, or -4°F to 221°F. Max. Operating Voltage: 200 V RMS, Max. Current: 0.9 Amps.

**SC26**: Shielded Cable with Polyurethane Jacket, ΦD = 2.6 mm. Voltage: ≤ 150 V, Temperature: -40 to 70°C.

**SC36**: Shielded Cable with Twisted Pair and PVC Jacket, ΦD = 3.6 mm. ≤ 300Vrms, -20 to 60°C.

**SC47**: Shielded Cable with Twisted Pair and Polyurethane Jacket, ΦD = 4.7 mm. ≤ 300 Vrms, -30 to 90°C.

**SC60**: Shielded Cable with Twisted Pair and PVC Jacket, ΦD = 6.0 mm. ≤ 300Vrms, -20 to 60°C.

**SC65:** Shielded Cable with Rubber Jacket, ΦD = 6.5 mm. ≤ 600 Vrms, -50°C to +90°C.

**SC**: Bespoke Shielded Cable (ΦD = 2.4 to 9.7 mm). Uses: Water Depth ≤ 300 m; Max. Operating Voltage: 300 Vrms or 600 Vrms available, Max. Current: 4 A.

**USC**: Unshielded Cable (ΦD = 8.7 to 15.3 mm), AWG18 Conductors. Uses: Water Depth ≤ 3000 m; Max. Operating Voltage: 600 Vrms, Max. 10 A.

**Shielded Cable with Twisted Pair (SCTP):** Recommended for hydrophone (receiver) without preamplifier.

**Cable Length:** Customized, up to 305 m or 1000 ft.
1. The cable has adverse effects on the transducer (projector) performances in high frequency range. The longer the cable is, the worse the adverse effects on the transducer (projector) performance are. If a long cable is needed for the project (comparing to electromagnetic wavelength), impedance matching is necessary between the transducer (projector) and the signal source (power amplifier).
2. To transmit received signals (receivers, hydrophones) over a long cable, using differential signal transmission is a good option, and matching impedances between receiver (hydrophone) and the cable.

**Wires and Cables with Service Temperature ≥ 120 °C. Cable Jacket: FEP, PTFE, Silicone, etc. 1 or 2 Conductors are in stock.**

**HTWR200**: High Temperature Wire, 14 to 392°F (-10° to 200° C), Maximum 600VAC.

**HTWR449**: High Temperature Wire, -40 to 840°F (-40° to 449° C), Maximum 600VAC. non-waterproof, for dry aerial use ONLY.

**RG178**: RG178B/U 50Ω Coax, 750 Vrms, 0.86 Arms, -70°C To +200°C, Diameter: Φ1.8 mm.

**RG316:** RG316/U 50Ω Coax, 900 Vrms, 2.0 Arms, -50°C To +200°C or -58°F to 392°F. Diameter: Φ2.5 mm.

**HTTPSC32**: Shielded Cable, Twisted Pair, Teflon (PTFE) Jacket, ΦD=3.2 mm, Maximum 600VAC, 1.2/2.2 Amps, -55 to 200°C. Non-waterproof, for dry aerial use ONLY.

**HTTPSC36**: Shielded Cable, Twisted Pair, Teflon (PTFE) Jacket, ΦD=3.6 mm, Maximum 600VAC, 2.1/3.5 Amps, -55 to 200°C. Non-waterproof, for dry aerial use ONLY.

**HTTPSC40**: Shielded Cable, Twisted Pair, Teflon (PTFE) Jacket, ΦD=4.0 mm, Maximum 600VAC, 5.0/10 Amps, -55 to 200°C. Non-waterproof, for dry aerial use ONLY.

**HTTPSC125:** High Temperature Twisted Pair Shielded Cable, 300 Vrms, 0.92 Arms, -50°C to +125°C or -58°F to 257°F.

**HTSC150**: High Temperature Shielded Cable, -94 to 302°F (-70° to 150° C), Maximum 600VAC.

**HTSC200**: High Temperature Shielded Cable, -65 to 392°F (-54° to 200°C), Maximum 600VAC.

**HTUSC**: High Temperature Unshielded Cable, -40 to 840°F (-40° to 449° C), Maximum 600VAC. non-waterproof, for dry aerial use ONLY.

| **Connectors (In-line or Panel Mount)** | | |
|---|---|---|
| **WL**: Wire Leads. | **BNC**: BNC Male (or Plug) 50Ω. | **BNCF or BNCJ**: BNC Female (or Jack) 50Ω. |
| **DIN3/4/6:** DIN Receptacle with 3/4/6 Male Pins. | **SBJ or SBP**: Sheathed Banana Jack or Plug. | **TRS**: 3.5mm or 1/8" TRS Plug or Jack. |
| ~~**LEMO:** PLUG 3 Contacts, Socket or Pin.~~ | ~~**SMA:** Plug, Male Pin, 50Ω.~~ | ~~**SMC**: Plug, Female Socket, 50Ω.~~ |
| **XLR3/4/5/6**: XLR Receptacle with 3/4/5/6 Male Pins. | **5015**: MIL-5015 style Circular Connector, Socket or Pin. | **SP**: Solder Pins. |
| **UMC**: Underwater Mateable Connector (See Note 2). | **BS**: +9V Battery Snap. | **Custom**: Customized Connector. |

Underwater Connectors are for uses underwater, other connectors and wire leads listed above are for dry uses ONLY in air.

**Maximum Diameter Size of Connectors: useful to choose mounting/installation parts of the transducers/hydrophones, Unit: mm.**

| **Connector:** | Male BNC | ~~SMA (Plug, Male Pin)~~ | ~~SMC (Plug, Female Socket)~~ | ~~LEMO (PLUG MALE 3 Pins)~~ | 1/8" (3.5mm) TRS | XLR | DIN | MIL-5015 | 9V Battery Snap | Underwater Connector |
|---|---|---|---|---|---|---|---|---|---|---|
| **Biggest Size:** | Φ14.3 | ~~Φ9.24~~ | ~~Φ6.4~~ | ~~Φ9.5~~ | Φ10.5 | Φ20.2 | Φ17 | Φ30 | Φ13 | Φ21.5 or Φ35 |

**Note 1: RG58 Coax with BNC connector.** Available lengths: 0.15m to 300 m. Please choose cable length which is much less than the Electromagnetic wavelength λ ≈ c/f. c: speed of light in Vacuum.

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| |
|---|
| **Warning**: It is buyer's sole responsibility to make sure that BNC/SMA/SMC shield of the signal source is firmly grounded for operating safety before hooking up the transducer (projector) to the signal source. **Coax with BNC/SMA/SMC is not intended for hand-held use at voltages above 30Vac/60Vdc.** |

| **Note 2: Underwater Mateable Connectors (UMC).** BII stocks wet-mateable connectors from global underwater connector manufacturers whose connectors and accessories are available worldwide. Buyers may purchase mating connectors and accessories from local suppliers or representatives of these global companies in buyers' countries or purchase these mating connectors from BII as integral parts of BII products. Please contact BII for details. | |
|---|---|
| **UMC2P**: Underwater Mateable Connectors with 2 pins. | **Major Uses**: (1) Hydrophones/AEs, no built-in preamp; (2) Transducers, no built-in T/R Switch. |
| **UMC3P**: Underwater Mateable Connectors with 3 pins. | **Major Uses**: (1) Hydrophones/AEs, no built-in preamp; (2) Transducers, no built-in T/R Switch. |
| **UMC4P**: Underwater Mateable Connectors with 4 pins. | **Major Uses**: Hydrophones/AEs with built-in fixed gain preamps. |
| **UMC6P**: Underwater Mateable Connectors with 6 pins. | **Major Uses**: (1) Hydrophones/AEs with built-in Programmable gain preamps. (2) Transducers with built-in T/R Switch. |
| Note 3: Underwater Mateable Connectors with 2/3/4/6 Sockets are available too. | |
| Note 4: Necessary accessories such as Locking Sleeve (MCDLS-F, MCDLS-M, DLSA-F, or DLSA-M), Nut, Washer, O-ring, if any, are included for installation. | |
| **Underwater Mateable Connector: Handling Instructions** | |
| BII stocks underwater mateable connectors of Standard Circular and Micro Series for signal transmission and power supply underwater. | |
| Always apply grease before mating. | Disconnect by pulling straight, not at an angle. |
| Do not pull on the cable and avoid sharp bends at cable entry. | Do not over-tighten the nuts. |
| Not be exposed to heat or direct sunlight. | Wet in fresh water before use. |

**Service Temperature Range:**

1. Default Operating Temperature: -10°C to +60°C (14°F to 140°F); Storage Temperature: -20°C to +60°C (-4°F to 140°F);
2. Bespoke high temperature transducers and hydrophones are available, please refer to respective datasheet for their service and storage temperatures.
a. Service Temperature: -10°C to 120°C (14°F to 248°F). b. Service Temperature: -10°C to 200°C (14°F to 392°F).


**Characteristics of Temperature Sensor Built inside Transducers (Hydrophones and Projectors):**

| -40 °C to 125 °C NTC Temperature Sensor: Resistance Vs. Temperature | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Temp. (°C)** | **Resistance (kΩ)** | **Temp. (°C)** | **Resistance (kΩ)** | **Temp. (°C)** | **Resistance (kΩ)** | **Temp. (°C)** | **Resistance (kΩ)** |
| -40 | 197.388 | 5 | 22.165 | 50 | 4.160 | 95 | 1.112 |
| -35 | 149.395 | 10 | 18.010 | 55 | 3.539 | 100 | 0.976 |
| -30 | 114.345 | 15 | 14.720 | 60 | 3.024 | 105 | 0.860 |
| -25 | 88.381 | 20 | 12.099 | 65 | 2.593 | 110 | 0.759 |
| -20 | 68.915 | 25 | 10.000 | 70 | 2.233 | 115 | 0.673 |
| -15 | 54.166 | 30 | 8.309 | 75 | 1.929 | 120 | 0.598 |
| -10 | 42.889 | 35 | 6.939 | 80 | 1.673 | 125 | 0.532 |
| -5 | 34.196 | 40 | 5.824 | 85 | 1.455 | | |
| 0 | 27.445 | 45 | 4.911 | 90 | 1.270 | | |

| -40 °C to 250 °C NTC Temperature Sensor: Resistance Vs. Temperature | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Temp. (°C)** | **Resistance (kΩ)** | **Temp. (°C)** | **Resistance (kΩ)** | **Temp. (°C)** | **Resistance (kΩ)** | **Temp. (°C)** | **Resistance (kΩ)** |
| -40 | 204.7 | 35 | 6.944 | 110 | 0.7483 | 185 | 0.1439 |
| -35 | 154.4 | 40 | 5.830 | 115 | 0.6603 | 190 | 0.1313 |
| -30 | 117.6 | 45 | 4.918 | 120 | 0.5840 | 195 | 0.1202 |
| -25 | 90.44 | 50 | 4.166 | 125 | 0.5176 | 200 | 0.1103 |
| -20 | 70.15 | 55 | 3.545 | 130 | 0.4598 | 205 | 0.1015 |
| -15 | 54.87 | 60 | 3.028 | 135 | 0.4093 | 210 | 0.0937 |
| -10 | 43.27 | 65 | 2.596 | 140 | 0.3651 | 215 | 0.0868 |
| -5 | 34.39 | 70 | 2.234 | 145 | 0.3263 | 220 | 0.0807 |
| 0 | 27.53 | 75 | 1.929 | 150 | 0.2923 | 225 | 0.0754 |
| 5 | 22.2 | 80 | 1.671 | 155 | 0.2624 | 230 | 0.0706 |
| 10 | 18.02 | 85 | 1.451 | 160 | 0.2361 | 235 | 0.0665 |
| 15 | 14.72 | 90 | 1.265 | 165 | 0.2128 | 240 | 0.0628 |
| 20 | 12.10 | 95 | 1.105 | 170 | 0.1923 | 245 | 0.0597 |
| 25 | 10.00 | 100 | 0.9679 | 175 | 0.1742 | 250 | 0.0570 |
| 30 | 8.311 | 105 | 0.8500 | 180 | 0.1581 | | |

1. By default, the temperature sensor measures the inner temperature of a transducer (sound projectors).
When a transducer (or a projector) transmits sound into water or load medium, fractional electrical energy is being converted to heat by piezoelectric materials. If a transducer (projector) transmits sound continuously underwater for a long time and the transducer can not cool down by ambient water or medium, the materials of the transducer might be overheated and damaged. The maximum inner temperature of BII transducers (projectors) varies from 120 to 200°C, or 248 to 392°F.
There is a formula on **How to determine pulse width, duty cycle and off-time with input pulse power (peak power)** in the data sheet of each BII transducer (projector).
The temperature inside the transducer (projector) is less than 120 °C or 248 °F during operation by following the formula.
If the transducer (projector) must operate continuously with high power in your application, please contact BII for custom-fit high temperature transducer.
2. The temperature sensor can also be built into a hydrophone to measure the ambient temperature.

Operating Static Pressure Range:
The maximum Operating Static Pressure varies with transducer types: ≤ 9.8 MPa, or 1000 m Ocean Depth. 1 m Water Depth = 9.8 kPa.

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**Underwater Transducer (Projector and Hydrophone) Daily Maintenance (Handling)**

Warning: Wrongful handling may damage the transducer and hydrophone beyond repair.

1. Do not drive underwater transducers and hydrophones when they are in air. Do not drive projector (transducer) with high power in non-resonance frequency range.
2. Do not drive the hydrophones with built-in preamplifiers and/or signal conditioning amplifiers.
3. Keep transducers, hydrophones, and the cable away from any sharp item.
4. Remove saltwater spray and moisture with cloth.
5. Do not move or lift the transducers and hydrophones by the cable in air.
6. Do not squeeze or step on the transducers, hydrophones, and the cable.
7. Handle the transducers and hydrophones gently, avoid impacts and collision.
8. Do not use strong solvents to clean the transducer faces and hydrophone faces.
9. Do not expose the transducers and hydrophones to direct sunlight or excessive heat.
10. After use, rinse the transducers, hydrophones, and the cable in fresh clean water, dry them with cloth.
11. Do not use high pressure water, sand blasting or metal tools to clean the transducer faces and hydrophone faces.

**Air Transducer Daily Maintenance (Handling)**

Warning: Wrongful handling may damage the air transducer beyond repair.

1. Do not use the air transducers in water.
2. Do not drive the transducers if it has built-in preamplifiers and/or signal conditioning amplifiers.
3. Keep transducers and the cable away from any sharp item.
4. After use, clean and remove moisture, dusts or dirties on the transducers, if any, with cloth.
   Do not use strong solvents to clean the transducer faces.
5. Do not move or lift the transducers by the cable in air.
6. Do not squeeze or step on the transducers and the cable.
7. Handle the transducers gently, avoid impacts and collision.
8. Do not expose the transducers to direct sunlight or excessive heat.
9. Do not use high pressure water, sand blasting or metal tools to clean the transducer faces.

**Operating Tips to Avoid Damage of BII Devices.**

Many electrical breakdowns and damages (overheating, over-voltage, over-current) are caused by accidental wrong wiring and improper power level of a DC supply. Observing following procedures may reduce the chances of the damage.

1. Read the datasheet carefully before wiring and powering the devices. Know well about the maximum and minimum ratings.
2. To avoid physical damage of transducers, please refer to Underwater Transducer (Projector & Hydrophone) Handling.
3. Choose suitable DC Supply.
   a. Use a DC Power Supply with adjustable limits for current and voltage. Make sure its maximum value is less than MAXIMUM RATINGS of BII devices. This can avoid accidental damage.
   b. Use DC Power Supply with fixed current and voltage which are less than MAXIMUM RATINGS of BII devices.
   c. Use Batteries whose maximum supply voltages are known and fixed such as 1.5V, 3V, 9V, 12V, 22V, 44V, standard, marine, or automobile Batteries.
      Warning: Fully charged and new batteries present higher voltage than the ratings. For example, fully charged 12V Automobile or Marine Battery are from 12.6 to 14.4 VDC. Measure voltage of batteries before assembly and wiring, ensure that voltage of battery pack is less than maximum DC supply voltage of the devices.
4. Calculate the electrical power (current and voltage) suitable for the system setup. Choose accessory components suitable to the power (current and voltage).
5. Operation:
   a. Set the current limit of DC supply to lowest permitted level, set voltage of DC supply to lowest operating level.
      Shut down the power.
   b. Start wiring among the system components.
      Check out the wirings carefully to avoid short circuit, wrong wiring, wrong polarity, etc.…
      Make sure firm grounding for safety.
      Any exposed bare wires must be insulated with insulation material to the electrical safety level.
   c. Wire the system to DC Power supply.
      Turn on power.
   d. Run the system at the lowest power level. Check out the operation and see if the system runs normally.
      Turn off power supply immediately and disconnect power supply if the abnormal occurs such as current limiting from DC supply, etc.… Trouble shooting.
6. If operation is normal, and wirings and setup are OK at lowest power level, increase power level gradually by adjusting power supply's voltage and current levels.

**Warning: It is buyer's responsibility and liability to make sure all electrical wirings and setup observe local electrical code for safety.**

**Choose DC Power Supplies for BII Devices and Electrical Safety.**

- BII devices are designed to be used with Battery-powered DC Supply for field applications (Ocean, Lake, River, Shore, or NDT).
- Every country has Electrical Safety Code Rule, and in some country such as Canada, each province and territory in Canada has its own legislation and dedicated authority to regulate electrical safety. Please check out details of Electrical Safety Code with electrical safety regulatory authorities in your country and/or province before you purchase products from BII.

We take Electricity Safety Authority (ESA) in Ontario, Canada as an example. **Please carefully read details of clause (b), (c), and (d) which are related to BII devices.**

"You must get approval for electrical products sold or used in Ontario, according to the Ontario Electrical Safety Code Rule 2-022. The following are exceptions:
(a) Equipment displayed at trade shows
(b) Certain Equipment connected to the output of a Class 2 power supply or equal
(c) Portable battery-operated equipment
(d) Equipment designed for use outside Ontario
(e) Fluorescent and HID lamps (not self-ballasted)
(f) Revenue billing devices and electricity meters.

**(b) Electrical equipment connected to the output of an approved Class 2 power supply or equal**
You don't need approval for electrical equipment connected to the output of:

- an approved Class 2 power supply (certified to CAN/CSA-C22.2 No. 223, or both CAN/CSA C22.2 No. 66.1 and CAN/CSA C22.2 No. 66.3). The output of this power supply may not exceed 100 VA, with the operating voltage not more than 30 V rms, 42.4 V peak, or 60 V dc.
- a limited power supply certified to CAN/CSA-C22.2 No. 60950-1.

Approval is still required for:
- Medical electrical equipment. (Note: Such equipment used in a veterinary practice is not considered medical electrical equipment.)
- Equipment for hazardous locations. The Ontario Electrical Safety Code defines these under Sections 18 and 20.

**(c) Portable battery-operated equipment**
You don't need approval for battery-operated, portable electrical equipment unless it is:
- located in hazardous locations;
- used to test, measure or show one or more electrical quantities and marked as Category III or IV.

You don't need approval for equipment in hazardous locations powered by at most two button-cell batteries (such as electronic wristwatches, hearing aids, or calculators). This is because they can't cause ignition under normal conditions.

For battery-operated medical devices as defined by the Food and Drugs Act, see Health Canada's approval requirements.

**(d) Equipment designed for use outside Ontario**
You don't need approval for electrical equipment intended solely for use outside Ontario, because no applicable Canadian standard or certification program applies. An example would be travel adapter plugs for using electrical equipment overseas. "

Please refer to following links for more details on Electricity Safety Authority (ESA) in Ontario, Canada:
https://esasafe.com/electrical-products/product-approval-exceptions/
https://esasafe.com/assets/files/esasafe/pdf/Electrical_Safety_Products/Exceptions-Product-Approval-Requirements.pdf

100 VA rated in clause (b), generally, refers to apparent power. VA (volt-amperes) = RMS voltage × RMS current.
Real Power (W) = VA × power factor = RMS voltage × RMS current x cos(ϕ).
Pulse Power (W) = Energy/Time. Energy is stored in a long period and released quickly as short bursts much higher than continuous rating.
Most BII devices is employed with pulse signal to deliver pulse power such as NDT, SONAR, Echo Sounding with portable batteries.

**Batteries, Linear DC Power Supplies, and Switching Mode DC Power Supplies.**
1. Batteries such as +1.5V (AA, AAA, C and D), +3V (CR123A and CR2032), +9V, +12V (Marine, Automobile and 23A), 22V and 44V are suitable for low noise and portable applications. The capacity can be increased with parallel or series of multiple batteries (Battery Pack). **Please refer to ESA Clause (c).**
Warning: Fully charged and new batteries present higher voltage than the ratings. For example, fully charged 12V Automobile or Marine Battery are from 12.6 to 14.4 VDC. Measure voltage of batteries before assembly and wiring, ensure that voltage of battery pack is less than maximum DC supply voltage of the devices.
2. A linear DC Power Supply is suitable for indoor applications such as a laboratory acoustic system. **Please refer to ESA Clause (b).**
3. Switching mode Power supply (SMPS) is NOT recommended for low noise applications. SMPS is a noisy source in the system due to its switching frequency (Turning on and off the switches). EMI/RFI is produced due to the current being switched on and off. Large peak "in-rush" surge current may be produced. Some types of SMPS might output very high voltage to destroy other electronic devices in the system if SMPS fails in some extreme cases.

**How to Calculate Service Time of a Battery**:
1. **Compute the total DC current draw of components**. For example, BII1067 preamp draws 1.55mA of quiescent current. The load current to driving 50m cable is 0.45mA$_{rms}$ with SINE signal of 0.2Vpp and 200kHz. So, the total DC current draw is 2mA.
2. **Check out battery datasheet for battery capacity**. Battery Capacity is measured in milliamp-hours (mAh), or amp-hours (AH). For example, from the datasheet of a 9V battery, it has capacity 700mAHrs when its voltage drops to 4.8V at constant current draw 10mA. Generally, the datasheet will specify several capacities with different constant current draw. Choose the one close to the current draw of your circuit.
3. **Calculate Service Time** with Battery Voltage dropping to 4.8V.
Service Time of a Battery = Battery Capacity/Current Draw of a Circuit = 700mAhrs/2mA = 350 hours
Because BII1067 can work at 2.7V, the service time of the battery will be much longer than the one calculated above. If the datasheet of a battery has capacity data with supply voltage dropping to 2.7V, the accurate service time can be computed.
4. Same procedures can be applied to calculation of the service time of a battery or battery pack for high power SONAR system which needs high battery capacity.

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**Preamplifiers for Hydrophones and Ultrasonics, Low Noise, Low Power, Broadband and Built-in Filter**

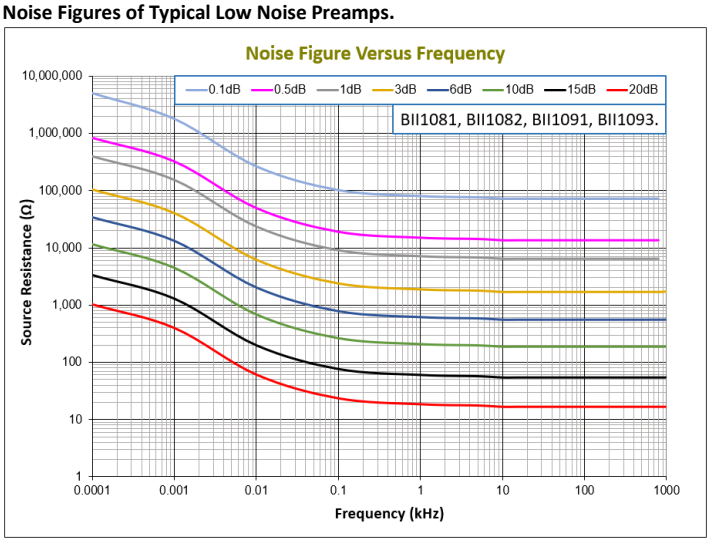
BII's low noise low power preamplifiers (amplifiers) have built-in filters and fixed or digitally programmable gains for uses in broadband (wideband) underwater SONAR, ultrasonic (Ultrasound, NDT, AE.) system and material study.

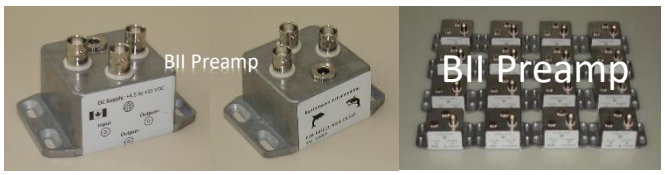
**Typical Applications**

| | |
|---|---|
| Hydrophone, SONAR, Underwater Communication. | Ultrasonic (Ultrasound, AE, NDT) Testing, Material Characterization. |

| Preamplifier | Description | Maximum Cable Length | Features |
|---|---|---|---|
| » BII1030 | Variable Gain Voltage Amplifier | 1000m or RG58 Coax | 1.8 nV/√Hz, 0.8 fA/√Hz, 30 Hz to 10 MHz, 70 dB Variable Gain Range. |
| » BII1040 | Fixed Gain Voltage Amplifier | 200m or RG58 Coax | 3 nV/√Hz, 4 fA/√Hz, 12 Hz to 17 MHz, 40 dB Gain. |
| » BII1050 | Fixed Gain Voltage Amplifier | 305m or RG58 Coax | 1 nV/√Hz, 0.8 fA/√Hz, 0.02 Hz to 10 MHz, 40 to 60 dB Gain. |
| » BII1060<br>» BII1010 | Fixed Gain Voltage Amplifier | 1000m | 0.1 Hz to 800 kHz, 40 dB Gain, Battery-operated Systems. |
| » BII1080 | Fixed Gain Voltage Amplifier | 200m | 5.2 nV/√Hz, 3.1 fA/√Hz, 20 to 60 dB Gain, 1 Hz to 2.2 MHz. |
| » BII1090 | Digitally Programmable Gain Voltage Amplifier | 1000m or RG58 Coax | 1 nV/√Hz, 0.8 fA/√Hz, 0.02 Hz to 8 MHz. Gains: 0, 20, 40, 60, 80 dB. |
| » BII2000 | Automatic Gain Control (AGC) Amplifier | 200m | -20 to 80 dB Automatic Gain Control, 100 Hz to 1 MHz Bandwidth. |

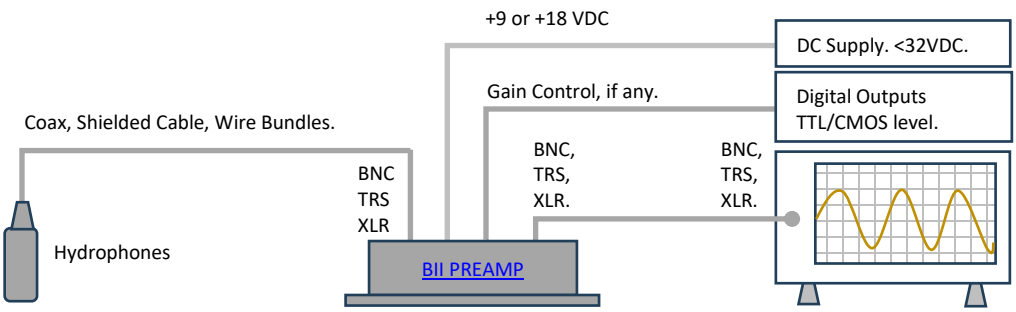
**Noise Figures of Typical Low Noise Preamps.**





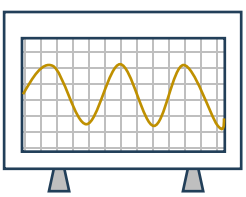
**System Wirings of Standalone Preamp.**




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


**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.

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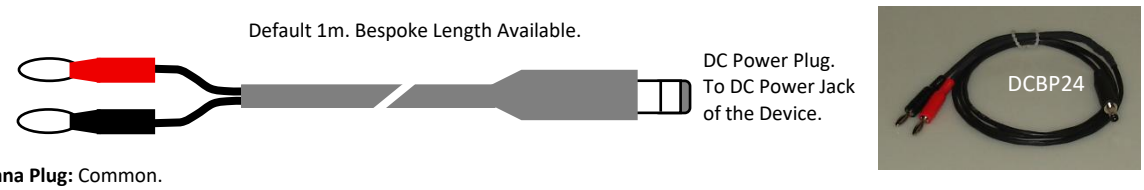
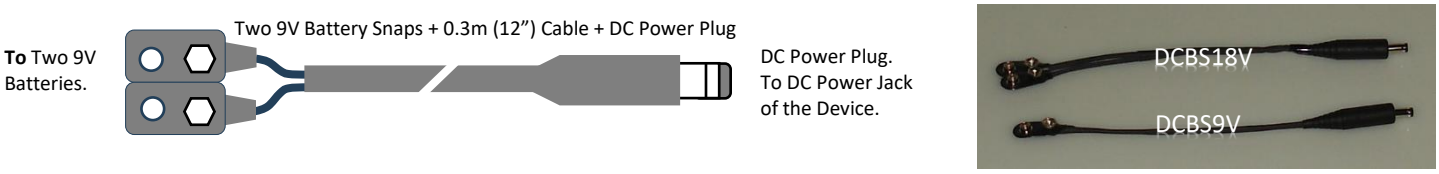
## Accessories of Preamps, Hydrophones, or Acoustical Receiving Instruments:

**DC Supply Cable: DCBP24. One 1m DC supply cable with Red and Black Banana Plugs, and DC Power Plug.**

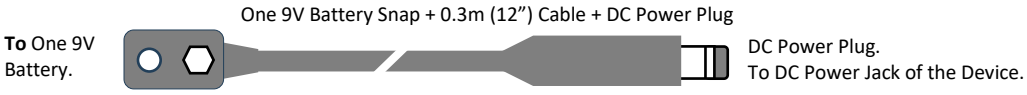



**Red Banana Plug:** +VDC. **Black Banana Plug:** Common.
One 1m DC supply cable. One end of the cable is with DC Power Plug; another end is Red and Black Banana Plugs. Depending on output terminals of buyer's DC Supply, buyer may assemble other types of connectors to DC supply cable at buyer's cost.

**DC Supply Cable: DCBS18V. One 0.3m (12") DC supply cable with two 9V Battery Snaps which supplies +18VDC to amplifiers, and one DC Power Plug.**




**DC Supply Cable: DCBS9V. One 0.3m (12") DC supply cable with one 9V Battery Snaps which supplies +9VDC to amplifiers, and one DC Power Plug.**




**DC Supply Cable: DCWL-24**. One 1m DC supply cable with Wire Leads and DC Power Plug.


**Accessory A1: BNCM-BNCM.** Bespoke length RG58, RG174, or RG178 Coax with BNC Male to BNC Male. Default: 0.6m.

**Recorders and Analyzers with BNC Jack.**

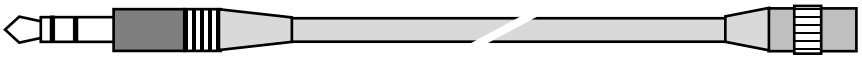
**Accessory A2: TRS-TRS.** Bespoke length cable with 3.5mm TRS Plug to 3.5mm TRS Plug. Default: 1.828m.

**Recorders and Analyzers with TRS Jack.**

**Accessory A3: TRS-WL.** Bespoke length cable with 3.5mm TRS Plug to Wire Leads. Default: 0.9m.


**Recorders and Analyzers with Screw-Tighten or Clamp Terminals.**

**Accessory A4: TRS-XLR3P.** Bespoke length cable with 3.5mm TRS Plug to XLR Receptacle with 3 Male Pins. Default: 0.9m.

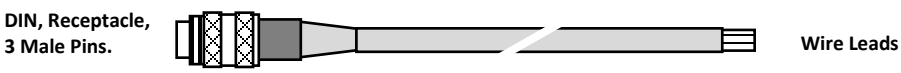



**Recorders and Analyzers with XLR Plug with 3 Female Sockets on front panel.**

**Accessory A5: DIN3P-XLR3P.** Bespoke length cable with DIN Receptacle with 3 Male Pins to XLR3 Receptacle with 3 Male Pins. Default: 1m.

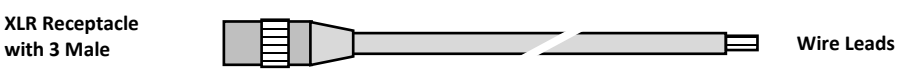

**Recorders and Analyzers with XLR Plug with 3 Female Sockets on front panel.**

**Accessory A6: DIN3P-WL.** Bespoke length cable with DIN Receptacle with 3 Male Pins to Wire Leads. Default: 1m.




**Recorders and Analyzers with Screw-Tighten or Clamp Terminals.**

**Accessory A7: XLR3P-WL**. Bespoke length cable with XLR Receptacle Male Pin to Wire Leads. Default: 1m.




**Recorders and Analyzers with Screw-Tighten or Clamp Terminals.**

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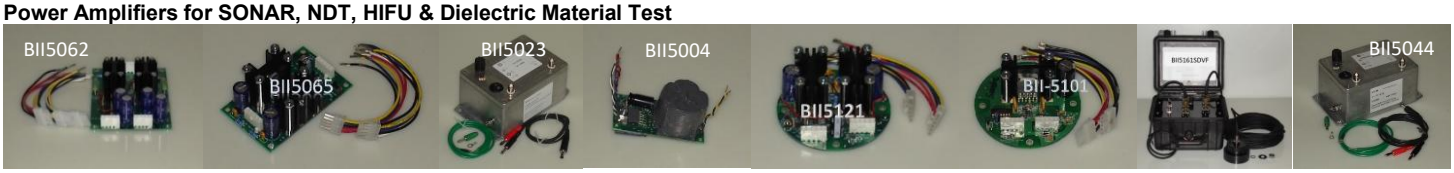
## Power Amplifiers for SONAR, NDT, HIFU & Dielectric Material Test



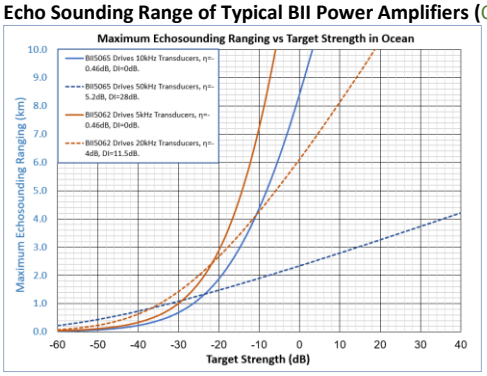

BII's power amplifiers are designed to drive underwater and ultrasonic transducers up to 10MHz: SONAR, NDT, HIFU and Ultrasonic Power Transducers. Linear and switch mode (Class D or Switching) power amplifiers are available.

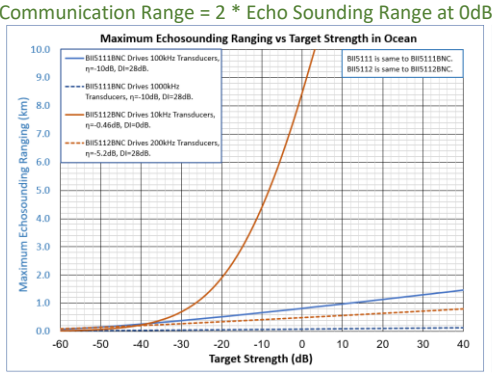
**Typical Applications**

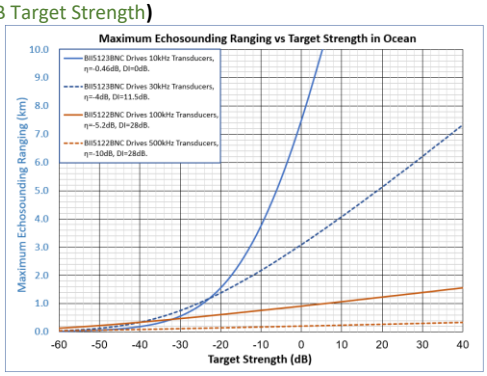
| | |
|---|---|
| Sub-bottom Profiler, Sea-floor Mapping, Depth Sounder, Noise Generation. | Ultrasonic (NDT) Testing, Dielectric Material Characterization. |
| Speedometer, Fishing Finding, Navigation, Acoustic Positioning. | Sonic Processing, Process Control, Cavitation, HIFU. |
| Underwater Communication, Telemetry, Acoustic Beacons, Remote Control. | Marine Animal Acoustics, Bioacoustics, Playback of Marine Sounds. |

| Power Amplifier | Output Power | Bandwidth | Source Level in Water | Quiescent Current | Type | Package |
|---|---|---|---|---|---|---|
| » BII5000 | 32 Watt | 10 Hz to 120 kHz | 184.0 + DI | 100mA active, 10μA Stand-by. | Linear | PCB |
| » BII5020 | 86 Watt | 0.1 to 500 kHz | 187.0 + DI | 36mA active, 16mA Stand-by. | Linear | PCB, Metal Enclosure. |
| » BII5040 | 31.3 Watt | 50 kHz to 10 MHz | 182.7 + DI | 53mA active, 0.8mA Stand-by. | Linear, Pulse. | PCB, Metal Enclosure. |
| » BII5060 | 208, 415 Watt | 0.1 to 70 kHz | 196.0 + DI | 59mA Active, 24mA Stand-by. | Linear | PCB, Metal Enclosure. |
| » BII5100 | 309 Watt | 1 to 500 kHz | 194.2 + DI | 13mA | Switch Mode (Class D) | PCB, Metal Enclosure. |
| » BII5110 | 108/216 Watt | 1 kHz to 10 MHz | 194.1 + DI | 1mA and 2mA | Switch Mode (Class D) | PCB, Metal Enclosure. |
| » BII5120 | 138 Watt | 20 Hz to 2 MHz | 189.2 + DI | 65mA active, 6mA Stand-by. | Linear | PCB, Metal Enclosure |
| » BII5160 | 208 Watt | 0.1 to 20 kHz | 194.0 + DI | 59mA Active, 24mA Stand-by. | Linear | Portable Case |
| **Switch Mode Operation:** Input signal of the PA is pulse or square signals with TTL/CMOS level or 2Vpp to 5Vpp. | | | | | | |
| **Source Level** (dB μPa*m) in water. **DI** is Directivity Index of a transducer, in dB. η: Transducer Efficiency, in dB. η = -1.55dB (η = 0.7) is used in the table above. η of broadband planar transducers such as NDT Transducers could be ⩽ -5dB, η of broadband spherical or cylindrical transducers could be ⩾ -0.5dB. | | | | | | |

**Echo Sounding Range of Typical BII Power Amplifiers (**Communication Range = 2 * Echo Sounding Range at 0dB Target Strength**)**




## BII6000 Series Matching Network: Impedance Matching between Transducers and Amplifiers


The complex impedance of a piezoelectric transducer (a projector or a hydrophone) is non-linear and frequency dependent. Its magnitude ranges from hundreds kΩ to several Ω, and its phase varies from -90° to +90°. The transducer is a capacitive, resistive, or inductive load at different frequency ranges. An impedance matching & tuning device is necessary to change the complex impedance of the transducer in a specific frequency range (generally around resonance frequency fs of the transducer) to meet load requirement of a power amplifier for **maximum and efficient power transfer from the electric to the mechanical**, or to match input impedance of a preamplifier for **maximum and efficient power transfer from the mechanical to the electric**, or achieve the optimum source resistance for **minimum noise factor NF**. Generally, -3dB bandwidth of a transducer with impedance matching and tuning is greater than that of original transducer. Besides, BII also manufactures custom-fit voltage step-up transformers for study of dielectric, ferroelectric, and piezoelectric materials.

Generally, there are two kinds of acoustic system: Broadband (Low Q) and Narrowband (High Q). **Narrowband Acoustic System** possesses merits of high-quality factor, and very low energy loss on the device itself. High sound energy with high efficiency can be delivered to subjects such as HIFU system, Ultrasonic Degassing/Cleaning/Physical & Chemical Processing, etc.... Generally, the sounds are continuous sounds or burst sounds with pulse width greater than 200mS. **Broadband Acoustic System** possesses merits of low-quality factor, wide bandwidth, much shorter "ringing" to reach stable state. High sound energy with low or median efficiency can be delivered to subjects such as Ultrasonic NDT system, SONAR Echo-sounding, Communication, AE Detection, etc... Generally, the sounds are pulsing sounds, burst sounds with pulse width of 10nS to 10mS, or continuous/burst communication signals. BII chooses BII6010 parts (Low Q broadband or High Q Narrowband) suitable for BII transducers. When buyer orders BII6010 for buyer's own transducers, buyer should specify Low Q or High Q BII6010 clearly when ordering.

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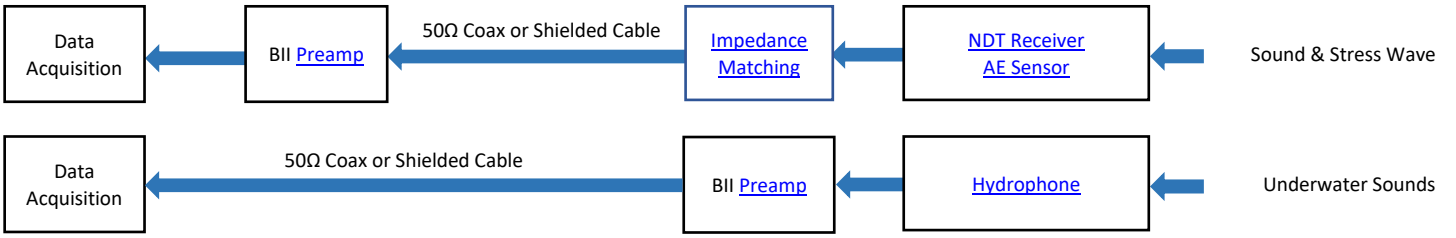
**Transmit and Receive Switch: SONAR & Ultrasound**


BII T/R switch module provides an integrated solution for a wide range of acoustic applications based on Emitting and Listening Timing Techniques. The device works at active mode (Transmitting Sounds) and passive mode (Listening Sounds) in a half-duplex acoustic system. It integrates an Impedance Matching Network (except BII2100 series), a T/R switch, a bandpass filter, and a low noise DPGA preamplifier (Digitally Programmable Gain Amplifier) or an AGC Amplifier into one compact housing. Gain-selection is accomplished by a two-bit or one-bit digital word (TTL/CMOS level compatible). BII T/R Switches feature low noise level and large dynamic range suitable to detect large signals from short distance and the highly attenuated signals from long distance.

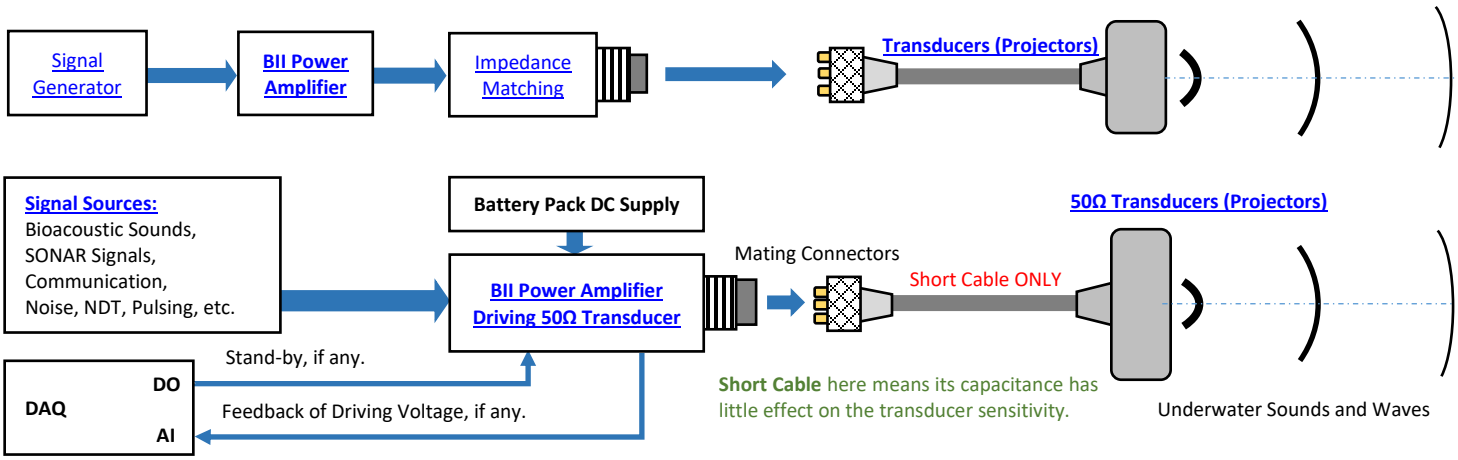
**Typical Applications:** Echo Sounding SONAR, Positioning/Communication, Artificial Acoustic Target, Marine Bioacoustics, NDT/Diagnostic Ultrasounds.

| T/R Switch Modules | Frequency Range | Receiving Gain Range | Gain Control | Built-in Impedance Matching |
|---|---|---|---|---|
| BII2100 Series | 10 Hz to 10 MHz. | 20, 40, 60, 80dB. | Digital, TTL/CMOS | No |
| BII2160 Series | 100 Hz to 1 MHz. | -20 to 80 dB. | None, AGC | Yes |
| BII2170 Series | 10 Hz to 10 MHz. | 20, 40, 60, 80dB. | Digital, TTL/CMOS | Yes |

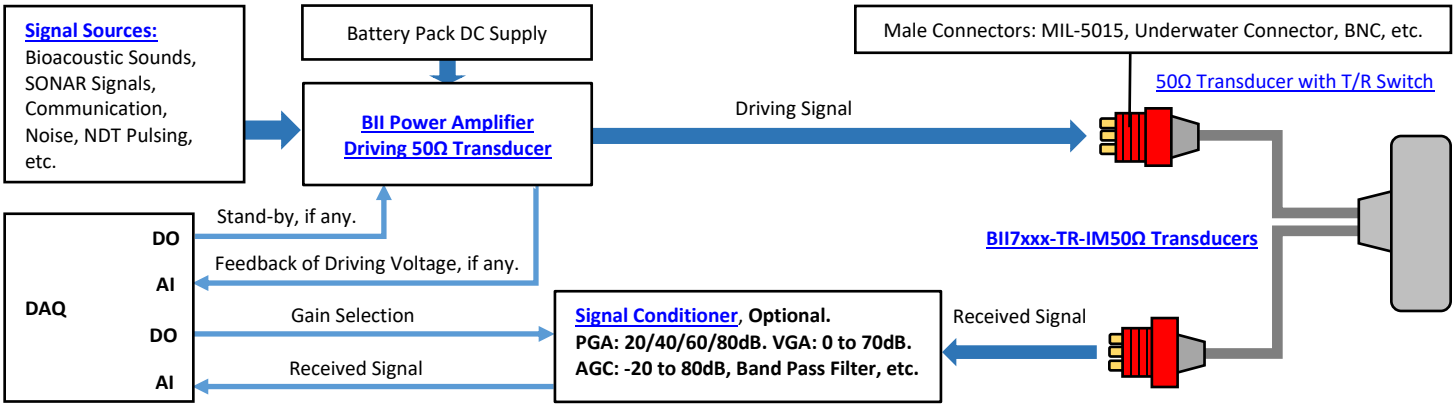
**Acoustic Receivers on Underwater Sounds, NDT and AE.**




**ACOUSTIC SYSTEM CONFIGURATION of GENERATION SOUNDS and WAVES.**




**ACOUSTIC SYSTEM CONFIGURATION of TRANSMITTING and RECEIVING SOUNDS AND WAVES.**

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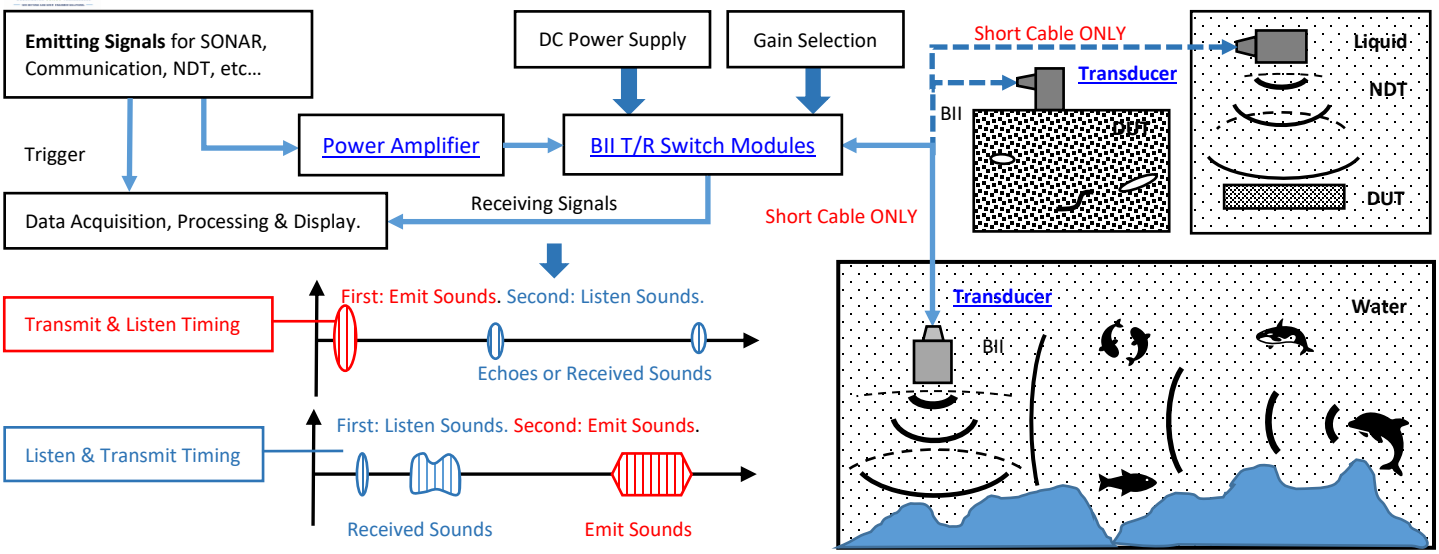
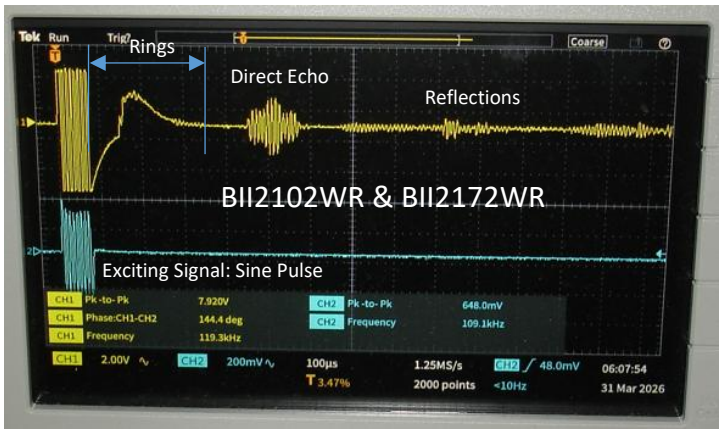
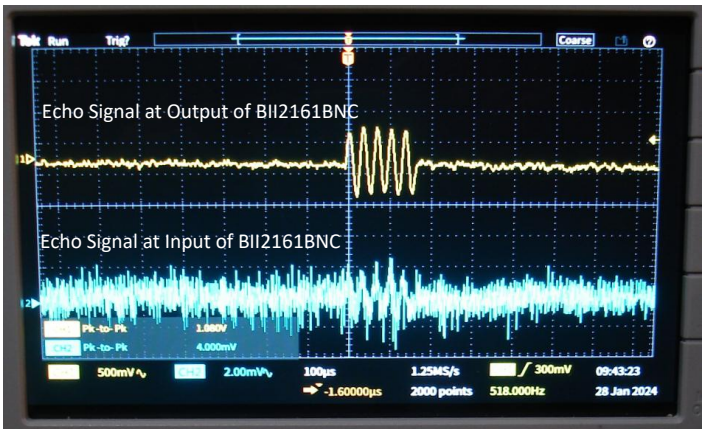



## Acoustic Pulse-Echo Systems in a Small-body Water Tank

**(1) 110 kHz Sine Pulse, System is Based on BII2102WR or BII2171WR.**




**(2) 30 kHz Sine Pulse, System is Based on BII2161BNC.**




**How to Choose BII TR Switch and Transducers (tuned or untuned) according to my acoustic project?**

**Acoustic Project I**: Sub-Bottom Profiling.
**Requisites**: **Electrical Average Power to Transducer** $P_{avg}$ = 1000W during 1ms pulse duration; **Operating Frequency**: 8 kHz.
Transducer Options: (1) **A untuned transducer** $G_{max}$ = 0.73mS, B= 0.8mS at $f_s$ = 8kHz.
(2) **A series-tuned transducer** $R_{TX}$ = 400Ω at $f_s$ = 8kHz.

Step 1. **Signal Types.** Referring to **Typical Signals for Active SONAR...** in BII's Acoustic Transducers and Measurement Handbook.
Step 2. Refer to BII210x Specs: Max. Transmit Current, Pulse Power Capacity during PD and Maximum Peak Pulse Voltage as function of Pulse Duration and Duty Cycle. Both BII2102WR and BII2102MIL meet limitations above.

| Signal Types | Exciting Voltage to Transducer | TR Switch | PD and D |
|---|---|---|---|
| **Sine Pulse** (**SP**) to untuned transducer achieving 1000W $P_{avg}$: | $V_{tx} = \sqrt{8 * P_{avg}/G_{max}}$ = 3310 $V_{pp}$. | BII2102WR | PD = 1mS and D ⩽ 1% |
| **Burst Square Signal** (**BSS**) to untuned transducer achieving 1000W $P_{avg}$: | $V_{tx} = \sqrt{4 * P_{avg}/G_{max}}$ = 2341 $V_{pp}$. | BII2102WR | PD = 1mS and D ⩽ 1% |
| **Sine Pulse** (**SP**) to series-tuned transducer achieving 1000W $P_{avg}$: | $V_{tx} = \sqrt{8 * P_{avg} * R_{TX}}$ = 1789 $V_{pp}$. | BII2102WR | PD = 1mS, D ⩽ 10% |
| **Burst Square Signal** (**BSS**) to series-tuned transducer achieving 1000W $P_{avg}$: | $V_{tx} = \sqrt{4 * P_{avg} * R_{TX}}$ = 1265 $V_{pp}$. | BII2102WR | PD = 1mS, D ⩽ 10% |
| | | BII2102MIL | PD = 1mS, D ⩽ 10% |

Step 3. **Determine Receiving Bandwidth.** Operating f is 8kHz. Refer to Refer to BII210x Specs: Input Referred Noise $e_n$.
To reduce electronic noise, at same time, to avoid affecting 8kHz echo signal, -3dB bandpass filter of receiving can be set to 0.8 to 80 kHz.
Take BII2102WR and FFVS = -180.0 dBV/µPa as an example, equivalent pressure noise level at input from electronics, approximately:
$P_n$ = -110.4 dBV – FFVS of the transducer = 69.6 dB µPa.

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**Acoustic Project II**: Underwater Communication.
**Requisites**: (1) **Electrical Average Power to Spherical Transducer** $P_{avg}$ = 300 W during 10 ms pulse duration, D=10%;
(2) Transmit and Receive **Communication Carrier Frequency**: 35 kHz.
**Transducer Options:** (1) **Untuned spherical transducer** BII7523 $G_{max}$ = 10.8 mS, B= 8 mS at $f_s$ = 35 kHz.
(2) **Series-tuned spherical transducer** BII7523ST $R_{TX}$ = 60 Ω at $f_s$ = 35 kHz.

Step 1. **Signal Types.** Referring to Typical Signals for Active SONAR... in BII's Acoustic Transducers and Measurement Handbook.
Step 2. Refer to BII210x Specs: Max. Transmit Current, Pulse Power Capacity during PD and Maximum Peak Pulse Voltage as function of Pulse Duration and Duty Cycle. BII2102WR, BII2102MIL, BII2102BNC, BII2103BNC, meet limitations above.

| Signal Types | Exciting Voltage to Transducer | TR Switch | PD and D |
|---|---|---|---|
| **Sine Pulse** (**SP**) to untuned transducer achieving 300W $P_{avg}$: | $V_{tx} = \sqrt{8 * P_{avg}/G_{max}}$ = 471.4 $V_{pp}$. | BII2102WR, BII2102MIL, BII2102BNC, BII2103BNC. | PD = 10mS, D = 10%. |
| **Burst Square Signal** (**BSS**) to untuned transducer achieving 300W $P_{avg}$: | $V_{tx} = \sqrt{4 * P_{avg}/G_{max}}$ = 333.4 $V_{pp}$. | | |
| **Sine Pulse** (**SP**) to series-tuned transducer achieving 300W $P_{avg}$: | $V_{tx} = \sqrt{8 * P_{avg} * R_{TX}}$ = 379.5 $V_{pp}$. | | |
| **Burst Square Signal** (**BSS**) to series-tuned transducer achieving 300W $P_{avg}$: | $V_{tx} = \sqrt{4 * P_{avg} * R_{TX}}$ = 268.4 $V_{pp}$. | | |

Step 3. **Determine Receiving Bandwidth.** Carrier frequency f = 35kHz. Refer to BII210x Specs: Input Referred Noise en.
To reduce electronic noise, at same time, to avoid affecting 35kHz communication signal, -3dB bandpass filter of receiving can be set to 3.5 to 350 kHz.
Take BII2102BNC and BII7523 FFVS = -197.0 dBV/µPa as an example, equivalent pressure noise level at input from electronics, approximately:
$P_n$ = -104.0 dBV – FFVS of the transducer = 93.0 dB µPa.

**Acoustic Project III**: 1MHz NDT.
**Requisites**: (1) **Electrical Peak Power to NDT Transducer** $P_{peak}$ = 2000 $W_{peak}$, Positive or Negative Voltage Spike: 50 nS to 1 µs, D ≤ 1%;
(2) Transmit and Receive **Frequency**: 1 MHz.
**Transducer Options:** 50Ω **Transducer**, Z = 50 Ω, 1 MHz.

Step 1. **Signal Types.** Referring to Typical Signals for Active SONAR... in BII's Acoustic Transducers and Measurement Handbook.
Step 2. Refer to BII217x Specs: Max. Transmit Current, Pulse Power Capacity during PD and Maximum Peak Pulse Voltage as function of Pulse Duration and Duty Cycle. BII2174BNC, meet limitations above.

| Signal Types | Approximately Exciting Voltage to Transducer | TR Switch | PD and D |
|---|---|---|---|
| Voltage Spike (**VS**) to 50Ω transducer achieving 2000W $P_{peak}$: | $V_{tx} = \sqrt{P_{peak} * R_{TX}}$ = 316.2 $V_{peak}$. | BII2174BNC. | PD = 50 nS to 1 µs; D ≤ 1%. |

Step 3. **Determine Receiving Noise Level at input**. Refer to BII217x Specs: Input Referred Noise en.
-3dB bandpass filter of receiving is fixed to 10 kHz to 17 MHz.
Take BII2104BNC and FFVS of NDT Transducer = -206.0 dBV/µPa as an example, equivalent pressure noise level at input from electronics, approximately:
$P_n$ = -95.6 dBV – FFVS of the transducer = 110.3 dB µPa.

**Acoustic Project IV**: 300 kHz Short Distance Underwater Echo Sounding.
**Requisites**: (1) **Electrical Average Power to NDT Transducer** $P_{avg}$ = 500 W, Sine Pulse Duration: 30 µs, D ≤ 0.1%;
(2) Transmit and Receive **Frequency**: 300 kHz.
**Transducer Options:** 50Ω **Transducer**, Z = 50 Ω, 300 kHz.

Step 1. **Signal Types.** Referring to Typical Signals for Active SONAR... in BII's Acoustic Transducers and Measurement Handbook.
Step 2. Refer to BII2161 Specs: Max. Transmit Current, Pulse Power Capacity during PD and Maximum Peak Pulse Voltage as function of Pulse Duration and Duty Cycle. BII2161MIL and BII2161BNC meet limitations above. But BII2161BNC has lower noise level.

| Signal Types | Approximately Exciting Voltage to Transducer | TR Switch | PD and D |
|---|---|---|---|
| Sine Pulse (**SP**) to 50Ω transducer achieving 500W $P_{avg}$: | $V_{tx} = \sqrt{8 * P_{avg} * R_{TX}}$ = 447.2 $V_{pp}$. | BII2161MIL. BII2161BNC. | PD = 30 µs; D ≤ 0.1%. |

Step 3. **Determine Receiving Noise Level at input**. Refer toBII2161 Specs: Input Referred Noise $e_n$.
-3dB bandpass filter of receiving set to 50 kHz to 1 MHz.
Take BII2161BNC and FFVS of 50Ω Transducer = -198.0 dBV/µPa as an example, equivalent pressure noise level at input from electronics, approximately:
$P_n$ = -99.0 dBV – FFVS of the transducer = 99.0 dB µPa.

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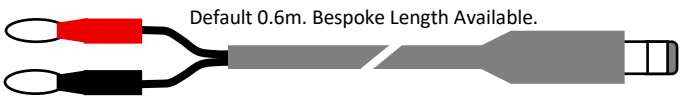
## Accessories of Power Amplifiers, Transducers, or Acoustical Transmitting and Receiving Instruments/Modules:

**DC Supply Cable Pair: Part Number DCBP20.**

**To Terminals of DC Supply:**
a. One Red 4mm Banana Plug.
b. One Black 4mm Banana Plug.





**Red Banana Plug:** +VDC. **Black Banana Plug:** Common.
One 0.6m DC supply cable. One end of the cable is with DC Power Plug, another end is Red and Black Banana Plugs.

**DC Supply Cable Pair: Part Number DCBP18.**

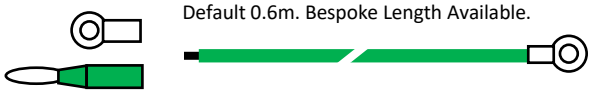
**To Terminals of DC Supply:**
One Red 4mm Banana Plug.
One Black 4mm Banana Plug.



Two 0.6m DC supply cables. Red and Black. One end of the cable is Red and Black Banana Plugs, another end is Sheathed Banana Plug.

**Grounding Cable and Terminals**

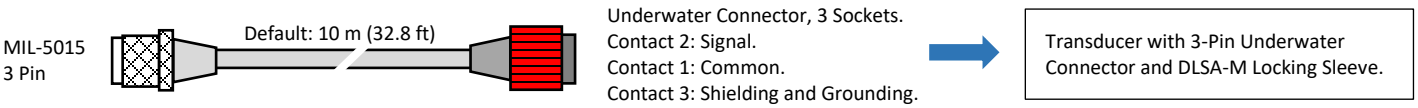
**Terminal to buyer's Grounding Terminal:**
a. Default: Wire Lead
b. One #10 Ring Terminal
c. One 4mm Banana Plug



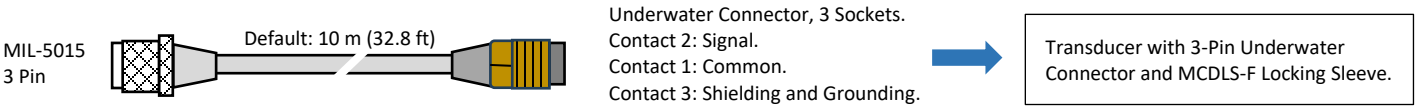


**Grounding Cable, Part Number: GWL18,** Support Single-Point Grounding with Multiple Devices.
One 0.6m AWG 18 Green Wire (or Green with a Yellow Stripe) with #10 Ring Terminal and Wire Lead. One #10 Ring Terminal and one 4mm Banana Plug (Green) are included. Depending on buyer's grounding terminal type, buyer assembles #10 Ring Terminal, 4mm Banana Plug, or other type of connectors to grounding cable at buyer's cost.

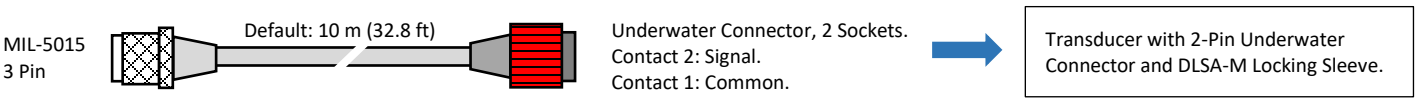
**Accessory A9: MIL-UMCF3S,** MIL-5015 (3 Pins) to UMC3S (Underwater Connector, 3 Sockets, Locking Sleeve: DLSA-F, Size: Φ35.5x33.5mm)



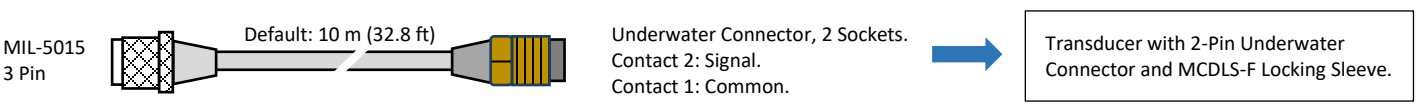

**Accessory A10: MIL-SUMC3S,** MIL-5015 (3 Pins) to Small UMC3S (Underwater Connector, 3 Sockets, Thread Locking, Size: Φ22x28mm)



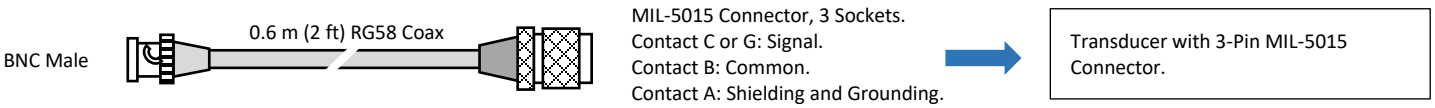

**Accessory A11: MIL-UMCF2S,** MIL-5015 (3 Pins) to UMC2S (Underwater Connector, 2 Sockets, Locking Sleeve: DLSA-F, Size: Φ35.5x33.5mm)



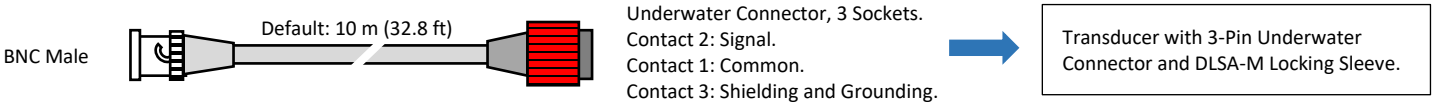

**Accessory A12: MIL-SUMC2S,** MIL-5015 (3 Pins) to Small UMC2S (Underwater Connector, 2 Sockets, Thread Locking, Size: Φ22x28mm)




**Accessory A13: BNC-MIL3S,** BNC Male (Pin) to MIL3S (MIL-5015 type 3-Socket Connector Thread Fastening)




**Accessory A14: BNC-UMCF3S,** BNC Male to UMC3S (Underwater Connector, 3 Sockets, Locking Sleeve: DLSA-F, Size: Φ35.5x33.5mm)

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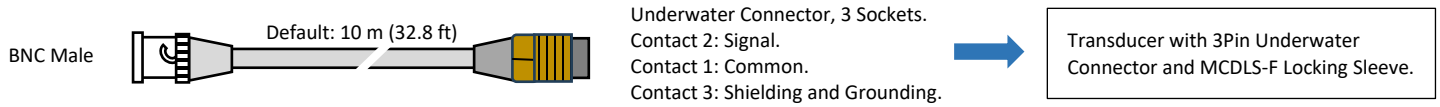
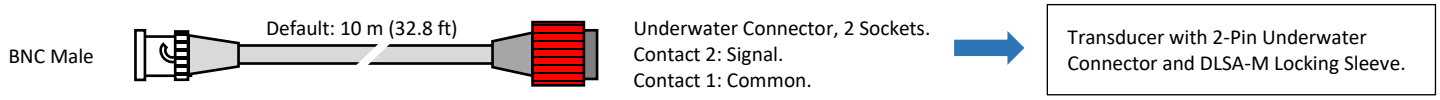
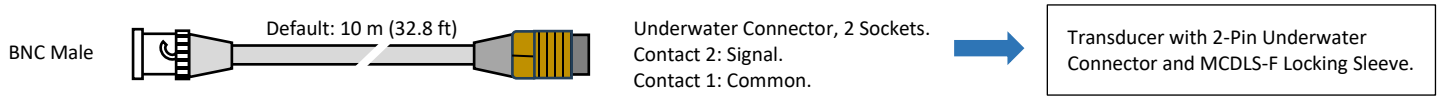
**Accessory A15: BNC-SUMC3S,** BNC Male to Small UMC3S (Underwater Connector, 3 Sockets, Thread Locking, Size: Φ22x28mm)




**Accessory A16: BNC-UMCF2S,** BNC Male to UMC2S (Underwater Connector, 2 Sockets, Locking Sleeve: DLSA-F, Size: Φ35.5x33.5mm)




**Accessory A17: BNC-SUMC2S,** BNC Male to Small UMC2S (Underwater Connector, 2 Sockets, Thread Locking, Size: Φ22x28mm)




**Are 50Ω Power Amplifiers suitable to drive non-50Ω transducers?**

(1) If the impedance of a transducer is greater than 50Ω at operating frequency, the 50Ω Power Amplifiers can drive this non-50Ω transducer, but the power delivered to non-50Ω transducer is reduced.

(2) A 50Ω Power Amplifiers should NOT drive a transducer whose impedance is less than 50Ω. The power amplifier is most likely to be damaged by overvoltage, exceeding rated power or overheating.

**How do I connect the BII Power Amplifier wires to my devices?**

WARNING: HIGH VOLTAGES MAY BE PRESENT AT THE OUTPUT OF THIS UNIT. DO NOT TOUCH THE DEVICE, ITS WIRES, CABLES, AND CONNECTORS BEFORE THE POWER SUPPLIES AND SIGNAL SOURCES ARE SHUT DOWN.

1. **Wire Splicing Methods: Soldering or Crimp**. 2. **Proper Insulation for Safety**: All exposed bare wires, metal wires, wire leads, solders, and joints are insulated with insulation material such as heat shrink tubing, fully insulated wire splice connector, etc. The insulation voltage must be greater than twice the maximum voltage of the device. 3. **Grounding the device** (including metal chassis and/or metal housing, cable shield, etc.) firmly for operation safety.

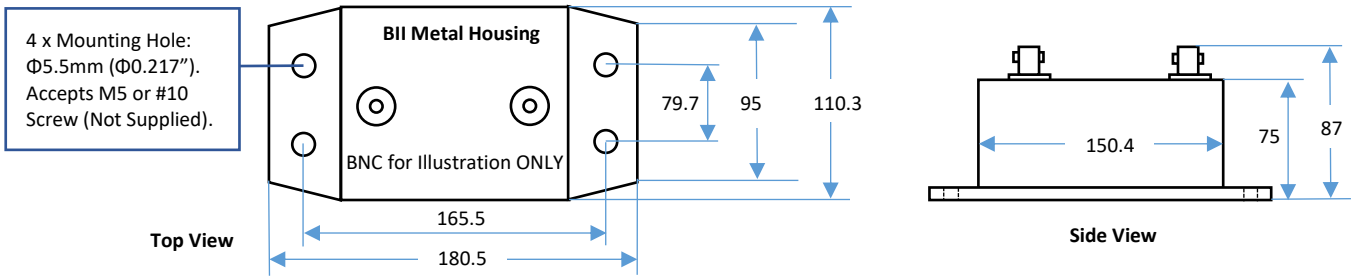
**How to Extend Input and Output Wires of Power Amplifiers (PCB Package for Embedded Applications.)?**

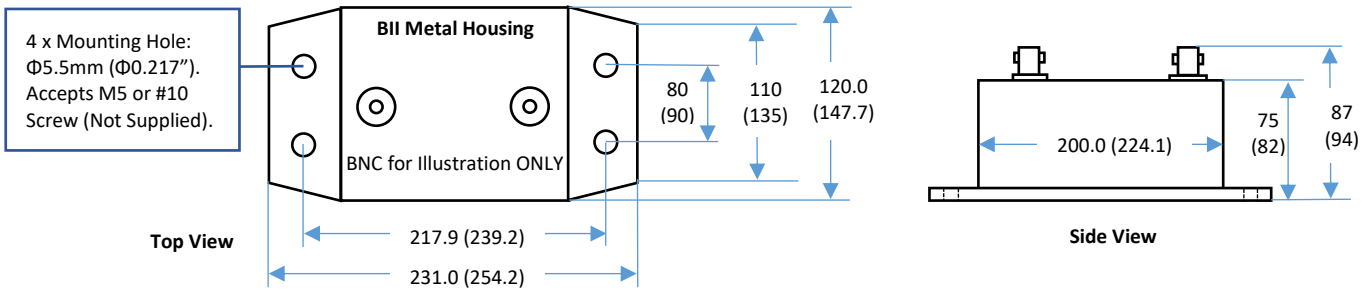
Input and output wires of BII PA (PCB Package) are 0.15m (6") **AWG16 wires** with wire leads.

1. **Butt Splice Connectors, Fully Insulated**. Buyers shall refer to the instructions of the manufacturer to strip proper wire leads and crimp the connector for secure connection. If possible, **heat shrink tube** is recommended to sheath the splice and function as strain relief.
2. **Banana Jack and Plug, Fully Insulated, Free Hanging (In-Line)**. Crimp or solder. Crimp is recommended.

**Note:** a. by default, BII does NOT provide these connectors. If buyer needs connectors, please specify when ordering.
b. When wiring, please ensure insulation (avoid short circuit to damage the devices) and safety of operation.

**Typical Metal Housings, Outline Dimensions (mm), Illustration only, the scale is not 1:1.**

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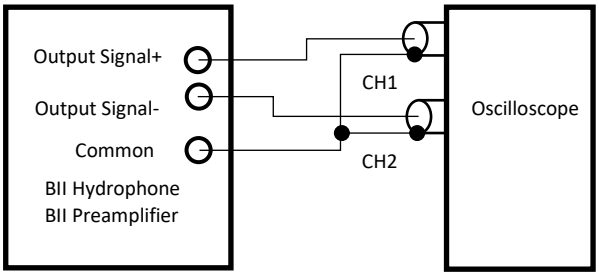
## Wiring Information

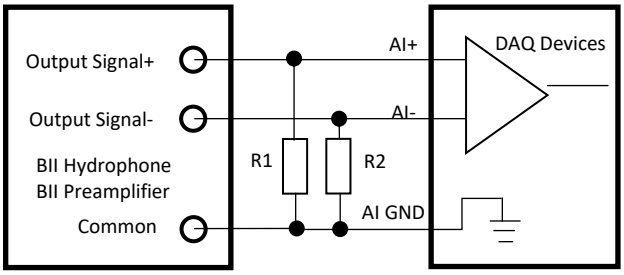
### Wirings of BII Hydrophones (Sound Receiver, AE Sensors, NDT Receivers, etc.)

**1. Preamplifier Wirings to DAQ (Data Acquisition):** DAQ: Data Acquisition Hardware; AI: Analog Input; CH: Channel; GND: Ground.
R1 and R2 resistors are NOT necessary for most applications. If DAQ saturation occurs, use R1 = R2 = 10kΩ to 1MΩ resistors.

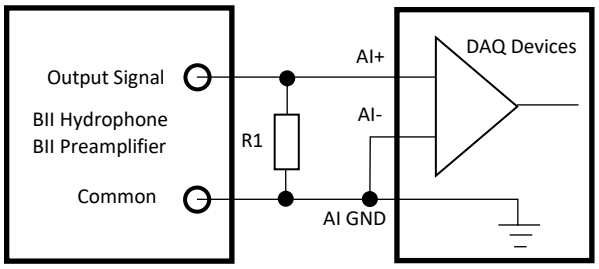
**BII's Differential Output to BNC Input of an Oscilloscope**



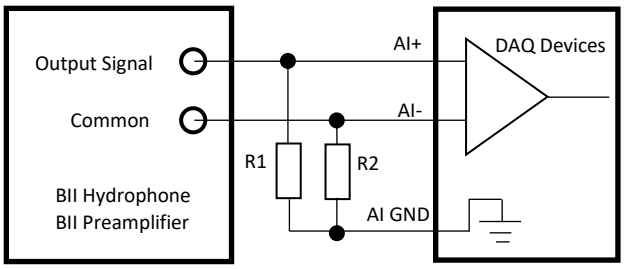

**BII's Differential Output to Differential Input of a DAQ**



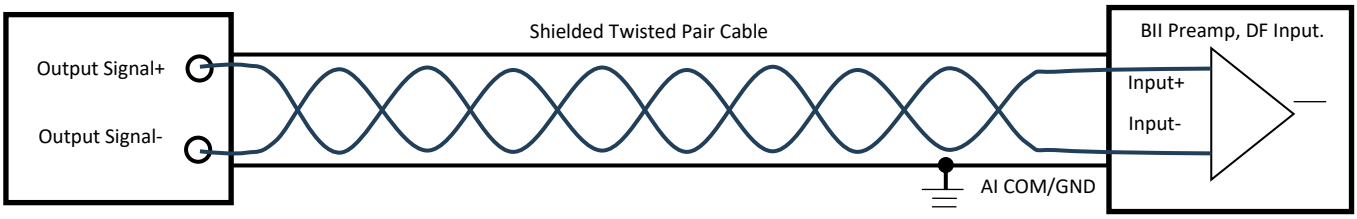

**BII's Single-Ended Output to Single-Ended Input of a DAQ**



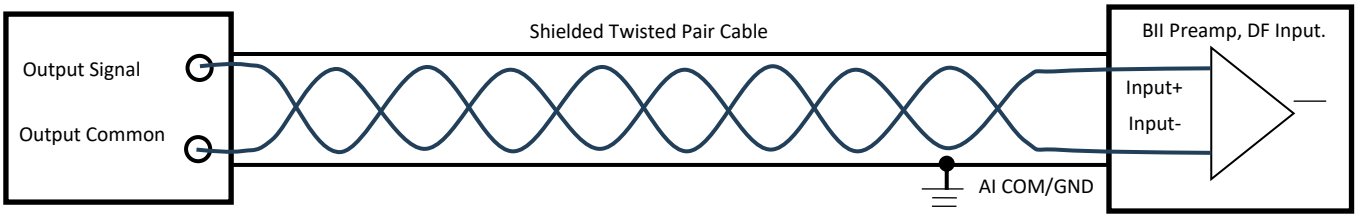

**BII's Single-Ended Output to Differential Input of a DAQ**



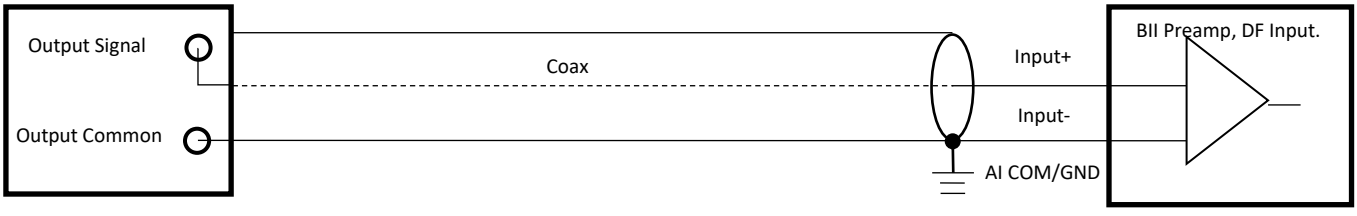

**BII's Differential Sound Receiver to Differential Input of a BII Preamp (Signal Conditioner)**




**BII's Single-ended Receiver to Differential Input of a BII Preamp**




**BII's Single-ended Receiver to Differential Input of a BII Preamp**




**Driving 100Ω Balanced Twisted Pair Cable/Wires and 50 or 75 Ω Coax.**

(1) Impedance of most Balanced Twisted Pair Cable/Wire is from 100Ω to 150Ω.
BII preamp has 100Ω output impedance or bespoke impedance to match the impedance of Balanced Twisted Pair Cable/Wires.
(2) Impedance of most Coax is 50Ω or 75Ω.
BII preamp has 50Ω output impedance or bespoke 75Ω impedance to match the impedance of coaxes.

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**2. Hydrophone (Sound Receiver, AE Sensor, NDT Receiver, etc.) Wiring without Built-in Preamplifier. Refer to Abbreviation List for Ordering.**

| **Differential Output:** | **Wire Leads** | **UMC3P** | **DIN3** | **TRS** | **XLR3** |
|---|---|---|---|---|---|
| **Signal +** | White or Red | Pin 2 | Pin 3 | Tip, Positive/Hot | Pin 2, Positive/Hot. |
| **Signal -** | Black | Pin 1 | Pin 1 | Ring, Negative/Cold | Pin 3, Negative/Cold. |
| **Common & Shielding** | Shield | Pin 3 | Pin 2 | Sleeve, Ground/Common | Pin 1, Shield/Ground. |
| **Single Ended Output:** | **Wire Leads** | **UMC3P** | **DIN3** | **BNC/SMA/SMC** | **Coax with Wire Leads** |
| **Signal** | White or Red | Pin 2 | Pin 3 | Center Contact | Coax Center Contact |
| **Signal Common** | Black | Pin 1 | Pin 1 | Shield | Coax Shield |
| **Shielding** | Shield | Pin 3 | Pin 2 | Shield | Coax Shield |
| **Wiring of Unshielded Cable:** | **Wire Leads WL** | **UMC2P** (0.6m USC Cable originally coming from manufacturer of the connector, Fixed.). Locking Sleeve: DLSA-M. | | | |
| Signal | White | Contact 2 | | | |
| Signal Common | Black | Contact 1 | | | |

**3. Hydrophone (Sound Receiver, AE Sensor, NDT Receiver, etc.) Wiring with Built-in Preamplifier. Refer to Abbreviation List for Ordering.**

**(1) Wiring Information of Hydrophones with Fixed-gain Preamps:**

| ~~**Single Ended Output:**~~ | ~~**Wire Leads**~~ | ~~**BNC + 9V BS**~~ | ~~**UMC4P/XLR4**~~ | ~~**DIN4**~~ | ~~**XLR3 + 9V BS**~~ | | ~~**TRS + 9V BS**~~ |
|---|---|---|---|---|---|---|---|
| ~~+VDC~~ | ~~Red~~ | ~~Female Snap~~ | ~~Pin 3~~ | ~~Pin 4~~ | ~~Female Snap~~ | | ~~Female Snap~~ |
| ~~Common~~ | ~~Black~~ | ~~Male Snap~~ | ~~Pin 1~~ | ~~Pin 1~~ | ~~Male Snap~~ | | ~~Male Snap~~ |
| ~~Signal~~ | ~~White~~ | ~~Center Pin~~ | ~~Pin 2~~ | ~~Pin 3~~ | ~~DIN Pin 3~~ | ~~XLR Pin 2~~ | ~~TRS Tip~~ |
| ~~Signal Common~~ | ~~Blue, Green, or Yellow.~~ | ~~BNC Shield~~ | ~~Pin 4~~ | ~~Pin 2~~ | ~~DIN Pin 1 & 2~~ | ~~XLR Pin 1 & 3~~ | ~~TRS Ring and Sleeve~~ |
| ~~Shielding~~ | ~~Shield~~ | ~~N/A~~ | ~~Metal Shell~~ | ~~Metal Shell~~ | ~~DIN and XLR Metal Shell~~ | | ~~N/A~~ |
| **Differential Output:** | **Wire Leads** | **UMC4P/XLR4P** | **DIN4P** | **DIN3/XLR3 + 9V BS** | | **BNC + 9V BS** | **TRS + 9V BS** |
| +VDC | Red | Pin 3 | Pin 4 | Female Snap | | Female Snap | Female Snap |
| Common | Black | Pin 1 | Pin 1 | Male Snap | | Male Snap | Male Snap |
| Signal+ | White | Pin 2 | Pin 3 | DIN3 Pin 3 | XLR3 Pin 2 | #1 BNC Center | TRS Tip |
| Signal- | Blue, Green, or Yellow | Pin 4 | Pin 2 | DIN3 Pin 1 | XLR3 Pin 3 | #2 BNC Center | TRS Ring |
| Signal Common | N/A | Pin 1 | Pin 1 | DIN3 Pin 2 | XLR3 Pin 1 | BNC Shell | TRS Sleeve |
| Shielding | Shield | Metal Shell | Metal Shell | DIN3 and XLR3 Metal Shell | | N/A | N/A |
| **4mm Banana Plug Pair**: Red Plug for +VDC, **Black Plug** for Common of the DC power supply. | | | | | | | |

**(2) Wiring Information of Hydrophones with One-Bit-Word Programmable Gain Preamps:**

| ~~**Single Ended Output:**~~ | ~~**Wire Leads**~~ | ~~**UMC6P/XLR6**~~ | ~~**DIN6**~~ | ~~**BNC+ 9V BS**~~ | ~~**DIN3/XLR3 + 9V BS**~~ | | ~~**TRS + 9V BS**~~ |
|---|---|---|---|---|---|---|---|
| ~~+VDC~~ | ~~Red~~ | ~~Pin 3~~ | ~~Pin 4~~ | ~~Battery Female Snap~~ | ~~Battery Female Snap~~ | | ~~Battery Female Snap~~ |
| ~~Common~~ | ~~Black~~ | ~~Pin 1~~ | ~~Pin 1~~ | ~~Battery Male Snap~~ | ~~Battery Male Snap, DIN Pin 2 or XLR Pin 1.~~ | | ~~Battery Male Snap, TRS Sleeve.~~ |
| ~~Output Signal~~ | ~~White~~ | ~~Pin 2~~ | ~~Pin 3~~ | ~~BNC Center~~ | ~~DIN Pin 3~~ | ~~XLR Pin 2~~ | ~~TRS Tip~~ |
| ~~Signal Common~~ | ~~Green~~ | ~~Pin 4~~ | ~~Pin 2~~ | ~~BNC Shield~~ | ~~DIN Pin 1~~ | ~~XLR Pin 3~~ | ~~TRS Ring~~ |
| ~~Digital A0 (FFVS Selection)~~ | ~~Blue~~ | ~~Pin 6~~ | ~~Pin 5~~ | ~~Blue~~ | ~~Blue~~ | | ~~Blue~~ |
| ~~Digital Common~~ | ~~Yellow or Brown~~ | ~~Pin 5~~ | ~~Pin 6~~ | ~~Yellow or Brown~~ | ~~Yellow or Brown~~ | | ~~Yellow or Brown~~ |
| ~~Shielding~~ | ~~Shield~~ | ~~Metal Shell~~ | ~~Metal Shell~~ | ~~Shield~~ | ~~XLR Metal Shell~~ | | ~~N/A~~ |
| **Differential Output:** | **Wire Leads** | **UMC6P/XLR6** | **DIN6** | **BNC + 9V BS** | **DIN3/XLR3 + 9V BS** | | **TRS + 9V BS** |
| +VDC | Red | Pin 3 | Pin 4 | Battery Female Snap | Battery Female Snap | | Battery Female Snap |
| Common | Black | Pin 1 | Pin 1 | Battery Male Snap, BNC Shield. | Battery Male Snap, DIN Pin 2 or XLR Pin 1. | | Battery Male Snap, TRS Sleeve. |
| Output Signal+ | White | Pin 2 | Pin 3 | "1" BNC Center Pin | DIN Pin 3 | XLR Pin 2 | TRS Tip |
| Output Signal - | Green | Pin 4 | Pin 2 | "2" BNC Center Pin | DIN Pin 1 | XLR Pin 3 | TRS Ring |
| Digital A0 | Blue | Pin 6 | Pin 5 | Blue | Blue | | Blue |
| Digital Common | Yellow or Brown | Pin 5 | Pin 6 | Yellow or Brown | Yellow or Brown | | Yellow or Brown |
| Shielding | Shield | Metal Shell | Metal Shell | BNC Shield | Metal Shell | | N/A |
| **4mm Banana Plug Pair**: Red Plug for +VDC, **Black Plug** for Common of the DC power supply. | | | | | | | |
| **Selecting Sensitivity of One-Bit-Word Digitally Programmable** | | | | | | | |
| **FFVS Selection Wire A0** | **BII7XXXPGDF Sensitivity FFVS at 1kHz.** | | | | ~~**BII7XXXPGSE Sensitivity FFVS at 1kHz.**~~ | | |
| 0 (Logic Low) | xxx + 6 dB V/µPa | xxx + 10 dB V/µPa | xxx + 20 dB V/µPa | xxx + 30 dB V/µPa | ~~xxx + 20 dB V/µPa~~ | ~~xxx + 6 dB V/µPa~~ | |
| 1 (Logic High) | xxx + 46 dB V/µPa | xxx + 40 dB V/µPa | xxx + 50 dB V/µPa | xxx + 60 dB V/µPa | ~~xxx + 60 dB V/µPa~~ | ~~xxx + 46 dB V/µPa~~ | |

**(3) Wiring Information of Hydrophones with Two-bit Programmable Gain Preamps:**

| ~~**Single Ended Output:**~~ | ~~**Wire Leads**~~ | ~~**BNC + 9V BS**~~ | ~~**UMC6P/XLR6**~~ | ~~**DIN6**~~ | ~~**DIN3/XLR3 + 9V BS**~~ | | ~~**TRS + 9V BS**~~ |
|---|---|---|---|---|---|---|---|
| ~~+VDC~~ | ~~Red~~ | ~~Female Snap~~ | ~~Pin 3~~ | ~~Pin 4~~ | ~~Female Snap~~ | | ~~Female Snap~~ |
| ~~Common~~ | ~~Black~~ | ~~Male Snap~~ | ~~Pin 1~~ | ~~Pin 1~~ | ~~Male Snap~~ | | ~~Male Snap~~ |
| ~~Digital Common~~ | | ~~Black~~ | | | ~~Black~~ | | ~~Black~~ |
| ~~Output Signal~~ | ~~White~~ | ~~BNC Center~~ | ~~Pin 2~~ | ~~Pin 3~~ | ~~DIN Pin 3~~ | ~~XLR Pin 2~~ | ~~TRS Tip~~ |
| ~~Signal Common~~ | ~~Green~~ | ~~BNC Shield~~ | ~~Pin 4~~ | ~~Pin 2~~ | ~~DIN Pin 1 & 2~~ | ~~XLR Pin 1 & 3~~ | ~~TRS Ring and Sleeve~~ |

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| ~~Digital A1~~ | ~~Yellow or Brown~~ | ~~Yellow or Brown~~ | ~~Pin 5~~ | ~~Pin 6~~ | ~~Yellow or Brown~~ | ~~Yellow or Brown~~ |
|---|---|---|---|---|---|---|
| ~~Digital A0~~ | ~~Blue~~ | ~~Blue~~ | ~~Pin 6~~ | ~~Pin 5~~ | ~~Blue~~ | ~~Blue~~ |
| ~~Shielding~~ | ~~Shield~~ | ~~Shield~~ | ~~Metal Shell~~ | ~~Metal Shell~~ | ~~Metal Shell~~ | ~~N/A~~ |
| **Differential Output:** | **Wire Leads** | **UMC6P/XLR6** | **DIN6** | **BNC + 9V BS** | **DIN3/XLR3 + 9V BS** | **TRS + 9V BS** |
| +VDC | Red | Pin 3 | Pin 4 | Female Snap | Female Snap | Female Snap |
| Common | Black | Pin 1 | Pin 1 | Male Snap | Male Snap, DIN Pin 2 or XLR Pin 1. | Male Snap, TRS Sleeve. |
| Digital Common | | | | BNC Shield | Black | Black |
| Output Signal + | White | Pin 2 | Pin 3 | "1"Center Pin | DIN Pin 3 / XLR Pin 2 | TRS Tip |
| Output Signal - | Green | Pin 4 | Pin 2 | "2"Center Pin | DIN Pin 1 / XLR Pin 3 | TRS Ring |
| Digital A1 | Yellow or Brown | Pin 5 | Pin 6 | Yellow or Brown | Yellow or Brown | Yellow or Brown |
| Digital A0 | Blue | Pin 6 | Pin 5 | Blue | Blue | Blue |
| Shielding | Shield | Metal Shell | Metal Shell | BNC Shield | Metal Shell | N/A |
| **4mm Banana Plug Pair**: Red Plug for +VDC, **Black Plug** for Common of the DC power supply. | | | | | | |
| **Selecting Sensitivity FFVS of Two-bit Digitally Programmable** | | | | | | |
| **FFVS Selection Wire A1** | | **FFVS Selection Wire A0** | | **Hydrophone Sensitivity at 1kHz** | | |
| 0 (Logic Low) | | 0 (Logic Low) | | FFVS of Sensing Element + 0 V/μPa | | |
| 0 (Logic Low) | | 1 (Logic High) | | FFVS of Sensing Element + 20 V/μPa | | |
| 1 (Logic High) | | 0 (Logic Low) | | FFVS of Sensing Element + 40 V/μPa | | |
| 1 (Logic High) | | 1 (Logic High) | | FFVS of Sensing Element + 60 V/μPa | | |

## Wirings of BII Transducers (Projectors)

WARNING: DANGER — HIGH VOLTAGE on wires. Wires shall be insulated for safety. DO NOT TOUCH THE WIRES BEFORE THE DRIVING SIGNAL IS SHUT DOWN. Cable shield must be grounded firmly for safety.

for 50Ω BNC connector, it is buyer's sole responsibility to make sure that the BNC shield of the signal source is firmly grounded for operating safety before hooking up transducer/hydrophone to the signal source. Coax with BNC is not intended for hand-held use at voltages above 30Vac/60Vdc.

**1. Wiring Information of a Transducer.**

| **Cables will be labelled with #1, #2, #3, #4, #5 ...for multiple arrays inside a transducer.** | | | | | | |
|---|---|---|---|---|---|---|
| **Transducer Wiring:** | **Shielded Cable** | **Coax, BNC.** | **UMC3P, Locking Sleeve: DLSA-M.** | **MIL3P** | **DIN3P** | **XLR3P** |
| Signal: | White or Red | Center Contact | Contact 2 | Contact C or G | Pin 3 | Pin 2 |
| Signal Common: | Black | Shield | Contact 1 | Contact B | Pin 1 | Pin 3 |
| Shielding and Grounding | Shield | Shield | Contact 3 | Contact A | Pin 2 | Pin 1 |
| Please contact us for bespoke wirings of differential transducers such as dipole, quadrupole, multimode rings, and flextensional sources. | | | | | | |
| **Wiring of Unshielded Cable:** | **Wire Leads WL** | **UMC2P** (0.6m USC Cable originally coming from manufacturer of the connector, Fixed.). Locking Sleeve: DLSA-M. | | | | |
| Signal | White | Contact 2 | | | | |
| Signal Common | Black | Contact 1 | | | | |

**Wiring Information of Temperature Signal, if any.**

| **Temperature Sensor Wiring:** | **Shielded Cable** | **Coax, BNC** | **Underwater Connector UMC2P. Locking Sleeve: DLSA-M.** | **DIN3S** | **TRS Plug** |
|---|---|---|---|---|---|
| Signal: | White or Red | Center Contact | Contact 2 | Socket 3 | Tip |
| Signal Common: | Black | Shield | Contact 1 | Socket 1 | Ring |
| Shielding and Grounding | Shield | Shield | N/A | Socket 2 | Sleeve |

**2. Wiring Information of Transmitting Sounds of a Transducer with T/R Switch.**

| **Transducer Wiring:** | **Shielded Cable** | **Coax, BNC.** | **UMC3P, Locking Sleeve: DLSA-M.** | **MIL3P** | **DIN3P** | **XLR3P** |
|---|---|---|---|---|---|---|
| Signal: | White or Red | Center Contact | Contact 2 | Contact C or G | Pin 3 | Pin 2 |
| Signal Common: | Black | Shield | Contact 1 | Contact B | Pin 1 | Pin 3 |
| Shielding and Grounding | Shield | Shield | Contact 3 | Contact A | Pin 2 | Pin 1 |
| Please contact us for bespoke wirings of differential transducers such as dipole, quadrupole, multimode rings, and flextensional sources. | | | | | | |
| **Wiring of Unshielded Cable:** | **Wire Leads WL** | **UMC2P** (0.6m USC Cable originally coming from manufacturer of the connector, Fixed.). Locking Sleeve: DLSA-M. | | | | |
| Signal | White | Contact 2 | | | | |
| Signal Common | Black | Contact 1 | | | | |

**Wiring Information of Receiving Sounds of a Transducer with T/R Switch.**

| **Differential Output:** | **Wire Leads** | **UMC4P/XLR4P** | **DIN4P** | **DIN3P/XLR3P + 9V BS** | **TRS + 9V BS** |
|---|---|---|---|---|---|
| +VDC | Red | Pin 3 | Pin 4 | Battery Female Snap | Battery Female Snap |
| Common | Black | Pin 1 | Pin 1 | Battery Male Snap | Battery Male Snap |
| Signal+ | White | Pin 2 | Pin 3 | DIN Pin3 / XLR Pin 2 | TRS Tip |
| Signal- | Blue, Green, or Yellow | Pin 4 | Pin 2 | DIN Pin1 / XLR Pin 3 | TRS Ring |
| Signal Common | N/A | Pin 1 | Pin 1 | DIN Pin2 / XLR Pin 1 | TRS Sleeve |
| Shielding | Shield | Metal Shell | Metal Shell | Metal Shell | N/A |
| **Optional DC Supply Connector: 4mm Banana Plug Pair,** Red Plug for +VDC, **Black Plug** for Common of the DC power supply. | | | | | |

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## Do-It-Yourself or BII Repair and Maintenance

Following information are with the assumption that the products are repairable. Some kinds of damages are unrepairable such as the piezoelectric material is overheated and destroyed.

**General Information for Do-It-Yourself Repair and Maintenance of Transducers.**
Before you do it yourself to repair and maintenance, please refer to BII's IMPORTANT NOTICE AND DISCLAIMER. Repairman (Buyer or End User) is responsible and liable to the repair and maintenance.
If a transducer has minor damages such as dents, scratches, or cracks on housing, and broken cable, end user may fix these issues by Do-It-Yourself.

| | Do-It-Yourself Repair and Maintenance | BII Repair and Maintenance |
|---|---|---|
| **Advantage** | Fast, convenient, and save money. | 1. Re-calibration after repair.<br>2. Free repair and warranty extension if warranty is NOT expired or not voided.<br>3. BII is responsible to the repair specified in BII sales terms and conditions in the quote. |
| **Disadvantage** | 1. Know well about the materials, processes, tools, and equipment.<br>**2. Warranty is voided even if the original warranty is NOT expired.**<br>3. Purchase repair compounds, tools, and equipment from third-party company.<br>4. Repairman (Buyer or End User) are liable and responsible to the repair and maintenance. | 1. Shipping cost to BII, and 2 to 4 weeks Repair Period.<br>2. Repair fees if warranty is expired or voided. |

| BII Transducers | Repair Compounds |
|---|---|
| **Metal Housing** | Excellent adhesion and water-proof sealing with marine epoxy, polyurethane, and rubber potting compounds. |
| **Plastic Housing** | Excellent adhesion and water-proof sealing with marine epoxy, polyurethane, and rubber potting compounds. |
| **Rubber Housing** | Good adhesion and water-proof sealing with polyurethane and other rubber potting compounds. |
| **Cable** | Good adhesion and water-proof sealing with flexible marine epoxy, polyurethane, and rubber potting compounds.<br>Cable jackets are PVC, EPDM, PUR, or other rubbers. |
| **Connectors** | Excellent adhesion and water-proof sealing with marine epoxy, polyurethane, and rubber potting compounds. |
| **Repair Processes** | |
| Before repair and maintenance, it is strongly recommended to test the adhesion between cured compounds and BII products by applying a small portion of compounds to a specific small repair area and then following the curing instruction of the compounds. | |
| **Surface Preparation:** | 1. Roughen surface with files or coarse sandpapers to provide the best adhesion.<br>2. Clean surface area of dirt, grease, oil, or loose debris. Use detergent or degreaser such as Isopropyl Alcohol to clean the surface to achieve best adhesion.<br>3. Some potting compounds might need primer to achieve better adhesion on rubber housing and cable. |
| **Weighting and Mixing:** | Following instructions of potting compounds. |
| **Curing:** | Following curing instructions of potting compounds.<br>1. It is strongly recommended to cure mixed compounds with temperature ≤ 60°C or 140°F.<br>2. Ensure enough curing time.<br>3. After turning off oven, keep devices in oven and ensure devices to cool down to room temperature by themselves. |

**Repair and Maintenance of Electronic Products or Instruments.**
BII does not suggest Do-It-Yourself for electronic products or instruments.
1. Contact BII for RMA number. BII will provide tech support and determine if or not the goods are repairable.
   If the goods are repairable, BII will issue RMA number, and send quote to buyer if the warranty is expired.
2. After receiving RMA number, send electronic products or instruments back to BII for repair.

**BII Repair and Maintenance of Transducers.**
1. Contact BII for RMA number. BII will provide tech support and determine if or not the transducer is repairable.
   If the transducer is repairable, BII will issue RMA number, and send quote to buyer if the warranty is expired.
2. After receiving RMA number, send the transducer back to BII for repair.

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## Acoustic Transducer Installation/Mounting

1. **Maximum Depths** listed in mounting parts description are the ratings of mounting/installation parts which are NOT the maximum depth ratings of transducers and hydrophones. Please refer to datasheet of respective transducers/hydrophones for their maximum depth underwater.
2. **Thread lockers** are recommended to prevent threaded fasteners from loosening due to shock and vibration. Thread lockers are NOT provided by BII.
3. **Maximum Diameter** listed in this table is the size of the mounting part, is NOT the size of the transducer (hydrophone and projector).
4. If the connector at the cable end is larger than the mounting hole, BII does NOT assemble the connector to cable end, and BII ships it to buyer. It is buyer's responsibility to assemble the connector to cable end at buyer's cost.

**Cable Options**

**Cable Types**: Wires, Coax Cables, Shielded Multi Conductor Cables, Shielded Cable with Twisted Pair, Unshielded Cable.

| | |
|---|---|
| **Cable Jacket:** PVC, Polyurethane, EPDM rubber, FEP, PTFE, etc. | **Cable Diameter Range**: ΦD= Φ1.4 to Φ15.3 mm |
| **Voltage and Current Rating:** Up to 600 Vrms, 10A. | **Service Temperature Range:** Up to -40° to 840° F or -40° to 449° C. |

**Connector**

| | | | |
|---|---|---|---|
| **WL**: Wire Leads | **BNC**: BNC Male (or Plug) 50Ω | **BNCF**: BNC Female (or Jack) 50Ω | **SMA:** Plug, Male Pin, 50Ω |
| **SMC**: Plug, Female Socket, 50Ω | **LEMO:** PLUG MALE 3 Pins. | **TRS**: TRS Plug | **TRS35**: 3.5mm or 1/8" TRS Plug |
| **XLR**: XLR Plug | **5015**: MIL-C-5015 style, Pins. | **SP**: Solder Pins | **BS**: +9V Battery Snap |
| **UMC**: Underwater Mateable Connector | **Custom**: Customized Connector | | |

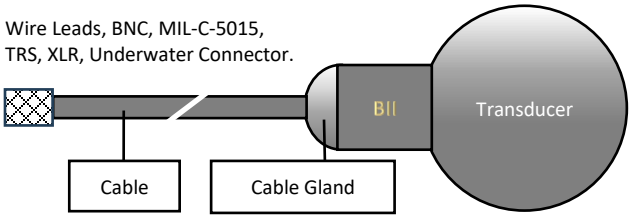
Note: Underwater Connectors are for uses underwater, other connectors and wire leads listed above are for dry uses ONLY in air.

**Maximum Diameter Size of Connectors: useful to choose mounting/installation parts of the transducers/hydrophones, Unit: mm.**

| **Connector:** | Male BNC | SMA (Plug, Male Pin) | SMC (Plug, Female Socket) | LEMO (PLUG MALE 3 Pins) | 1/8" (3.5mm) TRS | XLR Plug | MIL-C-5015 | 9V Battery Snap | Underwater Connector |
|---|---|---|---|---|---|---|---|---|---|
| **Max. Size:** | Φ14.3 | Φ9.24 | Φ6.4 | Φ9.5 | Φ10.5 | Φ20.2 | Φ30 | Φ13 | Φ21.5 or Φ35 |

## Free Hanging (FH) with Cable Gland

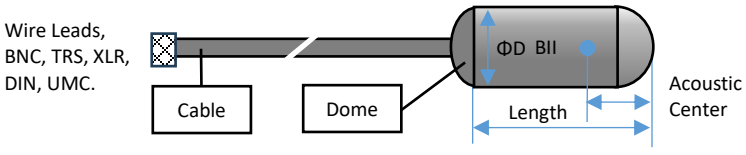
Maximum Depth: Plastics 300 m; Stainless Steel 2000 m.
Cable-Out: By default, the cable goes out of the device from the end face. To save space and have the device shorter, the cable can go out from the side wall of transducers. Specify this customization when ordering.
Maximum diameters of typical free-hanging mounting parts (mm): 1. **Plastics**: Φ16, Φ21, Φ25, Φ37 ..., 2. **Stainless Steel**: Φ22.

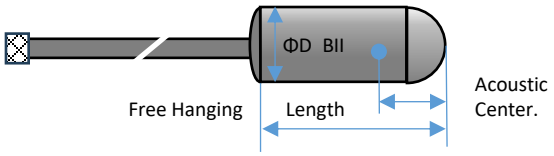



**The streamlined hemispherical domes minimize drag forces and hydrodynamic noises caused by the hydrophone in motion or the flow past the hydrophone.**

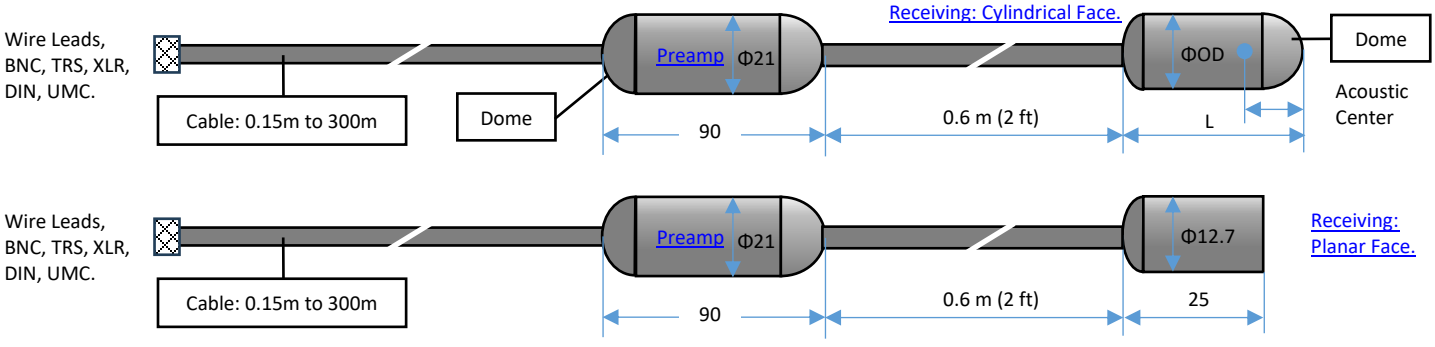
**BII7011/BII7012 Hydrophones: Default Free Hanging with Smooth Domes.**




**BII7011/BII7012 Hydrophones: Free Hanging with Short Length.**




**Hydrophone as Array Element: Free Hanging with Smooth Domes for Linear/Planar/Conformal Discrete Arrays. Illustration Only, Size Scale is NOT 1:1.**

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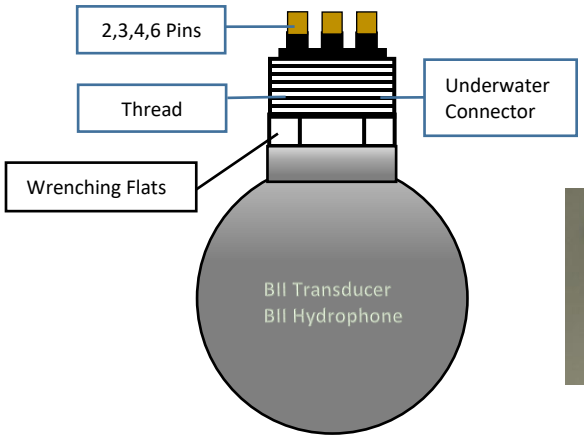
## Free Hanging with Underwater Connector (FHUWC) (Pin)

Maximum Depth: 2000m. Transducers/Hydrophone with Underwater Connectors: 3 pins, 4 pins and 6 pins. External thread for cable splice.

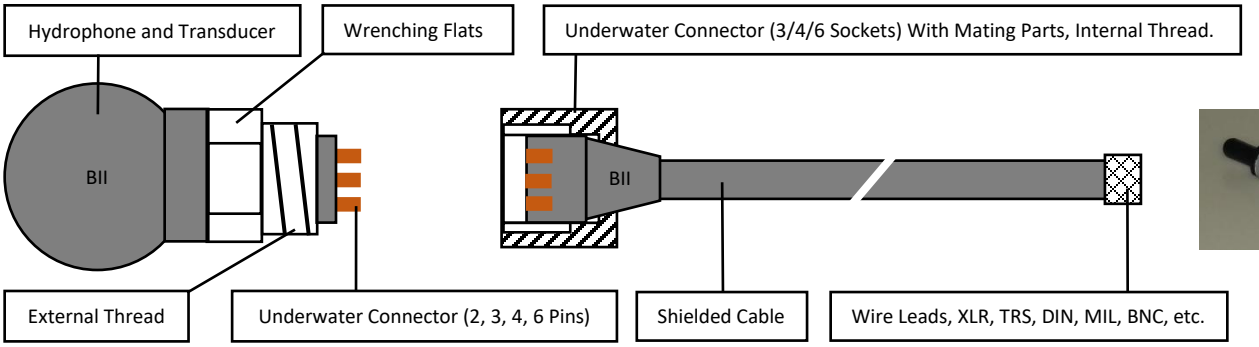




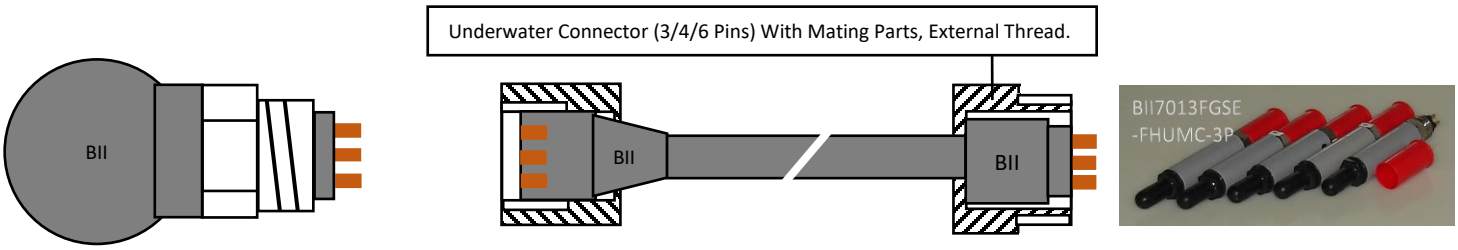




### Free Hanging with Underwater Connector (FHUWC) and Accessories





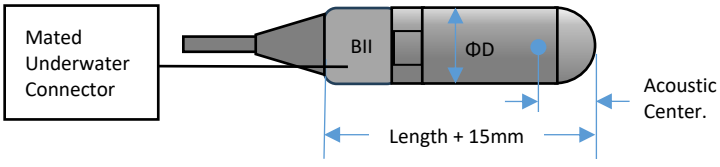


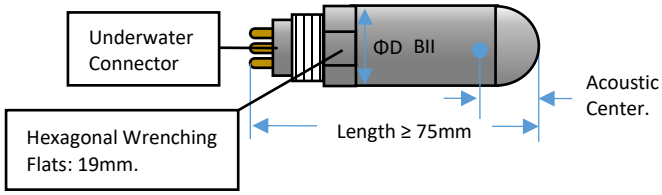




| **Underwater Connector and Accessories: Hookup to Data Acquisition System, Cable Extension, etc.** | |
|---|---|
| **Part Number:** | **Description (P: Pin, S: Socket.)** |
| **FHUWC-2P** | An Underwater Connector (2 Pins, External Thread) are encapsulated on Transducers/Hydrophones. |
| **FHUWC-3P** | An Underwater Connector (3 Pins, External Thread) are encapsulated on Transducers/Hydrophones. |
| **FHUWC-4P** | An Underwater Connector (4 Pins, External Thread) are encapsulated on Transducers/Hydrophones. |
| **FHUWC-6P** | An Underwater Connector (6 Pins, External Thread) are encapsulated on Transducers/Hydrophones. |
| **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:<br>**UMC4S-20m-WL:** 20 m cable with Underwater Mateable Connector 4 Sockets (**UMC4S**) on one end and wire leads (**WL**) on another end.<br>**UMC4S-20m-XLR3/BS**: 20 m cable with and Underwater Mateable Connector 4 Sockets (UMC4S) on one end and XLR Receptacle with 3 Male Pins (**XLR3**) and two +9V Battery Snaps on another end. |

**Hydrophone: Free hanging with Underwater Connector (FHUWC), 3 Pins (No Preamplifier), 4 Pins (Fixed Sensitivity), and 6 Pins (Programmable Sensitivity). Free-hanging with Underwater Connector FHUWC-4P, 4 Pins (Fixed Sensitivity); FHUWC-6P, 6 Pins (Programmable Sensitivity).**

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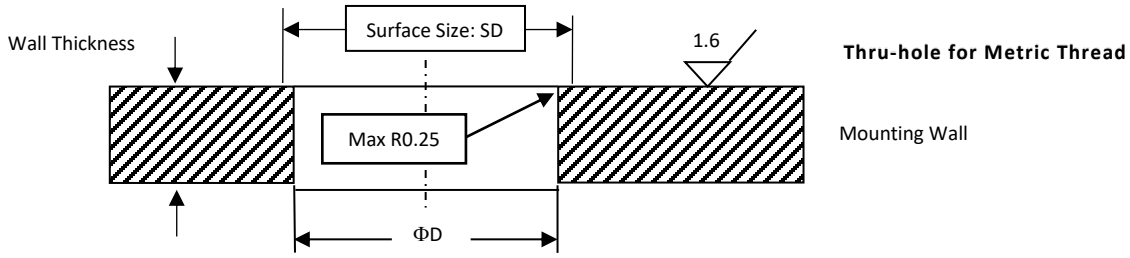
## Thru-hole Mounting (Metric Thread) with Single O-ring Sealing (Dimension Unit: mm)

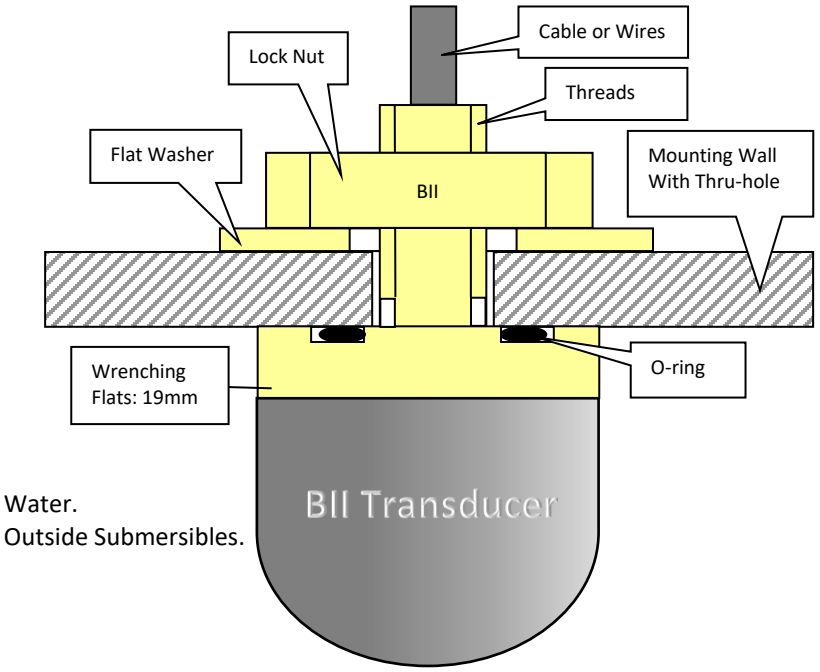
| **Part Number:** | ~~N/A~~ | **THM-M10x22** | **THM-M10x15** |
|---|---|---|---|
| **Thread Size:** | ~~Thread: M5x0.8x15 (Right Hand)~~ | **Thread: M10x1.5x22 (Right Hand)** | **Thread: M10x1.5x15 (Right Hand)** |
| **Hydrophone or Projector:** | ~~Single-ended Signal ONLY~~ | Single-ended or Differential | Single-ended or Differential |
| **Mounting Hole Size ΦD:** | ~~Φ5.21 mm ±0.1~~ | Φ10.26 mm ±0.1 | Φ10.26 mm ±0.1 |
| **Thickness of Mounting Wall:** | ~~≤9 mm with standard nut.~~ | ≤12 mm with standard nut. | ≤5 mm with standard nut. |
| **Maximum Diameters:** | ~~Φ11.5~~ | Φ21 | Φ21 |
| **Surface Size ΦSD:** | ~~Φ12.5~~ | Φ23 | Φ23 |
| **O-ring Included:** | ~~ID x OD = Φ6.1 x Φ9.3 mm~~ | ID x OD = Φ12 x Φ16 mm | ID x OD = Φ12 x Φ16 mm |
| **Four Wrenching Flats:** | ~~None~~ | 19 mm | 19 mm |
| **Fastening Torque:** | ~~≤2 Nm~~ | ≤10 Nm | ≤10 Nm |
| **Materials of the Body:** | ~~Stainless Steel~~ | Stainless Steel | Stainless Steel |
| **Accessories Included:** | ~~Nut, and Flat Washer.~~ | Nut, and Flat Washer. | Nut, and Flat Washer. |
| **Service Temperature:** | 1. Default: -40 to 140 °F or -40 to 60 °C. 2. Bespoke: -40 to 250 °F or -40 to 121 °C. 3. Bespoke: -40 to 400 °F or -40 to 204.4 °C. | | |
| Maximum Depth: 2500 m | | | |
| A transducer/hydrophone with thru-hole mount can also be installed into threaded hole of a wall. It is buyer's responsibility and liability to take measures at buyer's cost to prevent the installation from being loose or detached. | | | |
| **Thread lockers are recommended to prevent threaded fasteners from loosening due to shock and vibration. NOT provided by BII.** | | | |
| If the connector at the cable end is larger than the mounting hole, BII does NOT assemble the connector to cable end, and BII ships it to buyer. It is buyer's responsibility to assemble the connector to cable end at buyer's cost. | | | |

**Recommended Mounting Hole for Metric Thread Right Hand (Single O-ring)**




**Metric Thru-hole Installation with Nut and Washer**

It is buyer's responsibility and liability to take measures (such as thread lockers, etc.) at buyer's cost to prevent the installation from being loose or detached.




Dry Spaces,
Inside Submersibles.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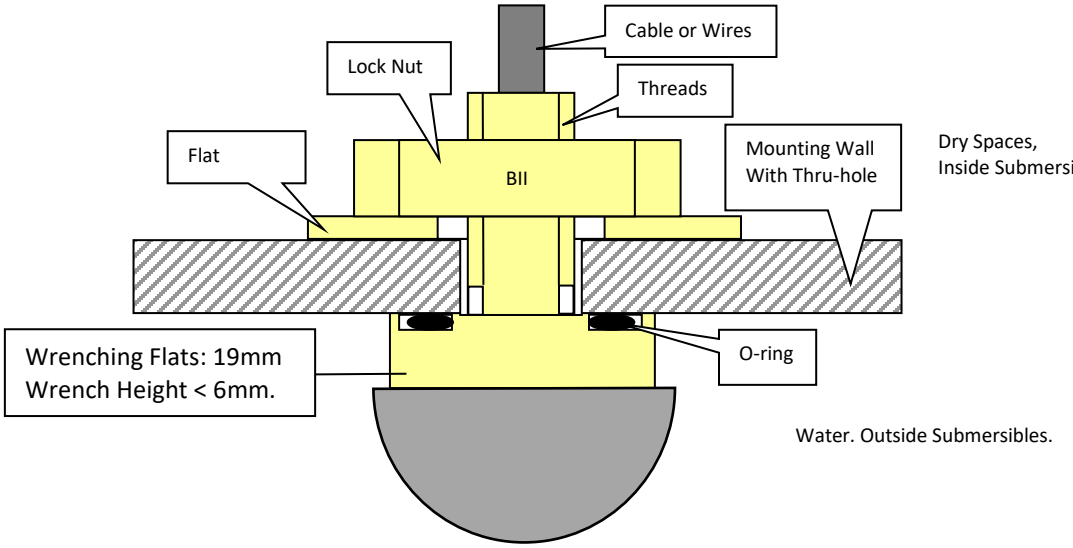
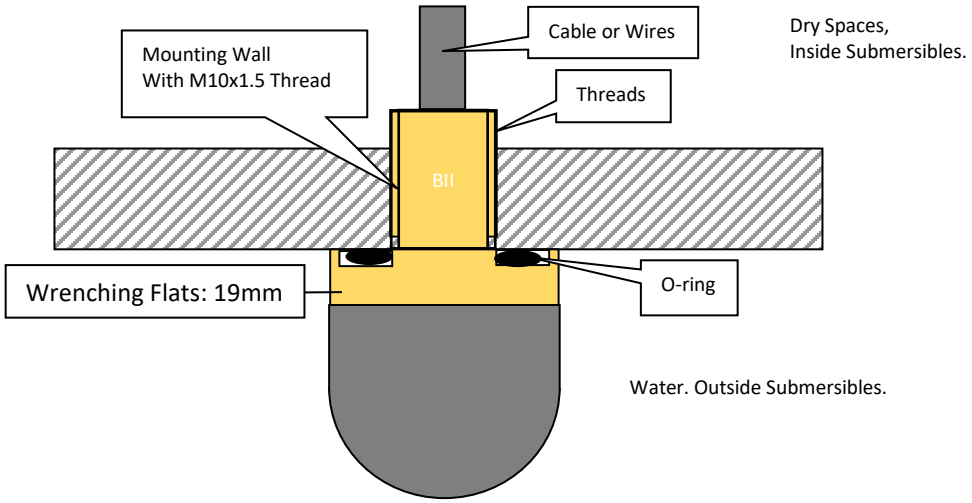
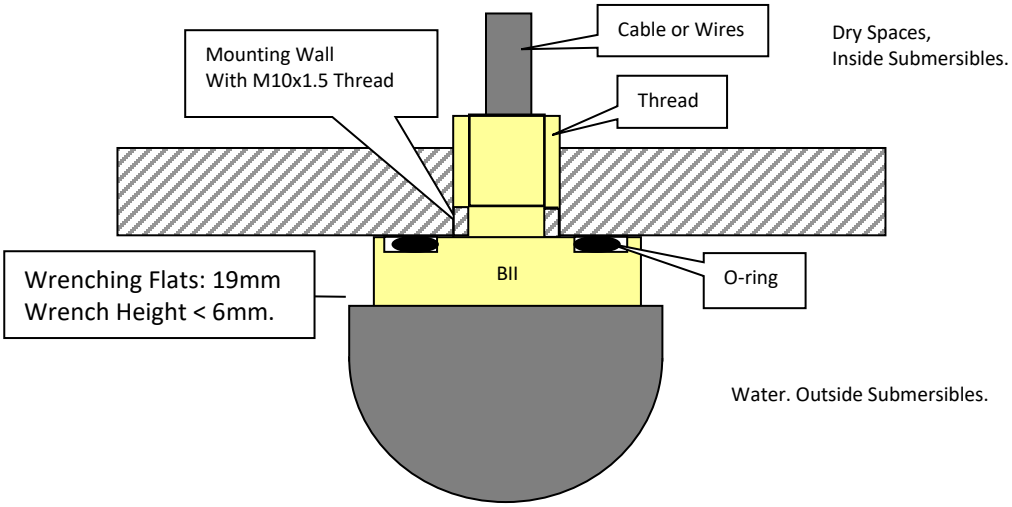



**Metric Thread Installation without Nut and Washer**

Refer to Thread Sealing Tips.

It is buyer's responsibility and liability to take measures (such as thread lockers etc.) at buyer's cost to prevent the installation from being loose or detached.

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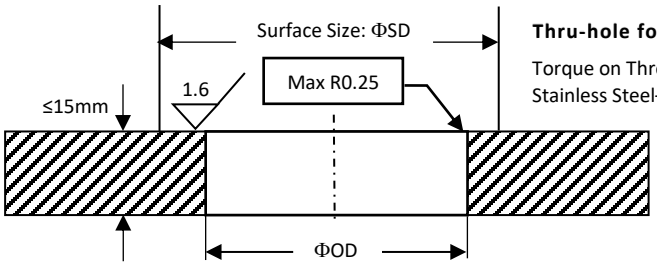
## Thru-hole Mounting + Free Hanging for Moorings, Buoys, Drifters and Ocean Observatories, (Dimension Unit: mm).

| Part Number: | THFH-M10 | THFH-7/16" | THFH-1/2" | THFH-5/8" | THFH-1" |
|---|---|---|---|---|---|
| Thread (Right Hand): | M10x1.5x22 | 7/16"-20x22 UNF-2A | 1/2"-13x22 UNC-2A | 5/8"-18x27 UNF-2A | 1"-14x25.4 UNS-2A |
| Application: | Projector or Hydrophone | | | Arrays | |
| Material: | Stainless Steel | Stainless Steel | Anodized Aluminum | Stainless Steel | Stainless Steel |
| O-ring (ΦID x C/S in mm): | Φ12 x 2 | 014 (Φ12.42 x 1.78) | 113 (Φ13.94 x 2.62) | 017 (Φ17.17 x 1.78) | 122 (Φ28.24 x 2.62) |
| Flat Washer and Nut: | Included | | | | |
| Maximum Diameter: | Φ21 mm | Φ22 mm | Φ24 mm | Φ27 mm | Φ38 mm |
| Wrenching Flats: | Four, 19 mm. | None | None | None | None |
| Fastening Torque: | ≤10 Nm | ≤30 Nm | ≤30 Nm | ≤50 Nm | ≤60 Nm |
| Thickness of Mounting Wall: | ≤12mm with nut. | ≤10mm with nut. | ≤9mm with nut. | ≤12mm with nut. | ≤10mm with nut. |
| Height of Thin Nut: | 5 mm | ¼" or 6.35 mm | N/A | 3/8" or 9.525 mm | 35/64" or 13.89 mm |
| Height of Standard Nut: | 8 mm | 3/8" or 9.525 mm | 7/16" or 10.94 mm | 35/64" or 13.89 mm | Not Used. |
| Surface Size ΦSD: | Φ23.0 mm | Φ23.0 mm | Φ23.0 mm | Φ28.0 mm | Φ39.0 mm |
| Mounting Hole Size ΦD: | Φ10.26mm ± 0.1 | Φ11.3 mm ± 0.1 | Φ12.8 mm ± 0.1 | Φ16.0 mm ± 0.1 | Φ26 mm ± 0.1 |
| Service Temperature: | 1. Default: -40 to 140 °F or -40 to 60 °C. 2. Bespoke: -40 to 250 °F or -40 to 121 °C. 3. Bespoke: -40 to 400 °F or -40 to 204.4 °C. | | | | |
| Maximum Depth: | 300 m to 500 m, depending on diametral clearance. | | | | |
| If the connector at the cable end is larger than the mounting hole, BII does NOT assemble the connector to cable end, and BII ships it to buyer. It is buyer's responsibility to assemble the connector to cable end at buyer's cost. | | | | | |
| **Thread lockers are recommended to prevent threaded fasteners from loosening due to shock and vibration. NOT provided by BII.** | | | | | |

**Mounting Hole:**

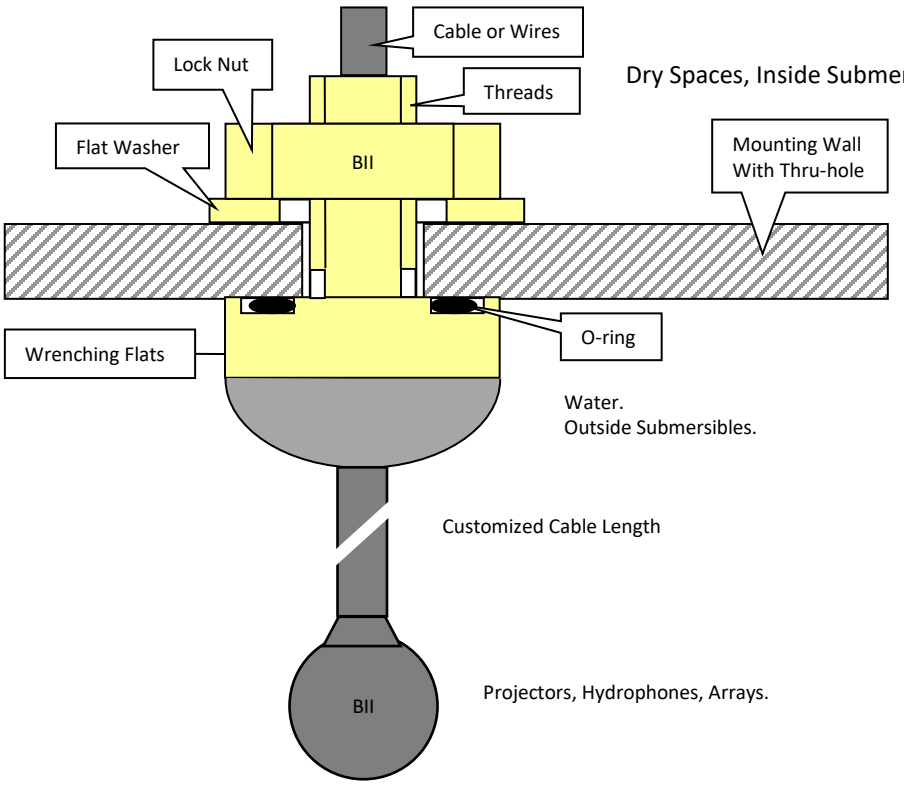



**Thru-hole for Metric Thread**

Torque on Threads:
Stainless Steel– 14 to 60 Nm



**Installation:**




Dry Spaces, Inside Submersibles.

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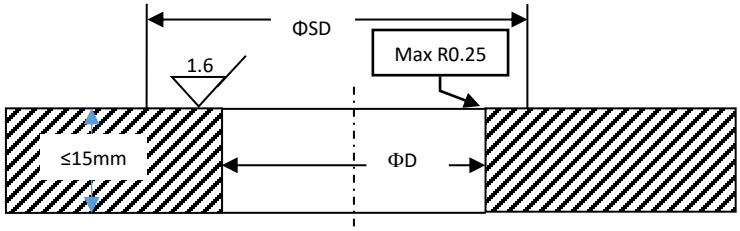
## Thru-hole Mounting (Inch Thread) with Single O-ring Sealing (Dimension Unit: mm)

| Part Number: | THM-7/16" | THM-1/2" | THM-5/8" | ~~THM-1"~~ |
|---|---|---|---|---|
| Thread (Right Hand): | 7/16"-20x22 UNF-2A | 1/2"-13x22 UNC-2A | 5/8"-18x27 UNF-2A | ~~1"-14x25.4 UNS-2A~~ |
| Application: | Projector or Hydrophone | | | |
| Material: | Stainless Steel | Anodized Aluminum | Stainless Steel | ~~Stainless Steel~~ |
| O-ring (ΦID x C/S in mm): | 014 (Φ12.42 x 1.78) | 113 (Φ13.94 x 2.62) | 017 (Φ17.17 x 1.78) | ~~122 (Φ28.24 x 2.62)~~ |
| Flat Washer and Nut: | Included | | | |
| Maximum Diameter: | Φ22 mm | Φ24 mm | Φ27 mm | ~~Φ38 mm~~ |
| Fastening Torque: | ≤30 Nm | ≤30 Nm | ≤50 Nm | ~~≤60 Nm~~ |
| Thickness of Mounting Wall: | ≤10 mm with nut. | ≤9mm with nut. | ≤12mm with nut. | ~~≤10mm with nut.~~ |
| Height of Thin Nut: | ¼" or 6.35 mm | N/A | 3/8" or 9.525 mm | ~~35/64" or 13.89 mm~~ |
| Height of Standard Nut: | 3/8" or 9.525 mm | 7/16" or 10.94 mm | 35/64" or 13.89 mm | ~~Not Used.~~ |
| Surface Size ΦSD: | Φ23.0 mm | Φ23.0 mm | Φ28.0 mm | ~~Φ39.0 mm~~ |
| Mounting Hole Size ΦD: | Φ11.3 mm ± 0.1 | Φ12.8 mm ± 0.1 | Φ16.0 mm ± 0.1 | ~~Φ26 mm ± 0.1~~ |
| Service Temperature: | 1. Default: -40 to 140 °F or -40 to 60 °C. 2. Bespoke: -40 to 250 °F or -40 to 121 °C. 3. Bespoke: -40 to 400 °F or -40 to 204.4 °C. | | | |
| Maximum Depth: | 2500 m, depending on diametral clearance. | | | |
| If the connector at the cable end is larger than the mounting hole, BII does NOT assemble the connector to cable end, and BII ships it to buyer. It is buyer's responsibility to assemble the connector to cable end at buyer's cost. | | | | |
| **Thread lockers are recommended to prevent threaded fasteners from loosening due to shock and vibration. NOT provided by BII.** | | | | |

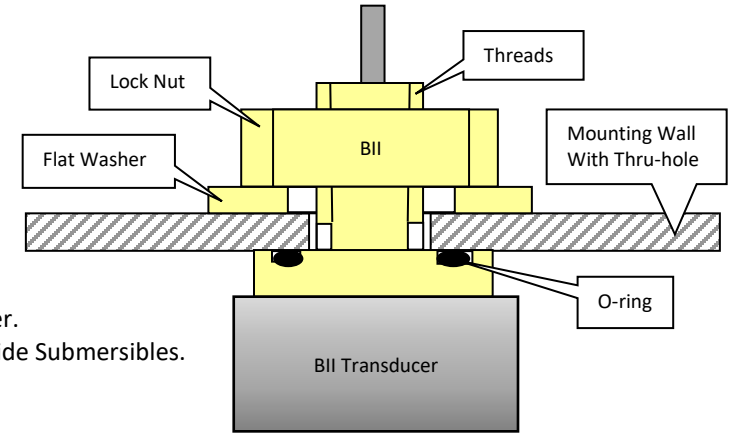
**Recommended Mounting Hole Size**





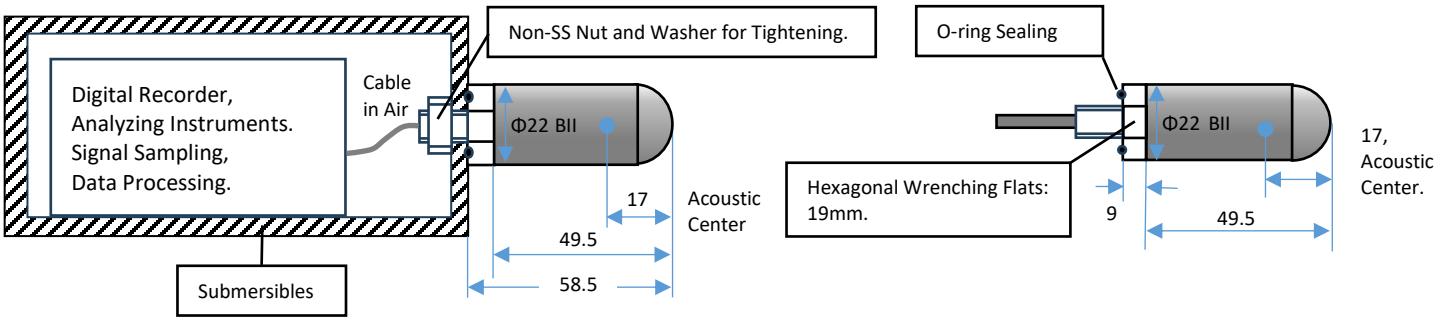
**Transducer/Hydrophone Installation:**

Dry Spaces,
Inside Submersibles.




Water.
Outside Submersibles.


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

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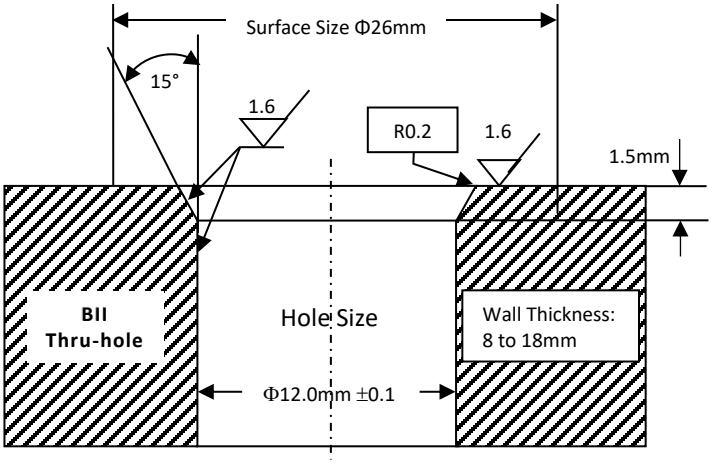
## Thru-hole Mounting (Inch Thread) with Double O-ring Sealing (Dimension Unit: mm)

**Part Number: THDO-7/16".**

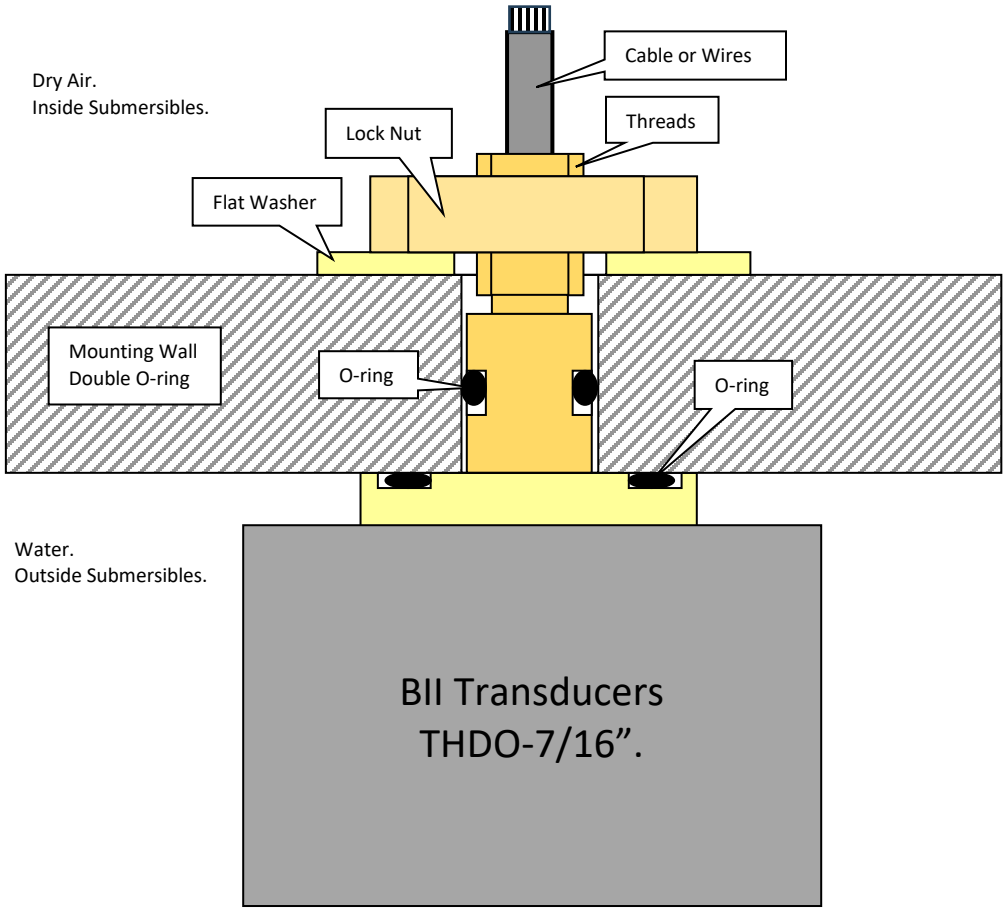
| | | | |
|---|---|---|---|
| Maximum Depth: 2500 m. | Thread: 7/16"-20x25 UNF-2A (Right Hand). | Maximum Diameter: Φ25 mm | Fastening Torque: ≤30 Nm. |
| O-rings (012 and 015), flat washer and nut are included. | | Thickness of Mounting Wall: 8 to 18 mm. | |
| Service Temperature: | 1. Default: -40 to 140 °F or -40 to 60 °C. 2. Bespoke: -40 to 250 °F or -40 to 121 °C. 3. Bespoke: -40 to 400 °F or -40 to 204.4 °C. | | |
| If the connector at the cable end is larger than the mounting hole, BII does NOT assemble the connector to cable end, and BII ships it to buyer. It is buyer's responsibility to assemble the connector to cable end at buyer's cost. | | | |
| Thread lockers are recommended to prevent threaded fasteners from loosening due to shock and vibration. NOT provided by BII. | | | |

Recommended Mounting Hole (Double O-ring)







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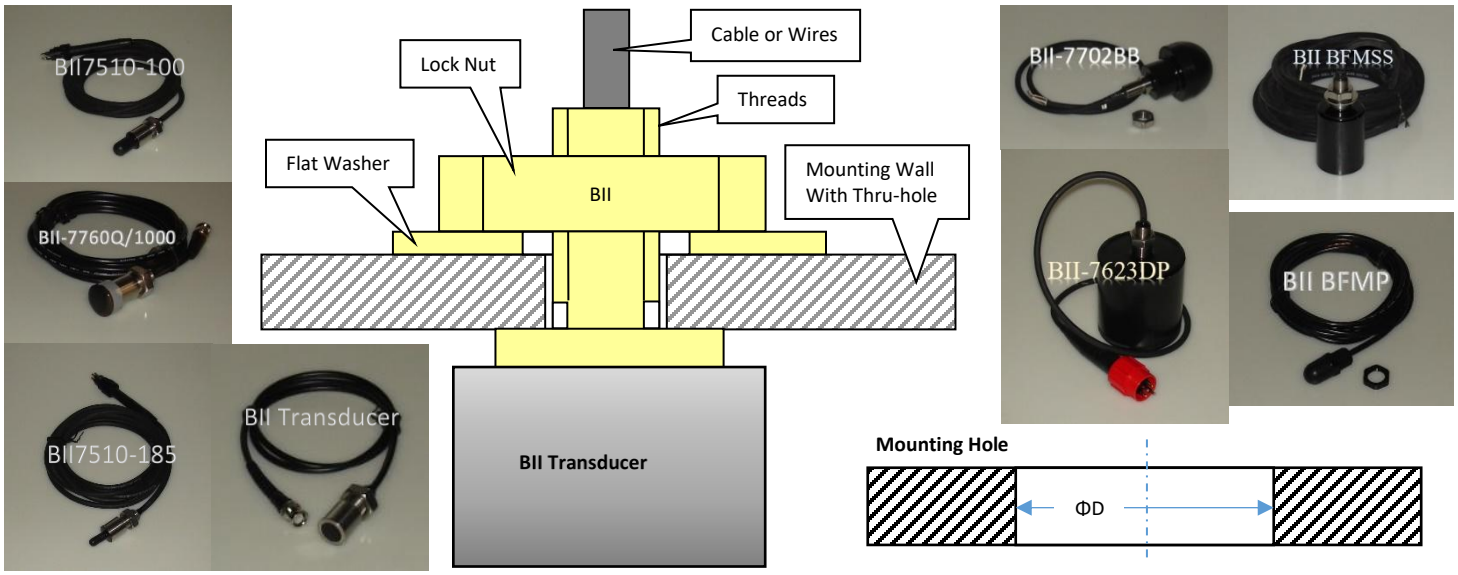
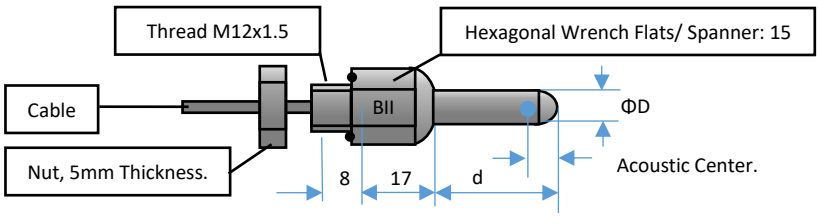
## Bolt-Fastening Mount (Dimension Unit: mm)

| Part Number | BFM-M6 | BFM-7/16" | BFM-5/8" | BFMFH | BFMP-M12 | BFMP-NPT3/8" |
|---|---|---|---|---|---|---|
| Application: (Portable Apparatus) | Small Device, Array Element. | Single Device, Array Element. | Single Device, Array Element. | Portable Devices | Small Light Device, Array Element. | Small Light Device, Array Element. |
| Material: | Stainless Steel | Stainless Steel | Stainless Steel | Stainless Steel | Plastics | Plastics |
| Thread (Right Hand): | M6x1x16 | 7/16"-20x22 UNF | 5/8"-18x22 UNF | 3/8"-16 x 1.0"<br>1/4"-20 x 0.8" | M12x1.5x8mm | NPT3/8"x15mm |
| Maximum Diameter: | Φ9.25 | Φ22 | Φ27 | Φ18<br>Φ14 | Φ20.5 | Φ24 |
| Maximum Depth: | 2000 m | 2000 m | 2000 m | 500 m | 300 m | 300 m |
| Accessories: | Flat Washer and Nut<br>Flat washer: included ONLY for heavy transducer (weight > 5 kg). | | | Hex Nut | Lock nut<br>Height: 5mm | Lock nut<br>Height: 5mm |
| Fastening Torque: | ≤ 3 Nm | ≤30 Nm | ≤ 50 Nm | ≤ 10 Nm | ≤ 1.5 Nm | ≤ 2.5 Nm |
| Thickness of Mounting Wall: | ≤ 9 mm | ≤10 mm | ≤ 10 mm | ≤ 10 mm | ≤ 3 mm | ≤ 8 mm |
| Mounting Hole Size ΦD: | Φ6.25 mm ± 0.1 | Φ11.3 mm ± 0.1 | Φ16.0 mm ± 0.1 | Φ9.7 mm ± 0.15<br>Φ6.8 mm ± 0.15 | Φ12.1 to Φ13.0 mm | Φ17.0 mm ± 0.1 |
| Service Temperature: | 1. Default: -40 to 140 °F or -40 to 60 °C.<br>2. Bespoke: -40 to 250 °F or -40 to 121 °C.<br>3. Bespoke: -40 to 400 °F or -40 to 204.4 °C. | | | | -4 to 176 °F or -20 to 80 °C. | -4 to 176 °F or -20 to 80 °C. |
| If the connector at the cable end is larger than the mounting hole, a slot cut on mounting apparatus is a must for cable passing though. | | | | | | |
| Thread lockers are recommended to prevent threaded fasteners from loosening due to shock and vibration. NOT provided by BII. | | | | | | |

**Bolt Fastening Mounting**

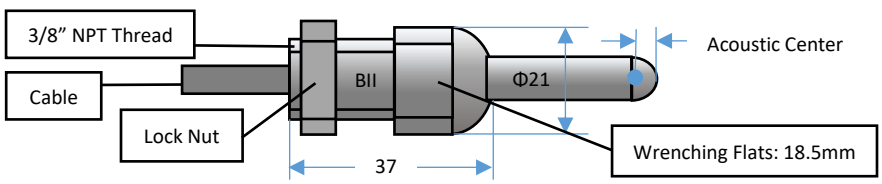



**Bolt-fastening Mounting (Plastics) BFMP-M12 (300m Depth or 3MPa Ratings) or Thread Mounting into a submersible enclosure (IP68, tighten with o-ring).**




Bolt-Fastening Mount (Plastics) (**BFMP-M12x1.5**)
**Thread**: M12x1.5, Lock nut: included.
**Maximum Depth**: 300 m.
**Mounting Hole**: Φ12.1 to Φ13.0 mm.
**Fastening Torque**: ≤ 1.5 Nm.
**Mounting Wall Thickness**: ≤ 3 mm.

**Physical Size (Dimensional Unit: mm) with BFMP-NPT3/8" Mounting Part:**




Bolt-Fastening Mount (Plastics) (**BFMP-NPT3/8"**)
**Thread**: NPT-3/8", Lock nut: included.
**Maximum Depth**: 300 m.
**Mounting Hole**: Φ17.0±0.1 mm.
**Fastening Torque**: ≤ 2.5 Nm.
**Mounting Wall Thickness**: ≤ 10 mm.

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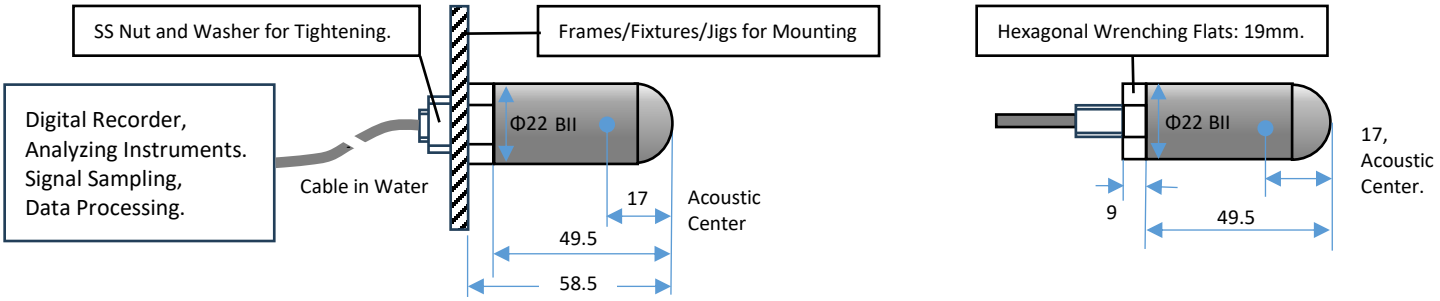
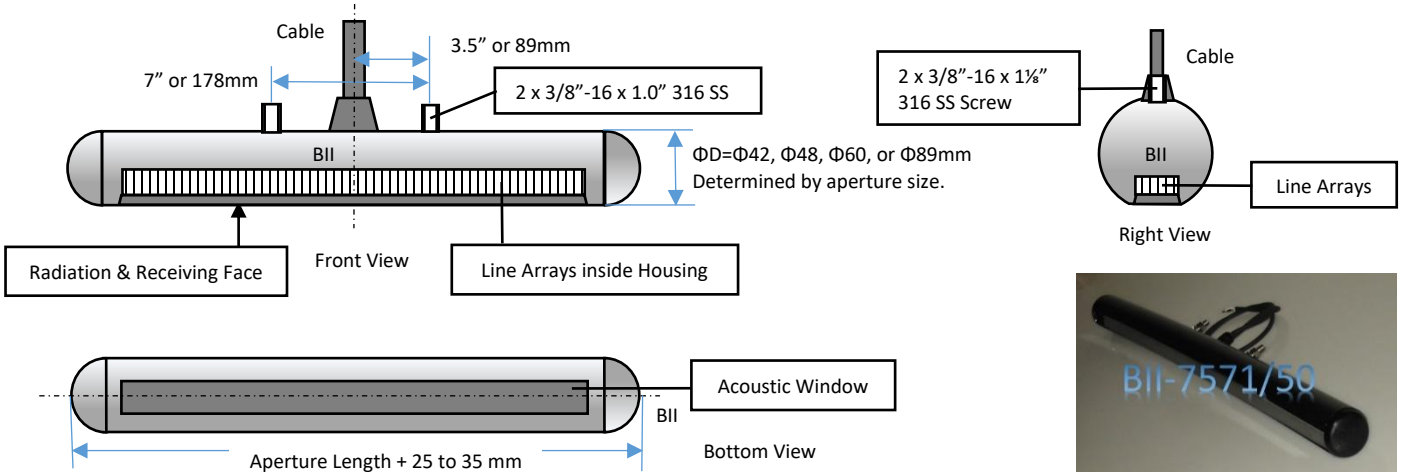
**Bolt-Fastening Mounting BFM-7/16" (7/16"-20x22 UNF-2A).**

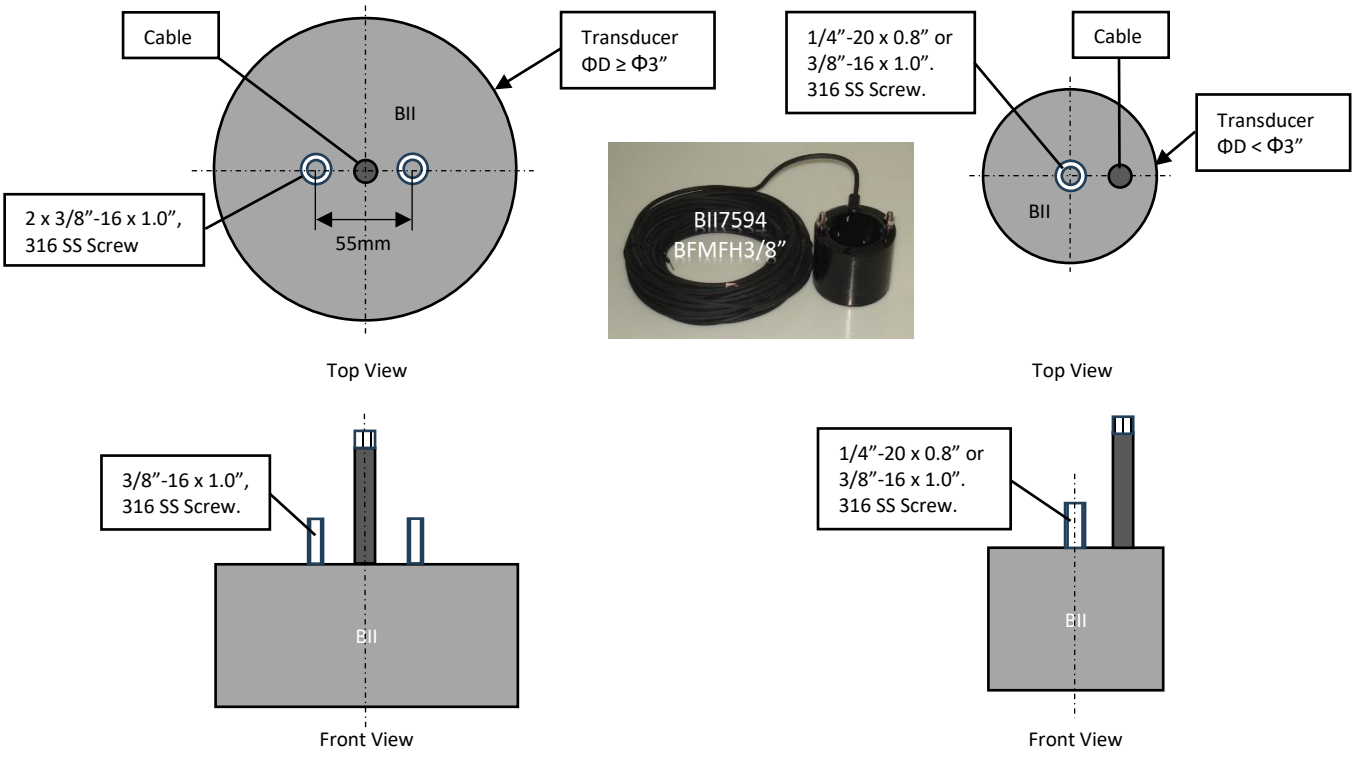



## Bolt-Fastening Mounting with Free Hanging BFMFH

**(1) BFMFH3/8" for Line (Rectangular) Array. Overall Size (Dimensional Unit: mm).** Following transducer structures are for illustration ONLY.




**(2) BFMFH1/4", BFMFH3/8" for Spherical, Hemispherical, Cylindrical, and Planar Transducers. Available Thread: 1/4"-20 x 0.8" and 3/8"-16 x 1.0").**

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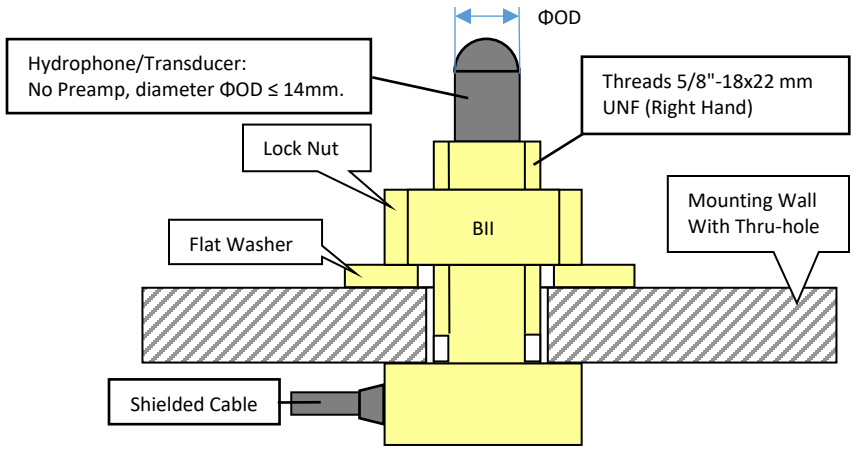
## Bolt-Fastening Front Mount (Dimension Unit: mm)

| Part Number: | BFFMRA | BFFMSA |
|---|---|---|
| Description: | Bolt-Fastening Front Mount with 90° Right Angle. | Bolt-Fastening Front Mount with 180° Straight Angle. |
| Material: | Stainless Steel | |
| Thread (Right Hand): | 5/8"-18x22 UNF | |
| Application: | Portable Apparatus, Single Device Array Element, Hydrophone (Receiver) Mooring Deployments. | |
| | Diameter of sensing (active) elements of hydrophones or transducers should be less than 14mm. | |
| Maximum Diameter: | Φ27 | |
| Maximum Depth: | 500 m | |
| Accessories: | Flat Washer and Nut | |
| Fastening Torque: | ≤ 20 Nm | |
| Thickness of Mounting Wall: | ≤ 8 mm | |
| Mounting Hole Size ΦD: | Φ16.0 mm ± 0.1 | |
| Service Temperature: | 1. Default: -40 to 140 °F or -40 to 60 °C. 2. Bespoke: -40 to 250 °F or -40 to 121 °C. 3. Bespoke: -40 to 400 °F or -40 to 204.4 °C. | |
| If the connector at the cable end is larger than the mounting hole, a slot cut on mounting apparatus is a must for cable passing though. | | |
| **Thread lockers are recommended to prevent threaded fasteners from loosening due to shock and vibration. NOT provided by BII.** | | |

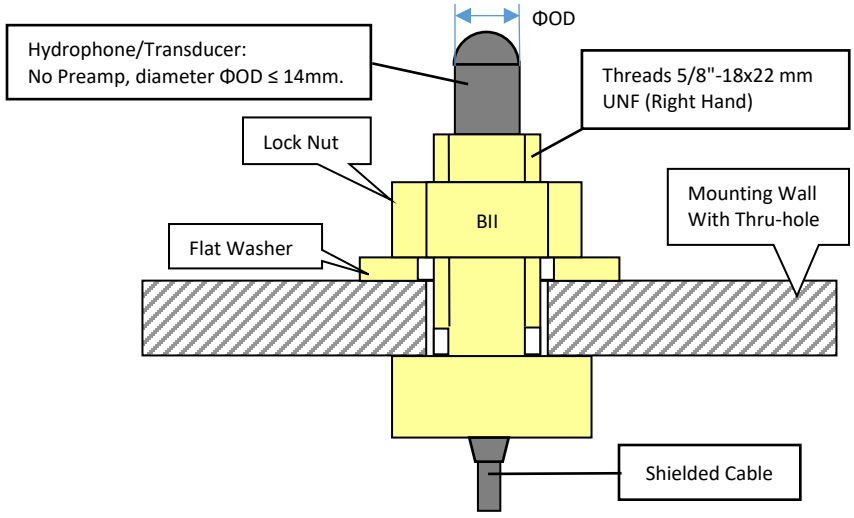
**Bolt Fastening Front Mounting with 90° Right Angle (BFFMRA)**





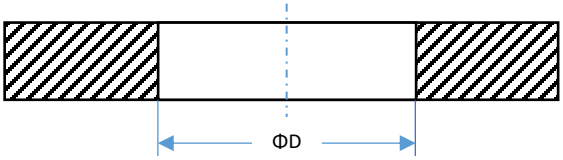
Sensing Element ≤ Φ14mm.
Mounting Hole: Φ16.0±0.1mm.
Fastening Torque: ≤30Nm.
Mounting Thickness: ≤12.7mm.

**Bolt Fastening Front Mounting with 180° Straight Angle (BFFMSA)**




Sensing Element ≤ Φ14mm.
Mounting Hole: Φ16.0±0.1mm.
Fastening Torque: ≤30Nm.
Mounting Thickness: ≤12.7mm.

**Mounting Hole**

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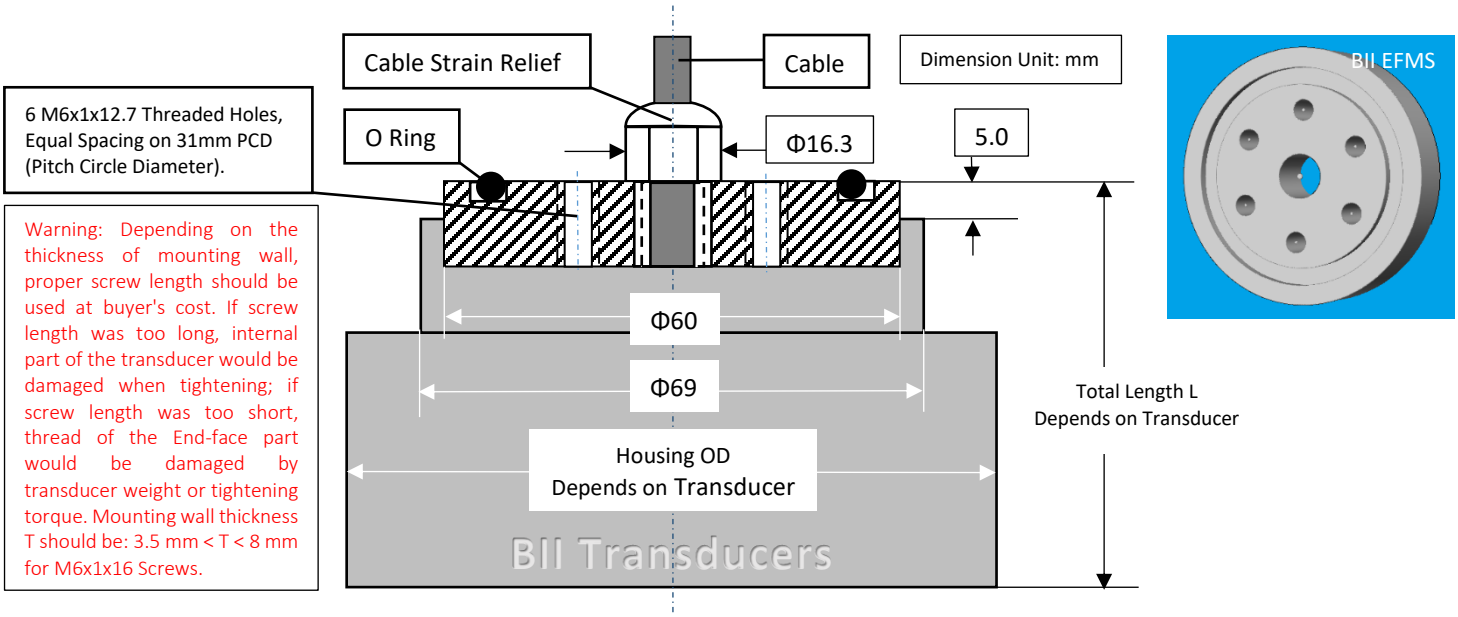
## End Face Mount with O-ring Sealing (Dimension Unit: mm)

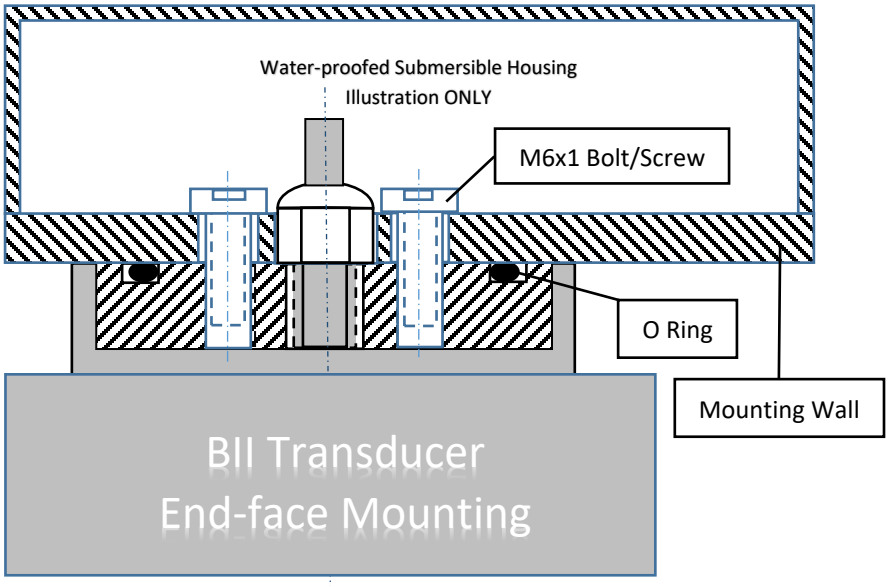
| Part Number: | EFMS | EFMM |
|---|---|---|
| Description | End Face Mount, O-ring Sealing. | End Face Mount, O-ring Sealing. |
| Material: | Anodized Aluminum | Anodized Aluminum |
| Application: | Single Transducer or Hydrophone | Array, for Multi Cables (Cable Bundle) |
| Outside Diameter: | OD = Φ60 mm, Maximum. | |
| Center Hole Diameter: | ID = Φ10.5 mm, for Cable Through. | ID = Φ26.0 mm, for Cable Bundle Through. |
| Threaded Mounting Holes: | 6 M6x1x12.7 Threaded Holes, Equal Spacing on 31mm PCD. | 6 M6x1x12.7 Threaded Holes, Equal Spacing on 37mm PCD. |
| | 1. PCD: Pitch Circle Diameter. 2. **Range of Engagement Length of Screw Threads: 8 to 12.5 mm.** | |
| | **Warning**: Depending on the thickness of mounting wall, proper screw length should be used at buyer's cost. If screw length was too long (**Engagement Length of Screw Threads > 12.5mm**), internal part of the transducer would be damaged during tightening; if screw length was too short (**Engagement Length of Screw Threads < 8mm**), thread of the End-face part would be damaged by transducer weight or tightening torque. | |
| Accessories: | 6 M6x1x16 Screws and O-ring ID x CS = Φ43 x 3. | 6 M6x1x16 Screws, and O-ring ID x CS = Φ48 x 3. |
| Mounting wall thickness T: | Mounting wall thickness T should be: 3.5 mm < T < 8 mm for M6x1x16 Screws. Refer to **Warning**. | |
| | **Choose proper screw length with known wall thickness T: 8mm + T < Screw Length < 12.5mm + T.** | |
| Fastening Torque: | ≤ 1 Nm | |
| Service Temperature: | 1. Default: -40 to 140 °F or -40 to 60 °C. 2. Bespoke: -40 to 250 °F or -40 to 121 °C. 3. Bespoke: -40 to 400 °F or -40 to 204.4 °C. | |
| Maximum Depth: | 1000 m | |
| **Thread lockers are recommended to prevent threaded fasteners from loosening due to shock and vibration. NOT provided by BII.** | | |

**End-Face Mounting (O-ring Sealing) (EFMS) for Single-channel Transducer or Hydrophone**




**Installation on Submersible**



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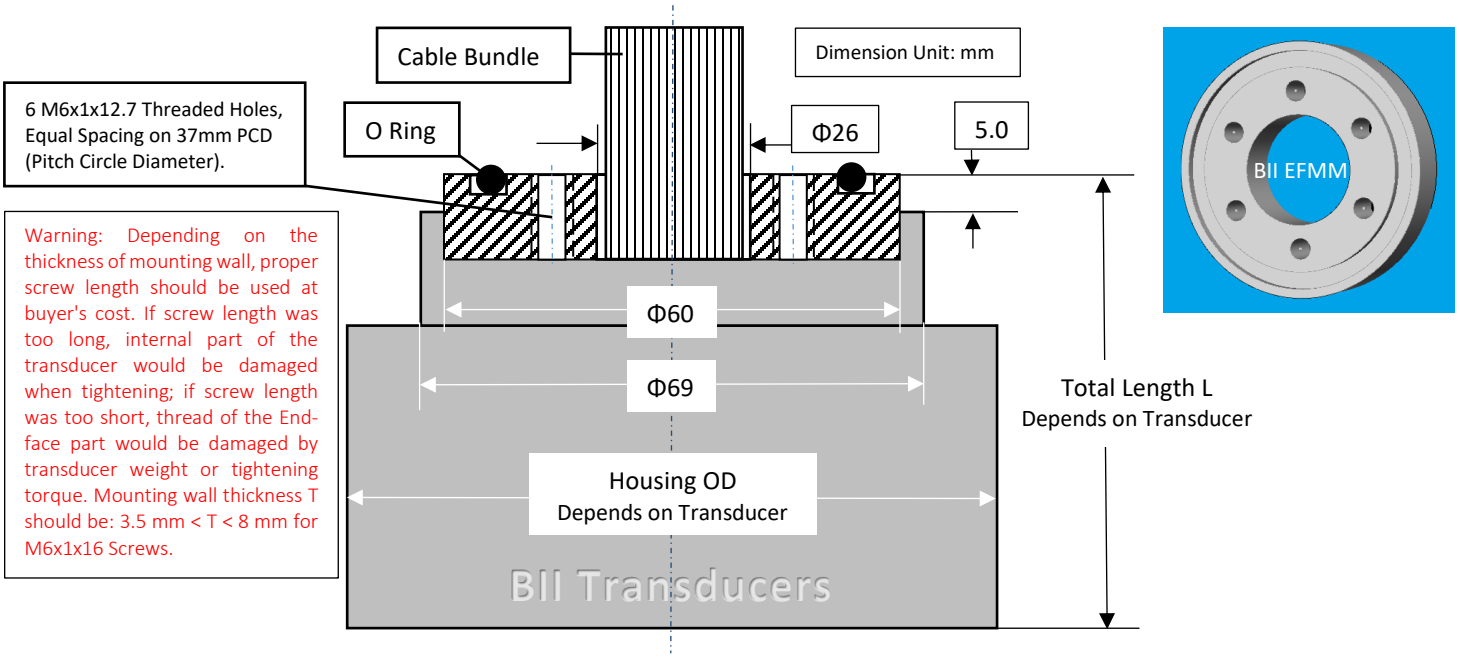
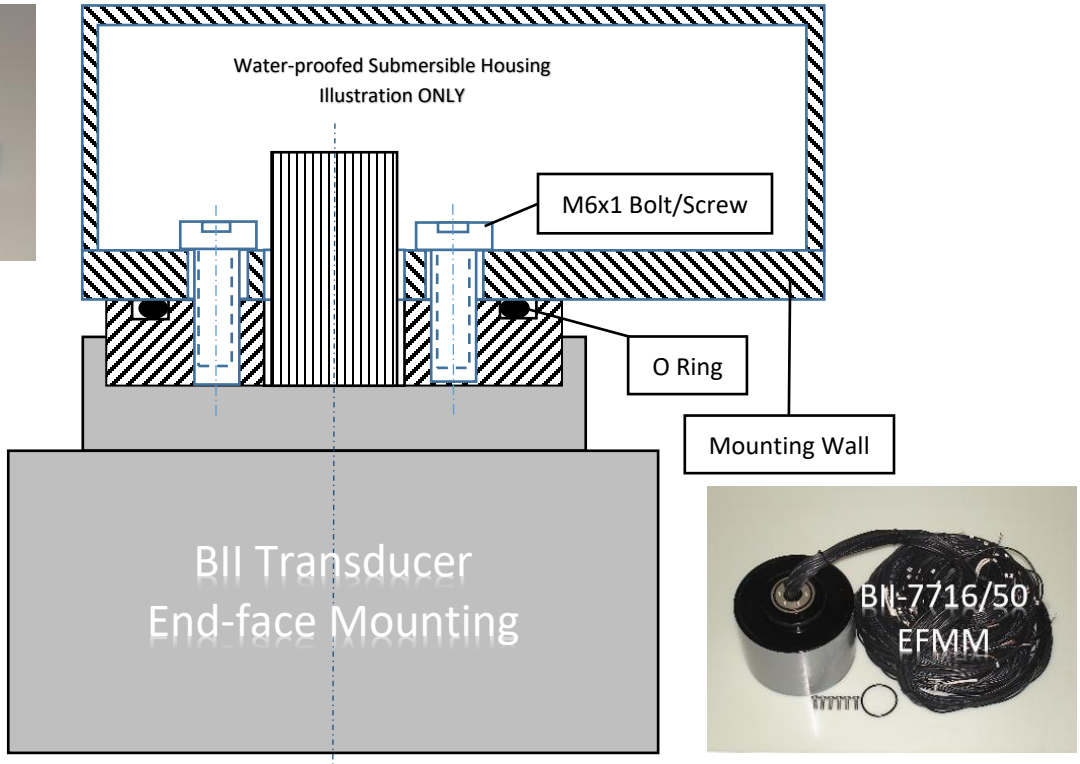
**End-Face Mounting with O-ring Sealing for Cable Bundle of Multi-channel Array Transducer (EFMM) (Dimension Unit: mm)**
Material: Anodized Aluminum.




**Installation on Submersible**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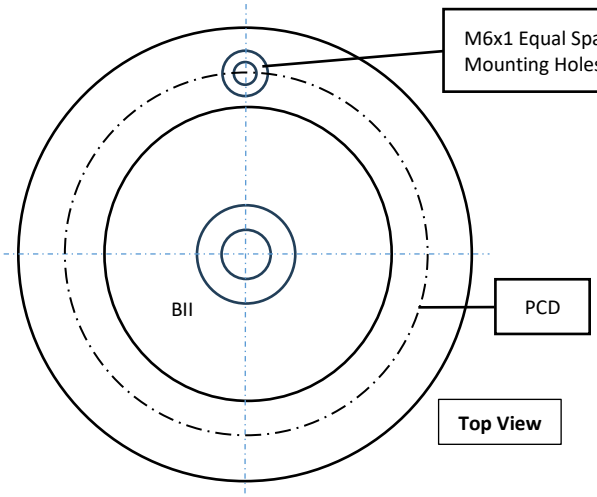
## Flange Mount (Marine Sealant) (FGM) (Dimension Unit: mm)

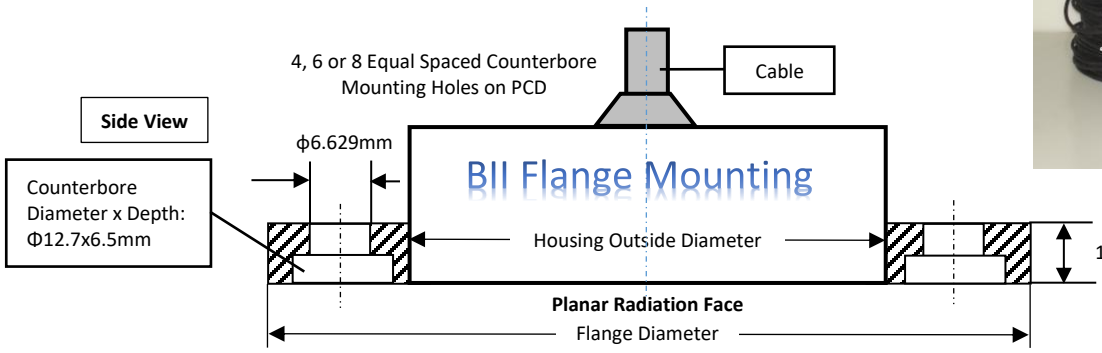
| | | | |
|---|---|---|---|
| Maximum Depth: 100 m | Material: Plastics. | M6x1 Screws and Nut: Not Included. | Marine Sealant: Not Included. |
| Service Temperature: | -40 to 140 °F or -40 to 60 °C. | | |
| Counterbored Mounting Holes for M6X1, Equal Spacing on PCD. PCD: Pitch Circle Diameter. | | | |
| Thread lockers are recommended to prevent threaded fasteners from loosening due to shock and vibration. NOT provided by BII. | | | |

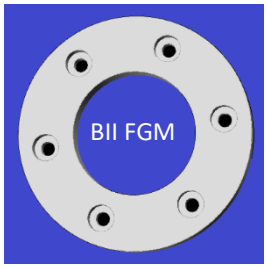
**Flange Mounting**

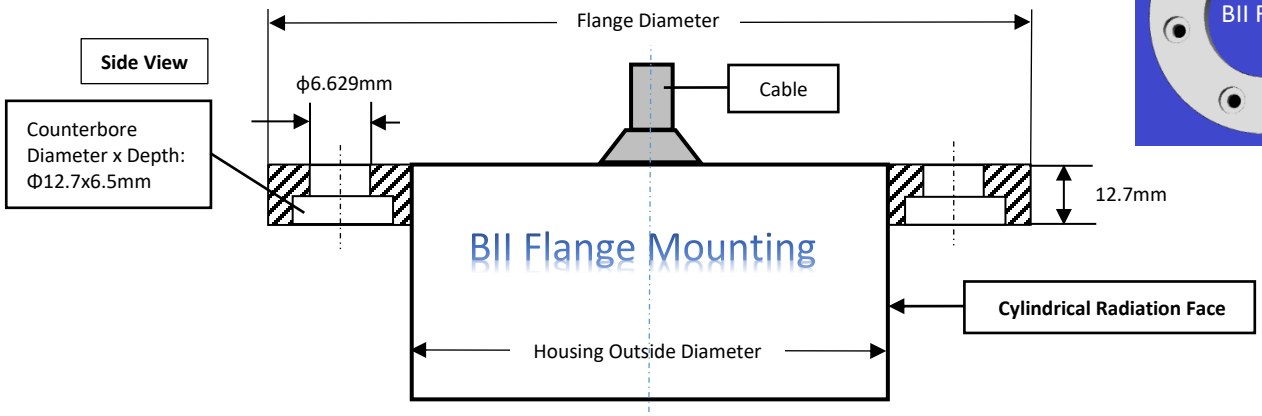







| Part Number | Flange Diameter (mm) | Pitch Circle Diameter PCD (mm) | Housing Outside Diameter (mm) | M6x1 Mounting Hole Number on PCD | Flange Thickness (mm) |
|---|---|---|---|---|---|
| **FGM-Φ220** | Φ220 | Φ195 | Φ168 | 8 | 12.7 |
| **FGM-Φ190** | Φ190 | Φ165 | Φ141 | 8 | 12.7 |
| **FGM-Φ165** | Φ165 | Φ140 | Φ114 | 6 | 12.7 |
| **FGM-Φ140** | Φ140 | Φ115 | Φ89 | 6 | 12.7 |
| **FGM-Φ110** | Φ110 | Φ85 | Φ60 | 6 | 12.7 |
| ~~**FGM-Φ80**~~ | ~~Φ80~~ | ~~Φ58~~ | ~~Φ33~~ | ~~4~~ | ~~12.7~~ |

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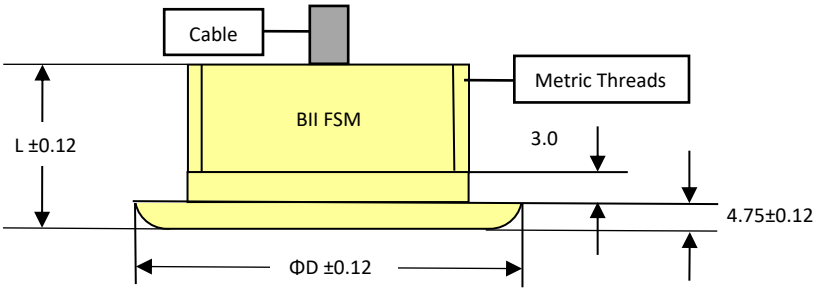
## Flush Mount (Marine Sealant or Gasket) (FSM) (Dimension Unit: mm)

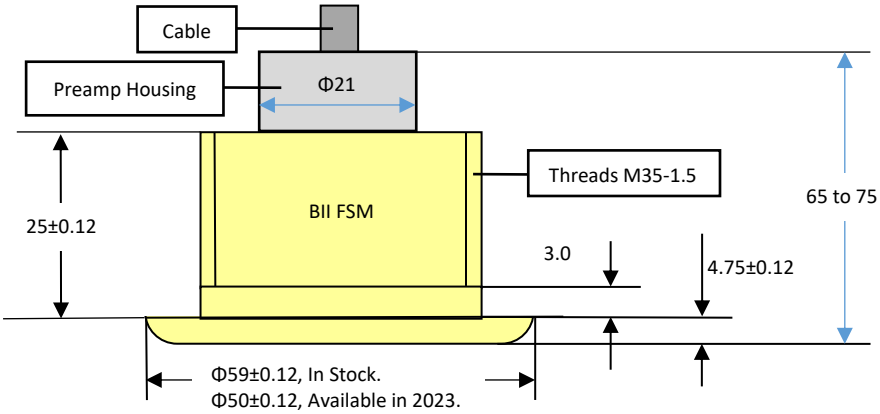
| Part Number | Acoustic Aperture | Material | Thread | Housing Length L | Flange Diameter ΦD | Mounting Wall Thickness | Fastening Torque |
|---|---|---|---|---|---|---|---|
| **FSM-M10** | ≤ Φ5 mm | Stainless Steel | M10x1.5 | 24.75 | Φ18 | ≤ (L – 14) | ≤ 20 Nm |
| **FSM-M14** | ≤ Φ10 mm | Anodized Aluminum | M14x1.5 | 26.75 | Φ22 | ≤ (L – 16) | ≤ 10 Nm |
| **FSM-M35** | ≤ Φ27 mm | Anodized Aluminum | M35x1.5 | 29.75, 50, 80. | Φ59 | ≤ (L – 13) | ≤ 20 Nm |
| ~~**FSM-M36**~~ | ~~≤ Φ27 mm~~ | ~~Anodized Aluminum~~ | ~~M36x4~~ | ~~29.75, 50, 80.~~ | ~~Φ59~~ | ~~≤ (L – 13)~~ | ~~≤ 20 Nm~~ |
| **FSM-M56** | ≤ Φ47 mm | Anodized Aluminum | M55x5.5 | 29.75, 50. | Φ70 | ≤ (L – 13) | ≤ 30 Nm |
| ~~**FSM-M72**~~ | ~~≤ Φ62 mm~~ | ~~Anodized Aluminum~~ | ~~M72x4~~ | ~~29.75, 50.~~ | ~~Φ85~~ | ~~≤ (L – 13)~~ | ~~≤ 40 Nm~~ |
| **Hex Nut**: Included, **for dry use ONLY**. Material: Steel. **Moisture-Resistant Grease is recommended to resist moisture to prevent corrosion if necessary.** | | | | | | | |
| BII does NOT provide sealing materials such as marine sealants and gaskets. Buyer may buy these materials from buyer's local stores of adhesives, boats, automobiles, and industry suppliers. | | | | | | | |
| Surface Finish of the flange against the mounting wall: 50.8 microns Ra, Linear tolerance +/-0.12 mm. Counterbored Mounting Hole is the best. | | | | | | | |
| Service Temperature: 1. Default: -40 to 140 °F or -40 to 60 °C. 2. Bespoke: -40 to 250 °F or -40 to 121 °C. 3. Bespoke: -40 to 400 °F or -40 to 204.4 °C. | | | | | | | |
| Maximum Operating Depth: 100 m to 300 m, limited by the performance of the sealing materials. For deeper underwater deployment (maximum 300m), one option is that O-ring grooves are cut on the mounting wall and O-rings are used besides marine sealants or casting sealants. | | | | | | | |
| **Thread lockers are recommended to prevent threaded fasteners from loosening due to shock and vibration. NOT provided by BII.** | | | | | | | |

**Flush Mounting Parts for Transducers/Projectors and Hydrophones (No Built-in Preamp), Physical Size (Dimensional Unit: mm):**



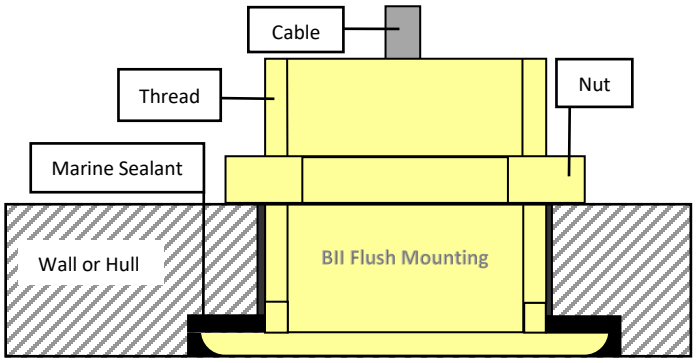


**Flush Mounting Parts for Hydrophones with Built-in Preamp, Physical Size (Dimensional Unit: mm):**

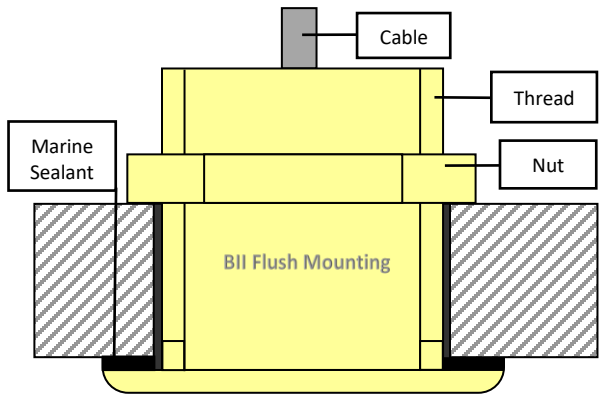



**Installation/Mounting**

**Flush Mounting with Counterbore Hole.**




**Low-profile Flush Mounting**

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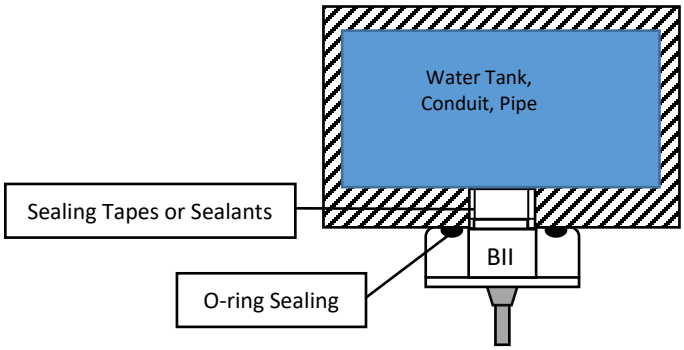
## Thread Mounting with Single O-Ring (TMSO) (Dimension Unit: mm)

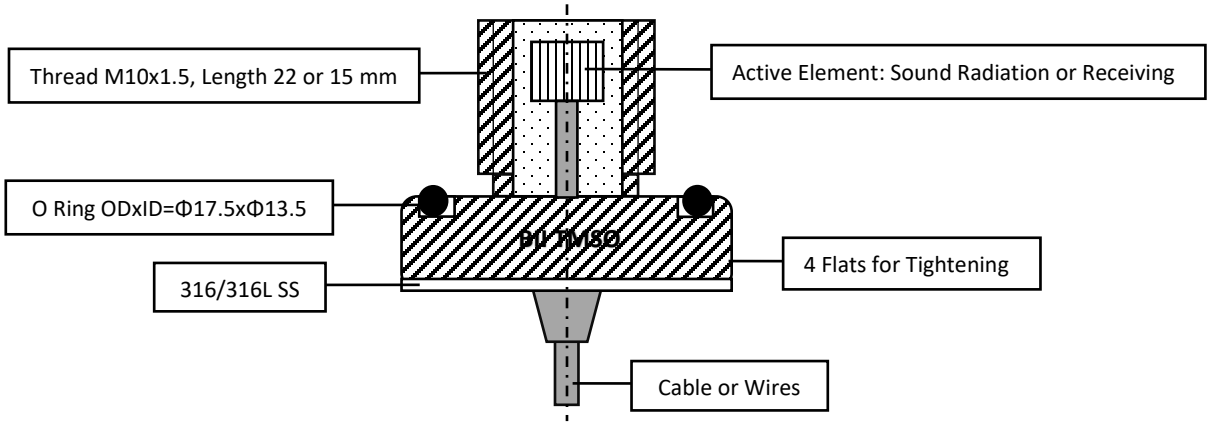
| Part Number: | TMSO-M10x22 | TMSO-M10x15 |
|---|---|---|
| TMSO Options: | Thread: M10x1.5, Length=22 (Right Hand) | Thread: M10x1.5, Length=15 (Right Hand) |
| | Metric Screw Thread: M Profile, or United Screw Threads (UTS). | |
| Hydrophone or Projector: | Single-ended or Differential | Single-ended or Differential |
| | Suitable frequency for hydrophones: 0.1 Hz to 10 MHz.<br>Suitable frequency for projectors: 50 kHz to 10 MHz. | |
| Protection Seal: | 1. With O-ring provided by BII: 70 PSI, 5 Bar or 0.5 MPa.<br>2. With proper sealing tape or sealant: Maximum 1450 PSI or 10 MPa with full engagement length of the thread. | |
| Thickness of Mounting Wall: | Warning: thickness of mounting wall affects Engagement Length of Threads. If Engagement Length of Screw Threads were too short, threads would be damaged by pressure. | |
| Maximum Body Diameters: | Φ21 | |
| Accessories: | 1. O-ring Included: ID x OD = Φ13.5 x Φ17.5 mm. Durometer 70 A.<br>2. Thread Sealant Tape is available upon request when ordering. Specify the sealant tape types according to your applications. | |
| Four Wrenching Flats: | FlatxH = 19x10 mm | FlatxH = 19x5 mm |
| Fastening Torque: | ≤10 Nm | |
| Materials of the Body: | Stainless Steel 316/316L | |
| Service Temperature: | 1. Default: -40 to 140 °F or -40 to 60 °C. 2. Bespoke: -40 to 250 °F or -40 to 121 °C. 3. Bespoke: -15 to 400 °F or -26.1 to 204.4 °C. | |
| Thread lockers are recommended to prevent threaded fasteners from loosening due to shock and vibration. NOT provided by BII. It is buyer's responsibility and liability to take measures at buyer's cost to prevent the installation from being loose or detached. | | |

**Thread Sealing Tips. (**Followings sealants and sealing tapes are NOT provided by BII by default. Some of them are available upon request when ordering.**)**

1. **High-Density Thread Sealant Tape**: This tape has a high density for a better seal between threads. Made of PTFE, it has a slippery surface that keeps threads from binding to make parts easy to assemble.
2. **Thread Sealant Tape for Stainless Steel Threads:** This tape contains nickel to prevent seizing and galling associated with stainless steel threaded connections. It's also good for use with other metals. This tape has a high density for a better seal between threads. Made of PTFE, it has a slippery surface that keeps threads from binding to make parts easy to assemble.
3. **Submersible Sealants:** Marine grade, stand up to water, corrosion from salt spray, mildew, and UV light.
4. **Structural Submersible Sealants:** The strongest submersible sealants, these combine the mechanical strength of an adhesive with excellent sealing properties and high flexibility. They're marine grade, so they stand up to water, corrosion from salt spray, mildew, and UV light.
5. **Cured in Place Seals and Formed in Place Seals and Gaskets**. If these sealants are necessary to end-user's specific applications, BII recommends end-user to purchase these sealants from local industrial suppliers in end-user's country. BII does not provide curing sealants.





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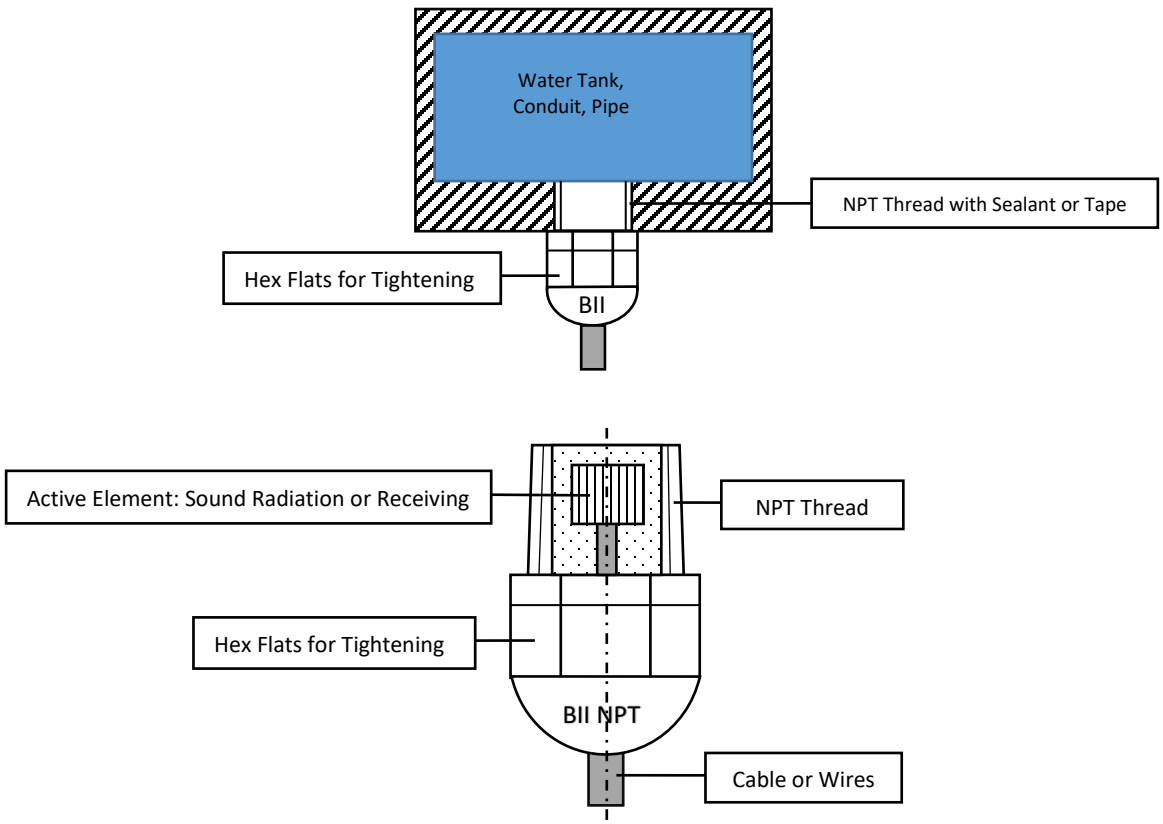
## NPT Thread Mounting (NPT) (Dimension Unit: mm)

| **Part Number:** | **NPT-3/8"P; NPT-1/2"P; NPT-3/4"P; ...** | **NPT-3/8"SS; NPT-1/2"SS; NPT-3/4"SS, NPT-1"SS** |
|---|---|---|
| **NPT Thread Options:** | Thread: 3/8", 1/2", 3/4", 1", 1-1/4", 1-1/2", 2". | Thread: 3/8", 1/2", 3/4", 1". |
| | American National Taper Pipe Threads (NPT). | |
| **Hydrophone or Projector:** | Single-ended or Differential | Single-ended or Differential |
| | Suitable frequency for hydrophones: 0.1 Hz to 10 MHz.<br>Suitable frequency for projectors: 40 kHz to 10 MHz. | |
| **Materials of the Body:** | Plastics | Stainless Steel |
| **Protection Seal:** | 70 PSI, 5 Bar or 0.5 MPa. | 1450 PSI or 10 MPa |
| **Thickness of Mounting Wall:** | Warning: thickness of mounting wall affects Engagement Length of Threads. If Engagement Length of Screw Threads were too short, threads would be damaged by pressure. To achieve maximum pressure rating, please use full engagement length of the thread. | |
| **Maximum Body Diameters:** | Depends on thread options. | |
| **Wrenching Flats:** | Hex | |
| **Fastening Torque:** | ≤1 Nm | ≤10 Nm |
| **Sealant:** | Sealant (tape or paste) should be used for sealing.<br>1. Default: BII does not provide sealant.<br>2. Thread Sealant Tape is available upon request when ordering. Specify the sealant tape types according to your applications. | |
| **Service Temperature:** | -40 to 176 °F or -40 to 80 °C. | -40 to 250 °F or -40 to 121 °C. |
| Thread lockers are recommended to prevent threaded fasteners from loosening due to shock and vibration. NOT provided by BII. It is buyer's responsibility and liability to take measures at buyer's cost to prevent the installation from being loose or detached. | | |

**Thread Sealing Tips. (**Followings sealants and sealing tapes are NOT provided by BII by default. Some of them are available upon request when ordering.**)**

1. **High-Density Thread Sealant Tape**: This tape has a high density for a better seal between threads. Made of PTFE, it has a slippery surface that keeps threads from binding to make parts easy to assemble.
2. **Thread Sealant Tape for Stainless Steel Threads:** This tape contains nickel to prevent seizing and galling associated with stainless steel threaded connections. It's also good for use with other metals. This tape has a high density for a better seal between threads. Made of PTFE, it has a slippery surface that keeps threads from binding to make parts easy to assemble.
3. **Submersible Sealants:** Marine grade, stand up to water, corrosion from salt spray, mildew, and UV light.
4. **Structural Submersible Sealants:** The strongest submersible sealants, these combine the mechanical strength of an adhesive with excellent sealing properties and high flexibility. They're marine grade, so they stand up to water, corrosion from salt spray, mildew, and UV light.
5. **Cured in Place Seals and Formed in Place Seals and Gaskets**. If these sealants are necessary to end-user's specific applications, BII recommends end-user to purchase these sealants from local industrial suppliers in end-user's country. BII does not provide curing sealants.

**Thread (NPT) Mount**

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**Underwater Connector Assembly**

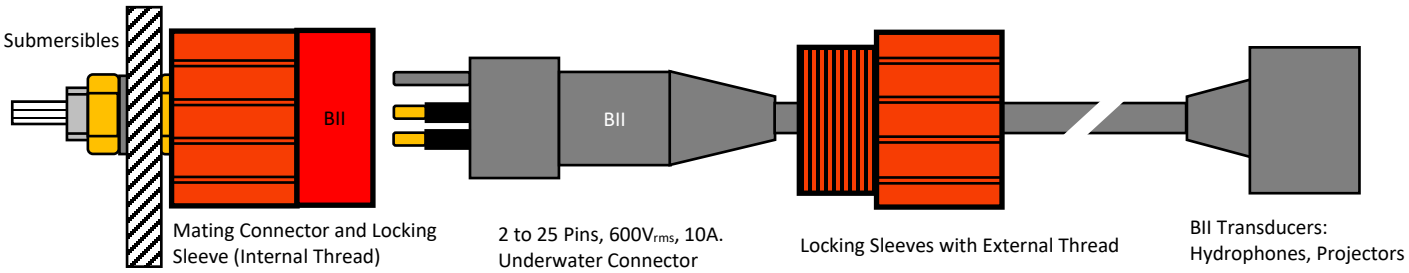
BII purchases underwater connectors from international underwater connector manufacturers who may have sales branches in buyers' countries. A buyer may purchase mating connectors from manufacturers directly or from BII as an integral part of BII transducers (hydrophones and transducers). Please contact BII for more information of the connectors such as manufacturers' name, part numbers, etc.

**1. Standard Circular Series Underwater Connectors**

**Buyer's Devices:**
Submersibles +
Wall-Mounting Underwater Connectors with Sockets +
Locking Sleeves with Internal Thread

⟷

**BII's Devices:**
Underwater Connectors with Pins + Locking Sleeves with External Thread +
Cables + Transducers (Hydrophone and Projectors)

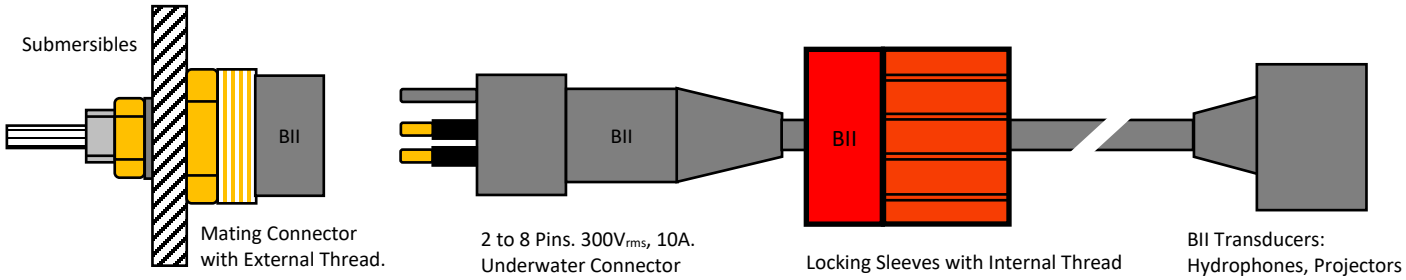



**2. Micro Circular Series Underwater Connectors**

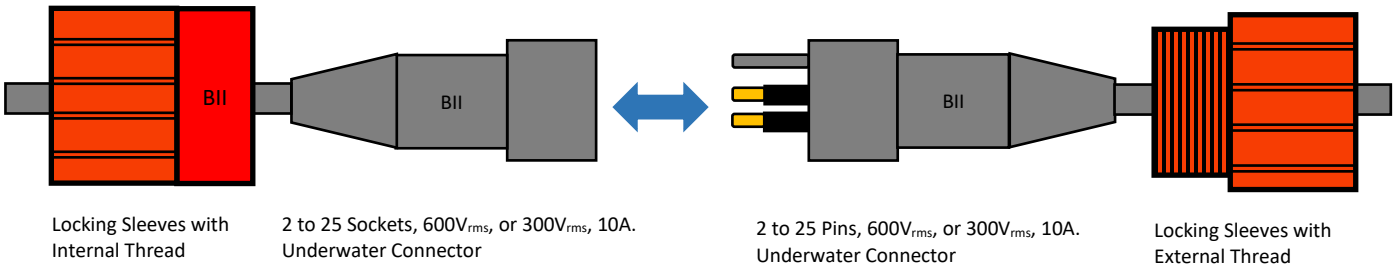
**Buyer's Devices:**
Submersibles +
Wall-Mounting Underwater Connectors with Sockets and External Thread

⟷

**BII's Devices:**
Underwater Connectors with Pins + Locking Sleeves with Internal Thread +
Cables + Transducers (Hydrophone and Projectors)




**3. In-line Mating of Underwater Connectors**





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## Export, Import, HS Code, Export Compliance, End-Use Statement, Shipping & Delivery

**Sales and Technical Support (**BII: Benthowave Instrument Inc.**)**
Selecting products, request quotes and technical support (Communication Language: English, in plain text or PDF): **info@benthowave.com**

To help BII issue official quotation, please email following info to BII in detail:
(1) **Consignee info**, (2) **Importer of Record info**, (3) Your **Customs Broker Info** if you do not want to use courier's customs brokerage service, (4) **Payor of import duties and taxes**, Consignee or Importer? Note: The necessary information includes complete address, phone number, Email and VAT, EORI, or TIN (SSN, EIN) which permits you to import goods.

Please check out your all email folders and/or check out your email-server's setting if you do NOT receive BII's response over 1 week and ensure that your Email Server can receive emails from our company.
Basic Receiving Email Server Settings: 1. Log into email server. 2. Check out settings: Mail Filter, Blocked Senders, Safe Senders, Security, Block Images, etc. Pay attention to default handling of suspected Spam and Virus. Some business email may be treated as spams or virus and be deleted automatically by the email server.

**Commercial Information**: DO NOT email or send any confidential information such as trade secrets and Intellectual Property to BII.

**Disclaimer:** BII provides information on shipping definitions and processes as a convenience only. BII does NOT guarantee its accuracy or completeness. It is customer's (importer and Consignee) responsibility to make sure you are complying with all applicable requirements when you import BII's goods into your country.

Before purchasing, (1) buyers should inquire buyer's Customs about import requirements of BII's products. (2) buyers should email BII the required Customs documents which require manufacturer to fill in and sign.

**HS Codes for Import and Export**

Harmonized System (HS) Code Reference and Description of BII Products, referring to Canadian Export Classification.

| Description of BII Products | HS Code | Description of BII Products | HS Code |
|---|---|---|---|
| Hydrophone as Parts and Accessories for Underwater (Oceanography) Acoustic Instruments | 9015.90.00 | Impedance Matching Transformer as Parts and Accessories for Acoustic Instruments | 8504.31.00 |
| Underwater Transducer as Parts and Accessories for Underwater (Oceanography) Acoustic Instruments | 9015.90.00 | Power Amplifier as Parts and Accessories for Acoustic Instruments | 8518.40.00 |
| High Intensity Focused Ultrasound Transducer as Parts and Accessories for Acoustic Instruments | 9027.90.00 | Electronic Preamplifier as Parts and Accessories for Acoustic Instruments | 8518.50.00 |
| Non-Destructive Testing Transducer as Parts and Accessories for Acoustic Measuring Instruments | 9027.90.00 | Electronic Amplifier (Transmit/Receive Switch, Time-Variable Gain, Automatic Gain Control, Band Pass Filter, Envelope Detection, Array Beamforming) as Parts and Accessories for Acoustic Instruments | 8518.50.00 |
| Acoustic Emission Transducer as Parts and Accessories for Acoustic Measuring Instruments | 9027.90.00 | Pulsed Signal Generator as Parts and Accessories for Acoustic Measuring Instruments | 8543.20.00 |
| Ultrasonic Air Transducer as Parts and Accessories for Acoustic Instruments | 9027.90.00 | Signal Pulser & Receiver as Parts and Accessories for Acoustic Measuring Instruments | 8543.20.00 |
| Underwater Sound Recorder as Scientific Oceanographic Instrument | 9015.80.00 | Scientific Echo Sounder as Rangefinder in Oceanography | 9015.10.00 |

(1) HS codes in BII's Quote, Commercial Invoice (**CI**), and Certificate of Origin (**COO**) are for export at Canadian Customs, which are from Canadian Export Classification, Statistics Canada.
(2) With Canadian HS Codes and product descriptions, please contact and inquire your country's customs for HS codes, tariffs, and import requirements.
(3) There might be minor difference on HS codes between Canada and your country.

**Consignee (Goods are Shipped to)** is the person, company, or party to whom the goods are shipped.
**Importer (Importer of Record)** is the person or company legally responsible for ensuring imported goods comply with the destination country's customs laws and regulations, for paying import duties and taxes, and all related fees.
**Customs Clearance** is the process of getting goods approved by customs authority of consignee's country, so the goods can legally enter consignee's country.

**Shipping with Commercial Network DHL/FedEx/UPS:**
**1. Customs Broker** is a licensed professional hired to help clear the goods through the border or handles customs clearance on behalf of the importer/IOR.
**2. Power of Attorney (POA)** is a legal document (agreement) used in shipping to grant a customs broker the authority to process Customs clearance on your behalf.
**3. Customs Broker Options:** (1) Importer clears goods through Customs by himself. (2) Importer uses brokerage services of Courier (DHL/FedEx/UPS) Internal Brokerage Division, and signs Power of Attorney agreement with courier. (3) Importer authorizes a licensed customs broker to clear goods through Customs on behalf of importer. Importer signs Power of Attorney agreement with this licensed customs broker.
**4. Most Common Cases Shipping with DHL/FedEx/UPS:** (1) Importer and Consignee are same person, company, or party. (2) Customs Broker: Courier's internal Brokerage Division.
**Importer and Consignee of a large entity** might not have the same address or they are different entities, and the large entity may have its own Customs Broker.

**Allocations of Costs to Buyer and Vendor according to Incoterms. Shipping with Commercial Network: DHL, FedEx, or UPS or Buyer's Freight Forwarder.**

**DAP**: Insurable risk is for the Vendor's (Benthowave) shipping account such as DHL, UPS, FedEx.
**EXW-Ex Works**: Insurable risk is for the Buyer's (Importer, Sold to, Consignee) courier account.

Before purchasing, buyers should inquire about import requirements of BII's products with buyer's customs. Refer to HS Codes for Import and Export.

| Incoterms 2020 | 1. Export Customs Declaration.<br>2. Loading Goods to Courier Truck at BII. | 1. Insurance (Shipment Protection).<br>2. Carriage to Place of Destination. | 1. Import Customs Clearance<br>2. Import Duties and Taxes | Unloading at Destination |
|---|---|---|---|---|
| **DAP** | Benthowave (Vendor) | Benthowave (Vendor) | Buyer | Buyer |
| **Ex Works** | Benthowave (Vendor) | Buyer | Buyer | Buyer |

**Shipping with Postal Network Canada Post:**
1. Importer and Consignee are same person, company, or party.
2. Customs Clearance: Postal Network sends customs documents to buyer's customs to clear the customs.

**Allocations of Costs to Buyer and Vendor. Shipping with Postal Network: Canada Post.**

**DAP**: Insurable risk is for the Vendor's (Benthowave) shipping account of Canada Post.

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| | | | | |
|---|---|---|---|---|
| **Incoterms 2020** | 1. Export Customs Declaration.<br>2. Loading Goods to Courier Truck at BII. | 1. Insurance (Shipment Protection).<br>2. Carriage to Place of Destination. | 1. Before shipping, buyers email BII import Customs documents required by buyer's Customs such as import license, permit, certificate, etc. for Import Customs Clearance though postal network.<br>2. Import Duties and Taxes. | Unloading at Destination |
| **DAP** | Benthowave (Vendor) | Benthowave (Vendor) | Buyer | Buyer |

**Complete Address of Importer and Consignee**: contact name, street name, city, state or province, country, and valid postal code, Email and phone number. **VAT** (Value Added Tax Identification) Number; **EORI** Number (EU, Northern Ireland, Norway and Switzerland); Employer Identification Number (**EIN**) (USA).

**To Importers in EU, Northern Ireland, Norway and Switzerland:**
**EORI number** (Economic Operator Registration and Identification number of VAT-registered businesses),
**Organization Number** in Norway, or Unique Identification (UID) Number in Switzerland.
**To Importers in USA:** for shipment value ≥ USD$2500, consignee's Tax Identification Number (**TIN**), which can be either a Social Security Number (**SSN**) or an Employer Identification Number (**EIN**), is required by USA customs.

**Shipping and Delivery**
**Shipping Date**: from January 5 to December 15. No shipping from December 16 to January 4 of the next year.
**Shipping Updates**: BII requests carrier's email-notifications service for shipping updates. BII emails the tracking number to buyer/consignee once BII creates waybill label. New online updates from courier website will be available about 5 to 24 hrs later.
**Shipping Package:** Cartons, maximum weight: 30 kg of each carton package.
**Delivery Terms**: BII prepares commercial invoice, fills out the FTA if any (Free Trade Agreement between buyer's country and Canada), and submit export-declarations-forms to Canada Border Services Agency (CBSA) in Canada.
1. **DAP, Ship-To Address as stated on the Commercial Invoice, Incoterms 2020.** Shipping with BII's courier account, Freight Prepaid.
2. **EXW Collingwood, Ontario, Canada, Incoterms 2020.** Customer's Freight Forwarder picks up goods at BII and arranges shipping.

**Tax, Duty and Exemption**
**For international customers**: buyer/importer is responsible for import customs clearance, and pays brokerage fees, import duties and taxes imposed by buyer/importer's country, and pays other costs such as import licenses fees, certificate fees, etc., if any.
No Canadian sales tax (GST, HST and PST) to international customers. Canadian GST/HST/PST is applicable to Canadian customers ONLY.
Many countries provide some form of customs duty, import tax, or VAT/GST relief for scientific components and instruments, especially Custom-made components and instruments for Research and Development uses in small quantities, and many import regulations do not apply to these goods simplify import processes, such as ROHS Directive. In most countries, government-funded projects, military/defense entities, Navy research centers, research centers of universities have import taxes and duty exemptions. Please contact your Customs for details. Please provide your exemption certificates to your broker, courier or Customs for import customs clearance.

**Sales Terms and Conditions:** The Sales Terms and Conditions is enclosed in BII official quote. Customers may refer to www.exportcontrols.gc.ca for more information on Area Control List, Export Prohibitions and Sanctions.

**Hours of Operation**
9:00a.m. to 5:00p.m., Monday to Friday.
Closed on Saturday, Sunday, and Public Holidays in Canada.
Please note that BII might shut down during severe weathers such as storms in summer and snow squalls in winter. Generally, there are many severe weathers in our area in December, January and February.

**Benthowave Instrument Inc.**
**89 Kells Crescent,**
**Collingwood, Ontario, L9Y 0B4**
**Canada**
Phone: +1 705 444 0187

## Ordering, Manufacturing and Shipping Process

BII directly sells products to buyers (importers and consignees) all over the world and BII ships products directly to buyers all over the world. Except Canada, BII does NOT have any branch and/or sales representative in any other country.
1. Buyers specify products in detail by referring to **<How to Order>** in respective datasheet. Email buyers' complete address to BII and specify payment methods (USA & Canada: Cheque, Bank Draft or Wire Transfer; Other Countries: Wire Transfer through Bank). **BII does not accept credit card payment**.
2. With Canadian HS Codes and product descriptions, buyer contacts and inquires your country's customs for HS codes, tariffs, and import requirements. For example, does importing BII products need any import license, permit, certificate, etc.? if yes, and you decide to purchase goods from BII, please apply required licenses, permits, certificates, etc.
Note: BII's products are components of acoustic instruments for uses in oceanography, hydrography and NDT. Most countries do NOT require any import license, permit, or certificates. You should pay attention to import Customs policies in detail, for example, some EU countries levy special tax on non-reusable plastic packaging, etc. Before placing order, you should email BII the customs documents which require manufacturer to fill in and sign.
3. BII issues official quote to buyer which enclose BII's sales terms and conditions. Buyer reads the quote in detail. Contact BII for any question and update and email BII the required customs documents which require manufacturer to fill in and sign.
4. Buyer places order with email confirmation or purchase order.
5. BII issues Proforma Invoice to Buyer, which encloses BII's bank information. Buyer starts to make payment to BII, and BII prepares to manufacture the order.
6. BII manufactures, tests, and calibrates the products.
7. BII prepares export documents and complete export declaration to Canadian Customs.
8. BII ships goods to Buyer with DHL, UPS, FedEx, Canada Post or Buyer's Freight forwarder, and notifies buyer with tracking number, commercial invoice and/or COO.
9. Buyer tracks the shipment online at carrier's website, complete the import customs clearances at buyer's country, and pay the taxes and duties imposed by buyer's country.
   a. Most Common Shipping Cases: (1) Importer and Consignee are same person, company, or party. (2) Customs Broker: Courier's internal Brokerage Division.
   b. Importer and Consignee of a large entity might not have the same address or they are different entities, and the large entity may have its own Customs Broker.
10. Buyer receives the shipment.

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**Estimated Processing Time of Quotations and Approximate manufacturing time for Bespoke Products.**

**Processing Time**: The time, after buyer releases complete and accurate bespoke info to BII, necessary for BII to complete corresponding design, simulation, manufacturing processes, and estimated or simulated specs.

| Products | Bespoke Parameters and/or Parts | Processing Time of Quote | Approximate manufacturing time[1] |
|---|---|---|---|
| Hydrophone AE Sensor NDT Sensor | **Shorter Cable, Connector**, others are same to standardized hydrophones. | 1-5 days | BII checks out inventory.<br>**In stock**: 2 to 3 days.<br>**Out of Stock**: 3 to 6 weeks. |
| | **Longer Cable, Connector**, others are same to standardized hydrophones. | 1-5 days | 3 to 6 weeks. |
| | **Output Type, Mounting, Cable Types, Cable Length, and/or Connectors.** | 1-5 days | 4 to 7 weeks. |
| | **-3dB Cut-off frequencies** of High Pass, Low Pass, or Band Pass Filters. | 3 days to 2 weeks. | 4 to 7 weeks. |
| | **Low Power Consumption** of Receiver with Preamps | 3 days to 2 weeks. | 4 to 10 weeks. |
| | **Free-filed Voltage Sensitivity (FFVS)** and/or **Pressure Noise Density**. | 2 to 4 weeks | 6 to 10 weeks. |
| | **-3dB Beam Angle**, **Directivity Response**, and/or **Sidelobe Level**. | 2 to 4 weeks | 6 to 10 weeks. |
| | **Linear/Line Array**: FFVS, -3dB Bean Angle and/or Sidelobe Level. | 2 to 4 weeks | 7 to 10 weeks. |
| | **Depth Rating** in Water of Ocean, Lake, or River. | 2 to 4 weeks | Shallow Water: 3 to 6 weeks.<br>Deep Water: 8 to 12 weeks. |
| | **Service Temperature** in Liquid, in Air or on Solid Surface. | 2 to 4 weeks | 4 to 10 weeks. |
| Sound Projector | **Shorter Cable, Connector**, others are same to standardized projectors. | 1-5 days | BII checks out inventory.<br>**In stock**: 2 to 3 days.<br>**Out of Stock**: 3 to 6 weeks. |
| | **Longer Cable, Connector**, others are same to standardized projectors. | 1-5 days | 3 to 6 weeks. |
| | **Mounting, Cable Types, Cable Length, and/or Connectors.** | 1-5 days | 4 to 7 weeks. |
| | **Impedance matching to non-50Ω** | 1-5 days | 6 to 9 weeks. |
| | **Transmitting Voltage Response (TVR), Power Rating.** | N/A | N/A |
| | **-3dB Beam Angle**, **Directivity Response**, and/or **Sidelobe Level**. | 2 to 4 weeks | 6 to 10 weeks. |
| | **Linear/Line Array**: FFVS, -3dB Bean Angle and/or Sidelobe Level. | 2 to 4 weeks | 7 to 10 weeks. |
| | **Depth Rating** in Water of Ocean, Lake, or River. | 2 to 4 weeks | Shallow Water: 3 to 6 weeks.<br>Deep Water: 8 to 12 weeks. |
| | **Service Temperature** in Liquid, in Air or on Solid Surface. | 2 to 4 weeks | 4 to 12 weeks. |
| Transducer (Transmit & Receive) | **Shorter Cable, Connector**, others are same to standardized projectors. | 1-5 days | BII checks out inventory.<br>**In stock**: 2 to 3 days.<br>**Out of Stock**: 6 to 9 weeks. |
| | **Longer Cable, Connector**, others are same to standardized projectors. | 1-5 days | 6 to 9 weeks. |
| | **Mounting, Cable Types, Cable Length, and/or Connectors.** | 1-5 days | 6 to 9 weeks. |
| | **Impedance matching to non-50Ω** | 1-5 days | 6 to 9 weeks. |
| | **Transmitting Voltage Response (TVR), Power Rating.** | N/A | N/A |
| | **Free-filed Voltage Sensitivity (FFVS)** and/or **Pressure Noise Density**. | 2 to 4 weeks | 6 to 12 weeks. |
| | **-3dB Beam Angle**, **Directivity Response**, and/or **Sidelobe Level**. | 2 to 4 weeks | 6 to 10 weeks. |
| | **Linear/Line Array**: FFVS, -3dB Beam Angle and/or Sidelobe Level. | 2 to 4 weeks | 6 to 10 weeks. |
| | **Depth Rating** in Water of Ocean, Lake, or River. | 2 to 4 weeks | Shallow Water: 6 to 9 weeks.<br>Deep Water: 8 to 12 weeks. |
| | **Service Temperature** in Liquid, in Air or on Solid Surface. | 2 to 4 weeks | 6 to 12 weeks. |

Note [1]: Approximate manufacturing time depends on the complexity of various transducers. If bespoke transducer is a new one and/or some parts are out of stock from BII and/or our suppliers, the manufacturing time is much longer.

**Disclaimer:** BII does NOT guarantee the bespoke manufacturing time, and buyer may cancel the delayed order during manufacturing when the delay is not acceptable to buyer anymore.

1. BII is NOT responsible to buyer's any loss caused by the delay of delivery of BII goods.
2. BII is NOT responsible to buyer's any loss caused by the failure of BII manufacturing the goods.
3. After buyer cancel the delayed order, the ONLY liability of BII is to refund the buyer with the amount Buyer paid BII for the purchase.

**EXPORT AND SANCTIONS LAWS AND COMPLIANCE.** BII Products are subject to control under the authority of the Export and Import Act administered by the Export Control Division of Foreign Affairs, Trade and Development Canada (www.exportcontrols.gc.ca). Without export permit issued by the minister of Foreign Affairs under the Export and Import Act of Canada, Products may not be exported or re-exported to any country, any person or entity in Area Control List (ACL), or in Export Prohibitions and Sanctions List imposed by Canada government, and Products on the Export Control List (ECL) may not be exported to customer. Customer agrees it will comply with the export laws, trade prohibitions, and sanctions of all applicable countries and will not export, re-export or transfer Products purchased from BII without the required authorization, including an export or re-export license issued by the Canada authorities, or to any prohibited destination or for a prohibited end-use. Products may also require export license(s) issued by the applicable authorities before being returned to BII, and the repaired products may also need export permit for returning it back to the customer.

The issuance of a Quote, a sales order acknowledgment (proforma invoice), or a RMA (Return Material Authorization) by BII does not constitute export authorization. BII reserves the right to refuse and/or cancel any order if, at any time, BII believes that any export controls may be violated. If a customer purchases Products on Export Control List, BII shall request an End User Statement from customer to apply for export license or permit. Orders requiring export licensing cannot be confirmed prior to receipt of approved export license from appropriate governing authority. Permits normally require 2-3 weeks to obtain.

**End-Use Statement for Export Controlled Goods.** A non-Canadian buyer shall email End-Use Statements to BII if the products are on the Canadian Export Control List (**Most BII products are NOT on Canadian export control list.**). The Export Control information is enclosed in official quote. An End-Use Statement must be dated (preferably within 6 months from the time the export permit application is submitted) and written on company letterhead in either English or French and should:

1. Identify the items, including quantities, which are the subject of the export permit application.
2. Identify the end-user and the location where the items will be delivered.
3. Identify any consignees, agents, or other entities involved in the export from Canada.
4. State the purpose and end-use of the products, including a statement of whether the intended end-use of the items is civilian (commercial) or military.

Go to Catalogue

5. State whether or not the goods or technology are intended for re-sale, re-transfer or re-export to another party or parties and, if so, describe the circumstances; or state that the goods or technology will not be resold, re-transferred or re-exported.
6. Declare whether or not the goods and technology will be used for any purpose associated with the development or production of chemical, biological or nuclear weapons, or their delivery systems (such as missiles).
7. State that the goods or technology will not be transhipped to other destinations or otherwise diverted from what has been previously described; and
8. Identify the name and title of the person signing the End-Use Statement, his/her address, telephone number, fax number, e-mail address and corporate website.
**Refer to End-use statement template.**

## IMPORTANT NOTICE AND DISCLAIMER

BII PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD-PARTY INTELLECTUAL PROPERTY RIGHTS.
These resources are intended for skilled developers designing with BII products. You are solely responsible for (1) selecting the appropriate BII products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements. These resources are subject to change without notice. BII grants you permission to use these resources only for development of an application that uses the BII products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other BII intellectual property right or to any third-party intellectual property right. BII disclaims responsibility for, and you will fully indemnify BII and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.
BII's products and services are provided subject to BII's **Terms and Conditions of Sale** enclosed in official quote.

## Careers at BII

Acoustics is an indispensable element of civilization which help understanding the world and improve livings. Benthowave staffs manufacture acoustical components and instruments to fulfill due contributions as acoustics benefits human beings.

While working at BII, we are challenged daily to meet and exceed various customers' requirements and solve the challenges during design, manufacturing, calibrations, and quality assurance with experiences and textbooks on mathematics, physics, chemistry, acoustics, mechanics, and electronics, and are rewarded for outstanding performances.

Proud tradition at BII is to emphasize individuality, respect, growth, and creativity. BII is a workplace where the staff can learn, contribute, innovate, and be rewarded as a career and not just a job, and values the staff as most important factors of success.

We believe in fair compensation that reflects the hard work and expertise our team members bring, we aim to provide opportunities for growth, and we believe the optimum match among wage, manufacturing capability, quality, and price is a successfully cooperating bridge between global customers and our business.

Following knowledge and experiences are our companions in daily working tasks:

| | | |
|---|---|---|
| Electroacoustics, Ultrasonics, Underwater Acoustics. | Electrical & Electronics. | Manufacturing/Mechanical Engineering. |
| Materials, Solid State Chemistry & Physics. | Ceramics, Polymer, Composite. | Marine/Ocean Engineering. |

If you're available and capable of following positions, Benthowave'd be grateful for your assistance.

| NOC 2021 | Job Title and Responsibilities | Job Types | Job Vacancy | Contact |
|---|---|---|---|---|
| 94201 | 1. Electronics Assemblers, Fabricators, Inspectors and Testers.<br>2. Necessary Training Provided by Benthowave. | Full Time | Please refer to: Careers at BII. | hr@benthowave.com |
| 22310 | Electronics Engineering Technologists and Technicians | Full Time | | |
| 22301 | Mechanical Engineering Technologists and Technicians | Full Time | | |
| 12200 | Accounting Technicians and Bookkeepers | Full Time | | |
| 21301 | Acoustics (Electroacoustics) Engineers (Mechatronic Engineering) | Full Time | | |
| 21322 | Materials Engineers | Full Time | | |
| 90010 | Manufacturing Managers (Mechatronic Engineering) | Full Time | | |
| Note: Please send resume (PDF Format is preferred) to apply the job available. | | | | |
| 1. Work time with 30-minute meal break: 9:00 AM to 5:30 PM, no shifts, Monday to Friday.<br>2. Hourly pay with a bonus every half-year (semi-annually). | | | | |

**Career Training at BII**
BII provides necessary training to staff to fit for tasks of acoustic components and systems.

**News in 2025**: New expansion of 200m² facility increases BII's capabilities of production and indoor calibration.

**END-USER STATEMENT - REQUEST AND REQUIREMENTS:**

Please note that this document must be completed by the final user of the goods, in English or French, and be completed on company letterhead. This document cannot be completed by the exporter, an intermediate consignee, a broker/freight forwarder or their agents.

**********

Date: Day-Month-Year

Canada Border Services Agency
Export Control Unit

END-USER STATEMENT (Sample)

We hereby declare that:

- Name of End-User (Individual/Company)

Are purchasing/acquiring:

- Complete list of the goods contained in the shipment.
- Location where the goods will be used.
- Identify any consignees (both intermediary and final), agents, or other entities involved in the export from Canada.
- State the purpose and end-use of the products, including a statement of whether the intended end-use of the items is civilian (commercial) or military.
- State whether or not the goods or technology are intended for re-sale, re-transfer or re-export to another party or parties and, if so, describe the circumstances; or state that the goods or technology will not be resold, re-transferred or re-exported.
- Declare whether or not the goods and technology will be used for any purpose associated with the development or production of chemical, biological or nuclear weapons, or their delivery systems (such as missiles).
- State that the goods or technology will not be transhipped to other destinations or otherwise diverted from what has been previously described/declared.

Signature/Authority:

- Name and title of the person signing the End-Use Statement.
- Complete address, telephone number and fax number.
- e-mail address and corporate website.

DÉCLARATION D'UTILISATEUR FINAL - DEMANDE ET CONDITIONS :

Veuillez noter que ce document doit être complété par l'utilisateur final des marchandises, en français ou en anglais, et doit être complété sur papier à en-tête de l'entreprise. Ce document ne peut être complété par l'exportateur, un destinataire intermédiaire, un coutier/transitaire ou leurs agents.

**********

Date : jour-mois-année

Agence des services frontaliers du Canada
Section des contrôles à l'exportation

DÉCLARATION D'UTILISATEUR FINAL (Échantillon)

Nous déclarons par la présente :

- Nom de l'utilisateur final (Individu/Entreprise)

Nous achetons/acquérons :

- Liste complète des marchandises contenues dans la cargaison.
- Endroit où les marchandises seront utilisées.
- Désigner les destinataires (intermédiaires et finaux), les agents ou toute autre entité intervenant au cours du processus d'exportation au départ du Canada.
- Décrire la fin et l'utilisation finale des produits et déclarer si l'utilisation finale prévue des articles est civile (commerciale) ou militaire.
- Indiquer si les marchandises ou la technologie sont destinées ou non à être revendues, retransférées ou réexportées à une ou plusieurs autres parties et, le cas échéant, décrire les circonstances de ces opérations; ou déclarer que les marchandises ou la technologie ne seront pas revendues, retransférées ou réexportées.
- Déclarer si les marchandises et les technologies seront utilisées ou non à des fins associées au développement ou à la production d'armes chimiques, biologiques ou nucléaires ou de leurs vecteurs (comme des missiles).
- Déclarer que les marchandises ou la technologie ne seront pas réexpédiées vers d'autres destinations ou autrement détournées de ce qui a été précédemment décrit.

Signature/autorisation :

- Nom et titre de la personne qui signe la déclaration d'utilisation finale.
- Adresse, numéro de téléphone et numéro de télécopieur.
- Adresse courriel et adresse du site Web de l'entreprise.

# MANUFACTURER'S AUTHORIZATION

**<End-User Address Here>**

**BENTHOWAVE INSTRUMENT INC. (BII)** is an official manufacturer of acoustic products (Underwater, Air, AE, NDT, and HIFU) at **< BII Official Address>**. (www.benthowave.com. Contact: BII Email.)

**<Buyer's company name and address here>** will directly purchase **<Product Part Number Here>** from BII.

BII (BENTHOWAVE INSTRUMENT INC.) will provide full warranty and technical support to the end user of BII products during the warranty period based on BII sales terms and conditions. After Warranty expired, BII will continue to provide technical support to end users of BII products. Information of **original buyer's name, BII's quote number (or invoice number), and BII product number** are necessary during technical support. Without this information, postponed and delayed support is expected, and BII might refuse to provide technical support.

This Authorization consist of ___one___ Pages, including all attachments.

<table>
<tr><td colspan="3">This Authorization is valid till <input a date here>. Validity of one year ONLY starting from the issue date of this authorization.</td></tr>
<tr><td>Authorization Signature:</td><td colspan="2">Company:<br>Benthowave Instrument Inc.</td></tr>
<tr><td>Name:</td><td colspan="2">Title:<br>Sales Manager</td></tr>
<tr><td>Date:</td><td>Telephone:<br>BII Phone Number</td><td>Email:<br>BII Email</td></tr>
</table>