# BII

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# Benthowave Instrument Inc.

Acoustic Solutions for SONAR, HIFU, NDT, AE, Physical Acoustics, Imaging, Material Study ...

## Acoustic Transducers and Measurement Systems

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.

**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**: 40 μA quiescent current with +5.2 to +15 VDC supply. +1.8 to +30 VDC supply with 1.3 mA quiescent current.

**Low Frequency Detection**: Down to 0.1 Hz infrasonic sounds can be detected.

**Ocean Depth**: up to 1000 m.

**Frequency Range**: 0.1 Hz to 10 MHz, usable up to 30 MHz at 3$^{rd}$ harmonics.

**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.

**Service Temperature**: -10 °C to +60 °C or 14 °F to 140 °F by default. Customized on request, available from -15 to 198 °C, or 5 to 390 °F.

**Calibration**: Reciprocal and comparison indoor calibration system in air and water measures TVR, FFVS, and Directivity Pattern from 20 Hz to 10 MHz.

### 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, 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:
**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 -30 dB and less.

**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.

**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 | » BII7030 | Automatic Sensitivity Control Hydrophone: 80 dB range |
| » BII7040 | Hemispherical Hydrophone | » BII7550 | Split Beam Transducer: Target Angle Estimation |
| » BII7060 | Vector Hydrophone: Measurement of Bearing | » BII7070 | Directional Hydrophone (Conical Beam) |
| » BII7080 | Programmable Sensitivity Hydrophone | » BII7090 | Vibration Insensitive Hydrophone |
| » BII7100 | High Temperature Hydrophone (Up to 198°C/390°F) | » 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 | » BII7680 | Wide Beam Directional Transducer: 120°x30° View |
| » BII7230 | AE Sensor: Detect Acoustic Emission | » BII7630 | Phased Array Transducer: Beamforming & Imaging |
| » **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 Transducer: Low Q, Single & Dual Beams |
| » BII7740 | Annular Array Transducer: Array Shading & Focusing | » BII7750 | Torsional Transducer and Shear Force Sensor |
| » BII7760 | Spherical Sector Directivity Transducer: up to 60° | » BII7770 | High Temperature Transducer (198°C/390°F) |
| » **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 |
| **Acoustic Instrumentation: Preamplifier, Power Amplifier, Impedance Matching, …** | | | |
| » BII1000 | Hydrophone & Ultrasonic Preamplifier | » BII6000 | Impedance Matching for Transducers |
| » BII2000 | AGC Amplifier (Automatic Gain Control) | » BII8010 | Ultrasound Pulser & Receiver |
| » BII2100 | Transmit & Receive System: Sonar & Ultrasound | » BII8030 | Acoustic Transmitter: Underwater & Power Ultrasonics |
| » BII4000 | Signal Generator for SONAR, NDT, NDT Ultrasound | » BII8080 | Underwater Acoustic Transmitter and Receiver |
| » BII5000 | Power Amplifier: Sonar, HIFU and Headphone | » Material Study | Dielectric, Ferroelectric & Piezoelectric Material Measurement |



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## Signal Processing

### Sonar Signal Envelope Detector (Obsolete)

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 hundreds kHz to several MHz. This imposes cost on electronic processing circuit such as A/D converter and data storage. A Envelope Detector removes high frequency carrier signal and extract 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          Echosounder, Navigation Sonar, Sea-floor Mapping Sonar
Fishery/Plankton Sonar, Sediment Penetration/Parametric Sonar          Target Strength Measurement, Abundance Estimate

### Envelope Detection
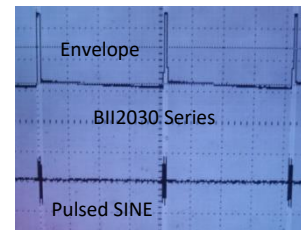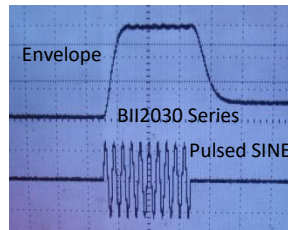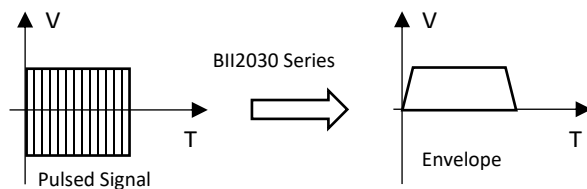


### Signal Demodulator (Obsolete)

The useful information of a known narrowband dignal is not contained in the carrier frequency, but in its modulation. BII2040 series 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, BII2040 series 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



**Received Signal:** $A(t)\cos[\omega c*t+\phi(t)]$
**Reference Signal:** $B\cos(\omega r*t)$ or $B\sin(\omega r*t)$

**BII2041** → **ADCs + DSP** →

**Vo** = $A(t)*B/20*\cos[(\omega c-\omega r)*t+\phi(t)]$, or $-A(t)*B/20*\sin[(\omega c-\omega r)*t+\phi(t)]$.
**Frequency Shift** = $\omega c-\omega r$.
**Envelope at ωc=ωr**: $A(t)*B/20*\cos\phi(t)$, or $-A(t)*B/20*\sin\phi(t)$.
**Envelope at ωc≠ωr**: $A(t)*B/20$ or $-A(t)*B/20$.



**Received Signal**: $A(t)\cos[\omega c*t+\phi(t)]$
**Reference Signal**: $\sin(\omega r*t)$

θ=-90° Phase Shifter → $\cos(\omega r*t)$

**BII2042**

**Output 1**: $-A(t)/20*\sin[(\omega c-\omega r)*t+\phi(t)]$
**Output 2**: $A(t)/20*\cos[(\omega c-\omega r)*t+\phi(t)]$

**ADCs + DSP** →

**Envelope**: $A(t)$.
**Frequency Shift**: $\omega c-\omega r$.
**Phase Shift**: $\phi(t)$.
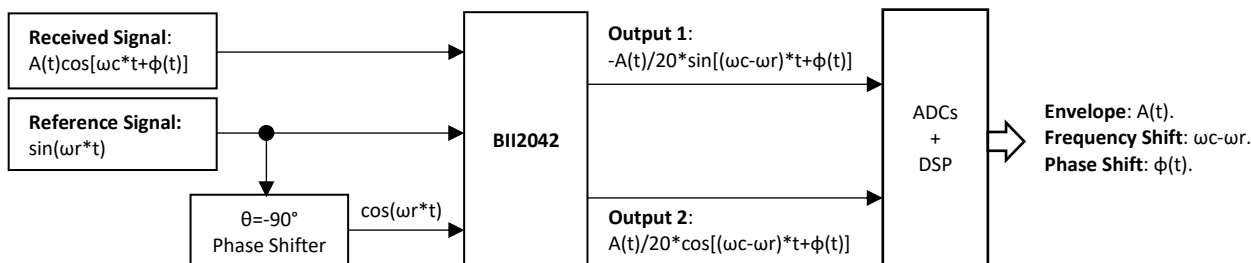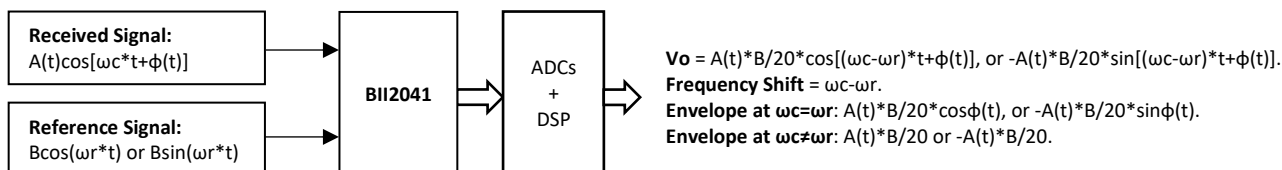
**t**: Time; **ωc**: Frequency of Received Signal; **ωr**: Frequency of Reference Signal; **A(t)**: Amplitude of Received Signal; **B**: Amplitude of Reference Signal; **φ(t)**: Phase Shift between Received Signal and Reference Signal.

### Target Angle Estimation (Obsolete)

BII2050 series 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 acosutic axis of the transducer.



Four-quadrant Split Aperture Transducer

**BII2051**

Output=tan(kθ)

**Spatial Angle Measurement**

Output=tan(kΨ)

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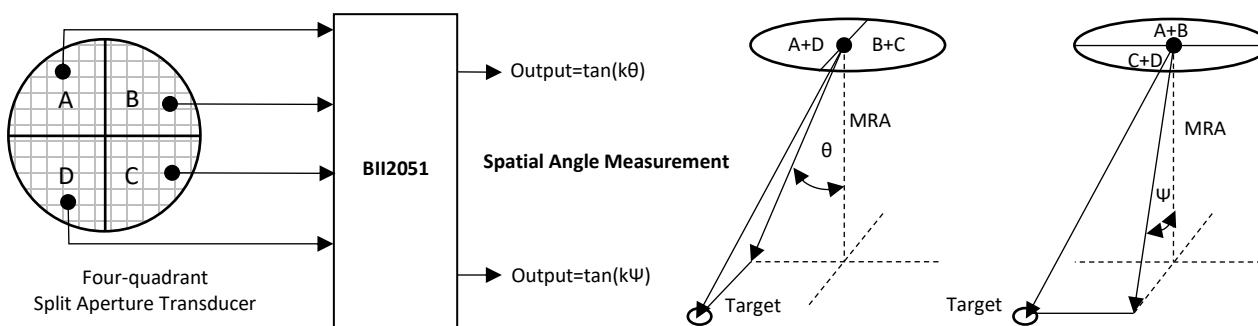
**K:** Angle Sensitivity = Phase Shift/Spatial Angle, transducer's parameter. **θ and Ψ**: Spatial Angles of a Sound Source Relative to MRA of the Transducer. **MRA**: Maximum Response Axis of Transducers, or **Acoustic Axis**.

**Typical Applications**

Target Tracking and Searching, Homing Torpedoes        Navigation, Positioning, Obstacle Avoidance Fishery Sonar        Seafloor Slope Mapping

**Array Beamformer (Obsolete)**

**Array Beamforming: Beam Steering and Array Shading/Weighting 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.

BII2070 series are 8-channel array beamformers for receiving and transmitting narrowband sounds:

- ✓ Wide View of Field ±90° (frequency dependant).
- ✓ Weighting Laws: Triangular, Dolph-Chebyshev, Cos, $Cos^2$, Hamming …
- ✓ N modules in parallel constitute 8*n channels.
- ✓ 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 (Obsolete)**

It is recommended that the signals are bandpass-filtered before they pass to BII2070 series.
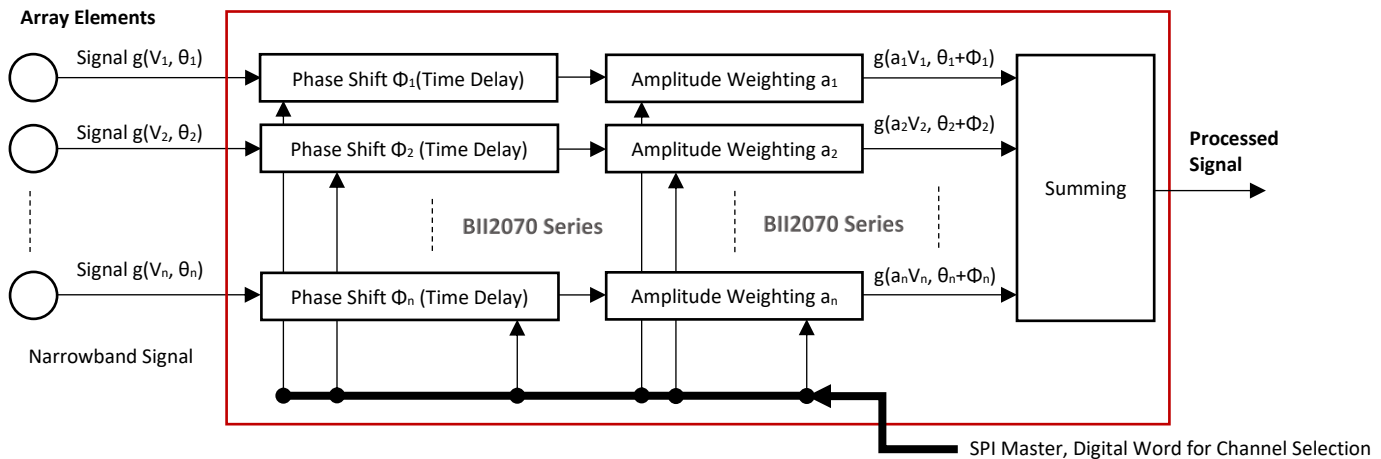


**Structure of Transmitting Array Beamforming**

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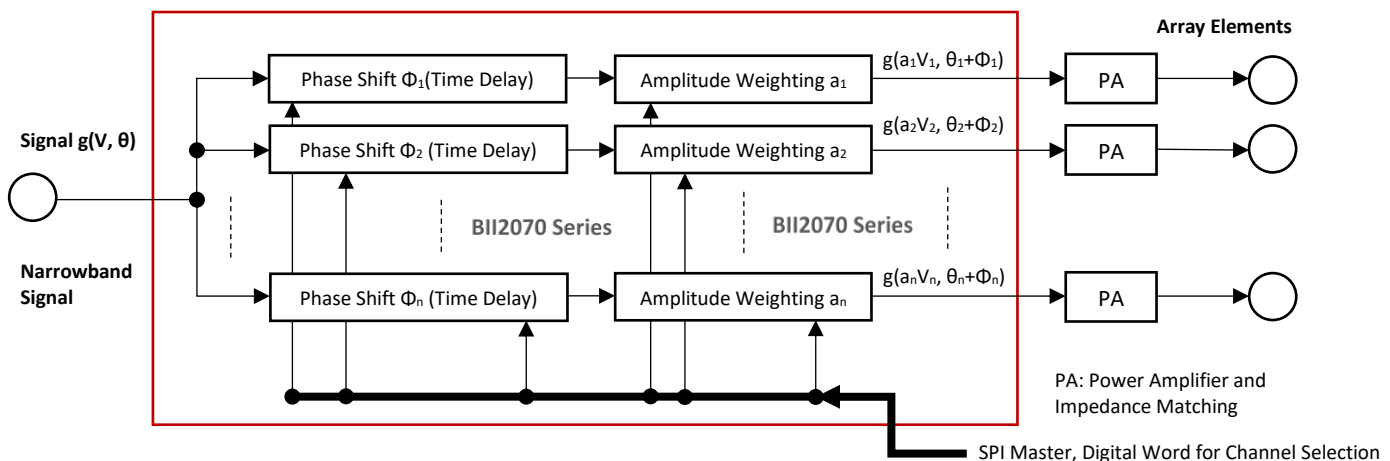
**Combination of BII Acoustic Transducers to a New Transducer (illustration ONLY)**

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

BII7631 Receive Linear Scan

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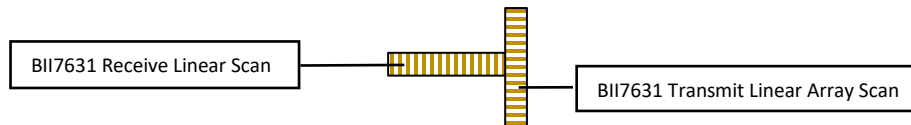
**2D Imaging Multibeam Transducer: one BII7631 Linear Phased Array (Rectangular Aperture) and one BII7682 Wide Beam Directional Transducer (Curvilinear or Cylindrical Sector Aperture).**

Front View: Acoustic Window

Right View

Top View

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

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

BII7682 Projector

BII7631 Linear Phased Array Hydrophone
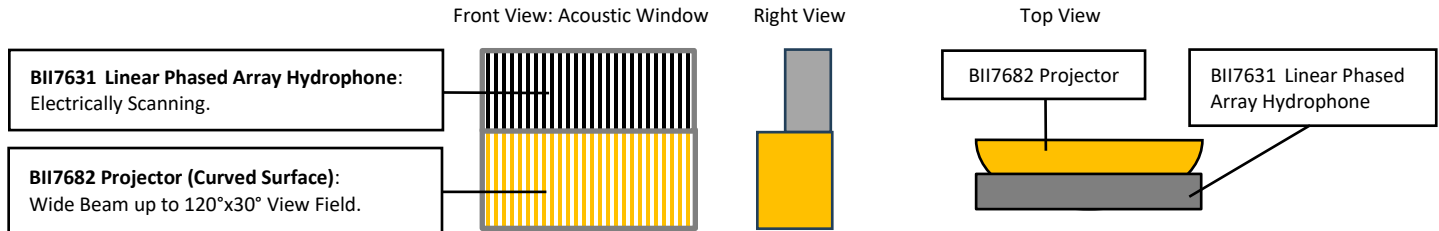
**Echo-ranging or Scanning Transducer: one BII7682 Wide Beam Directional Projector (Cylindrical Sector Aperture) and one bespoke BII7730 Hydrophone.**

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

Mechanically Scanning

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BII7682 Multi-element Projector:
1. Wide Horizontal Beam up to 120° View Field.
2. Narrow Vertical Beam 10° to 30° View Field.
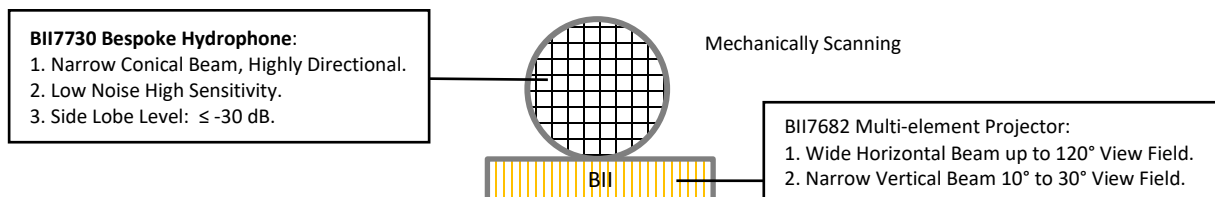
**Echo Ranging Transducer, typical directivity Pattern. Illustration ONLY at 60 kHz.**

Transmit Beam Pattern
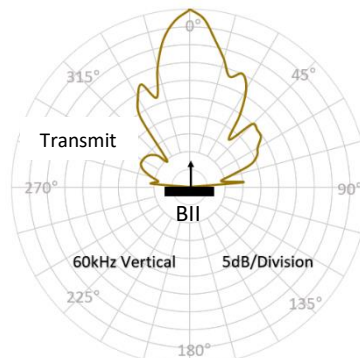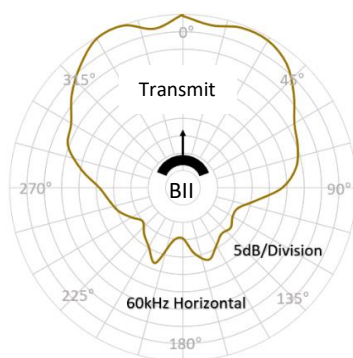
Receive Conical Beam Pattern

Transmit

BII

5dB/Division

60kHz Horizontal

Transmit

BII

60kHz Vertical    5dB/Division

Receive

BII

60kHz Vertical    5dB/Division
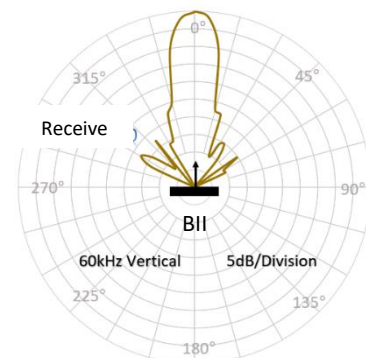
**Linear and Planar Array Beam Steering**

$0\Delta T$

$2\Delta T$

Wave Front

$4\Delta T$      $4\Delta T$

θ

$6\Delta T$

BII Array Elements and Transducers

$8\Delta T$
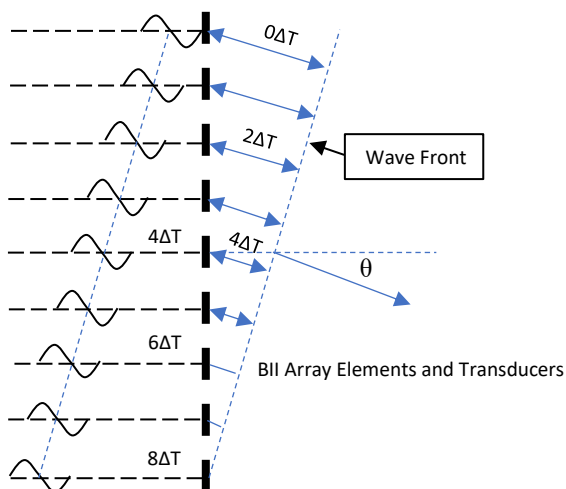
**Linear and Planar Array Beam Focusing**
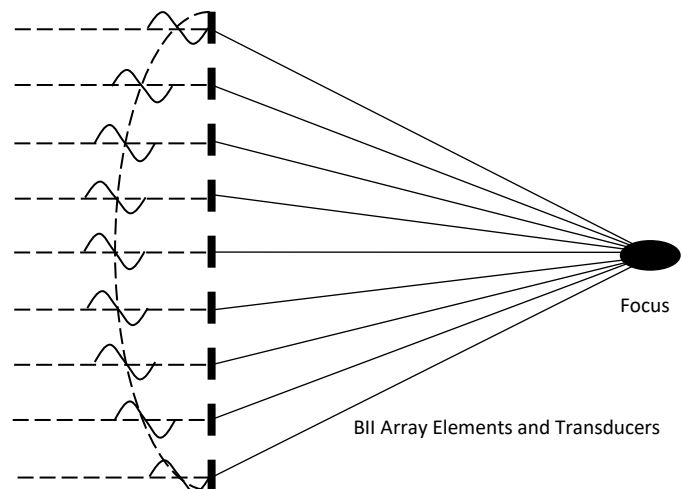
Focus

BII Array Elements and Transducers

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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.

### Pulsed/Burst SINE

| 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 $PW < t \le T$. |
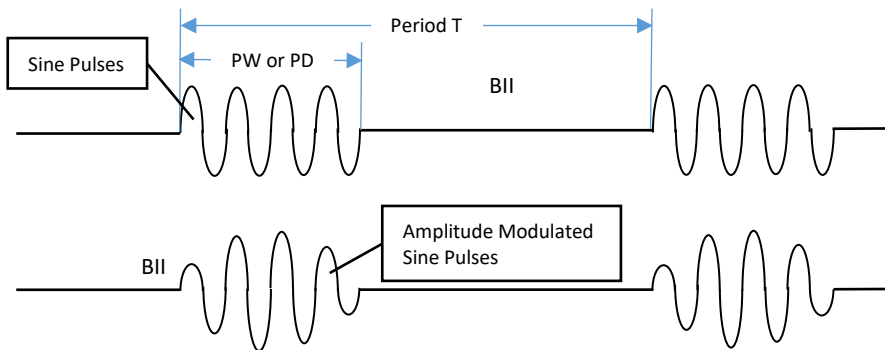


**PW**: Pulse Width or **PD**: Pulse Duration.
**PRR**: Pulse Repetition Rate. **Pulse Signal Period T** =1/ PRR.
**Duty Cycle D** = PW/T = PW * PRR.
**Bandwidth $\Delta f_{-3dB}$ of SINE Pulses** ≈ 0.89/T = 0.89 * PRR.
The amplitude A(t) of the signal can be modulated with different laws such as Gaussian-shape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

### Pulsed/Burst FM (Frequency Modulation) or Chirp

| 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. $s(t) = 0$, 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. $s(t) = 0$, if $PW < t \le T$. |
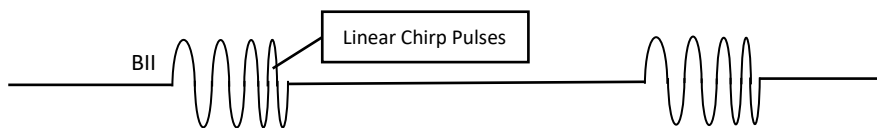


Comparing with SINE Pulses:
Chirp-Pulse SONAR System has higher SNR gain, better time resolution, heavier signal processing, and is much more complex.
-3dB width of Main lobe: $\delta t = 0.886/B$, B: signal Bandwidth.

### Pulsed/Burst BASK (Binary Amplitude Shift Keying) / Pulsed/Burst BFSK (Binary Frequency Shift Keying)

| Pulsed/Burst BASK (Binary Amplitude Shift Keying) | Pulsed/Burst BFSK (Binary Frequency Shift Keying) |
|---|---|
| Pulsed 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 $PW < t \le T$. | Pulsed 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 $PW < t \le T$. |

BASK Pulses, Digital: 1     0     1



Underwater Communication

BFSK Pulses, Digital: 1     0     1



Underwater Communication

### Pulsed/Burst PM (Phase Modulation)

| Pulsed/Burst BPSK (Binary Phase Shift Keying) | Pulsed/Burst QPSK (Quardrature Phase Shift Keying) |
|---|---|
| Pulsed BPSK $s(t) = A\sin(2\pi f_0 t + \Phi(t))$, if $0 \le t \le PW$. $s(t) = 0$, if $PW < t \le T$. $\Phi(t) = 0$ 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 $0 \le t \le PW$. $s(t) = 0$, if $PW < t \le T$. $\Phi(t) = 0, \pi/2, \pi$, or $3\pi/2$. |

BPSK Pulses, Digital: 1     0     1
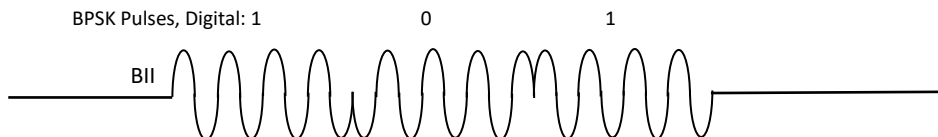


Underwater Communication
Accurate Time Measurement
High Time Resolution and Processing Gain

### Pulsed/Burst Pulse, Square, and Voltage Spike Signals.



Pulse Signal

Square Signal

Negative Spike

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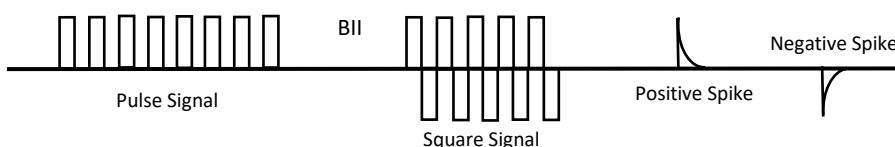
**Square Signal** can deliver 1.414 times electrical energy to transducer comparing with SINE Pulses.
**Pulse and Square Signal system** has much higher electrical efficiency than SINE pulsing system.
**Voltage Spike** has highest resolution in time domain for ultrasonic measurement.

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

Linear & Nonlinear Acoustics: HIFU, NDT, AE; Marine Animals; Fishery; Navigation; Communication; Oceanography; Seafloor-mapping; Sub-bottom Profiling.

## Transmitting Sounds

Signal Generation:
BII4000 Series
Computerized DAQ (D/A Converter) Device
Portable Digital Recorder: Playback, etc...

Signal Processing
Beamforming
BII2000 Series

Power Amplifier
BII5000 Series

Impedance
Matching
BII6000

BII-5023

BII-7650

HIFU Transducers
Power Transducers

Sound Energy Focus:
Ultrasonic Processing
Nonlinear Acoustics

BII7650

Transducers & Array

BII-7520

BII-7525

Signal Sources:
Playback of Recorded Sounds
Sonar Signals (sine pulses, chirp, ...)
Communication Signals (FSK, PSK, ...)
Spikes and Pulses for NDT, Ultrasound
etc....

Battery Pack DC Supply

**BII8030 Series
Acoustic Transmitter**

Mating Connectors

50Ω Transducers (Projectors)

Underwater Sounds

BII

**Digital Logic**

Optional: Shutdown

**Analog Input**

Optional: Feedback of Driving Voltage

BII

BII

BII

Acoustic
Focus

BII8030 series portable acoustic transmitters are bandpass system and designed for SONAR, artificial acoustic target, communication, bioacoustics, Power Ultrasonics (such as HIFU), and NDT (Non-destructive Test) Ultrasound. The BII8030s integrate power amplifiers and impedance matching networks into portable water-proof cases to drive 50Ω transducers in wideband frequency range. Besides, they can also drive ferroelectric and piezoelectric material samples for material study and characterization.

## Receiving Sounds

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

Preamplifier BII1000 Series
Signal Processing BII2000 Series
Array Beamforming/Focusing

Hydrophones, Transducers & Array

BII-7011FG
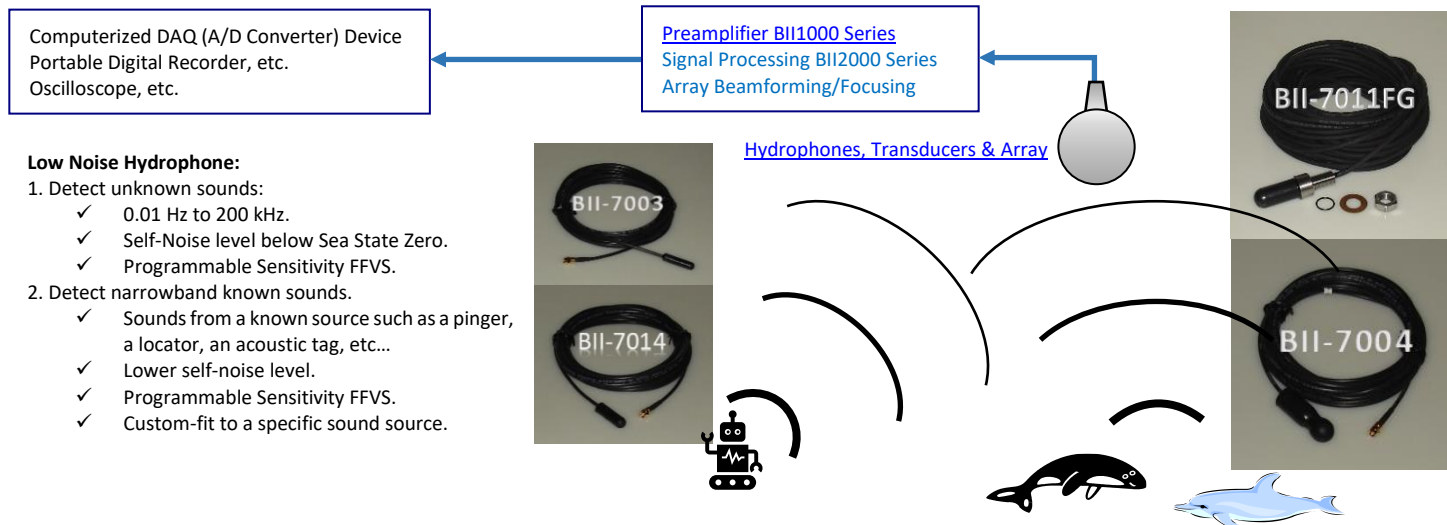
**Low Noise Hydrophone:**
1. Detect unknown sounds:
   ✓ 0.01 Hz to 200 kHz.
   ✓ Self-Noise level below Sea State Zero.
   ✓ Programmable Sensitivity FFVS.
2. Detect narrowband known sounds.
   ✓ Sounds from a known source such as a pinger, a locator, an acoustic tag, etc...
   ✓ Lower self-noise level.
   ✓ Programmable Sensitivity FFVS.
   ✓ Custom-fit to a specific sound source.

BII-7003

BII-7014

BII-7004

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## Transmitting and Receiving Sounds (Pulsing Acoustics): Echosounding, NDT, Communication…



BII7640 Series Acoustic Transceiver: a transmitter and a receiver in one device.

Acoustic Transducers & Array



50Ω Transmit and Receive Transducer
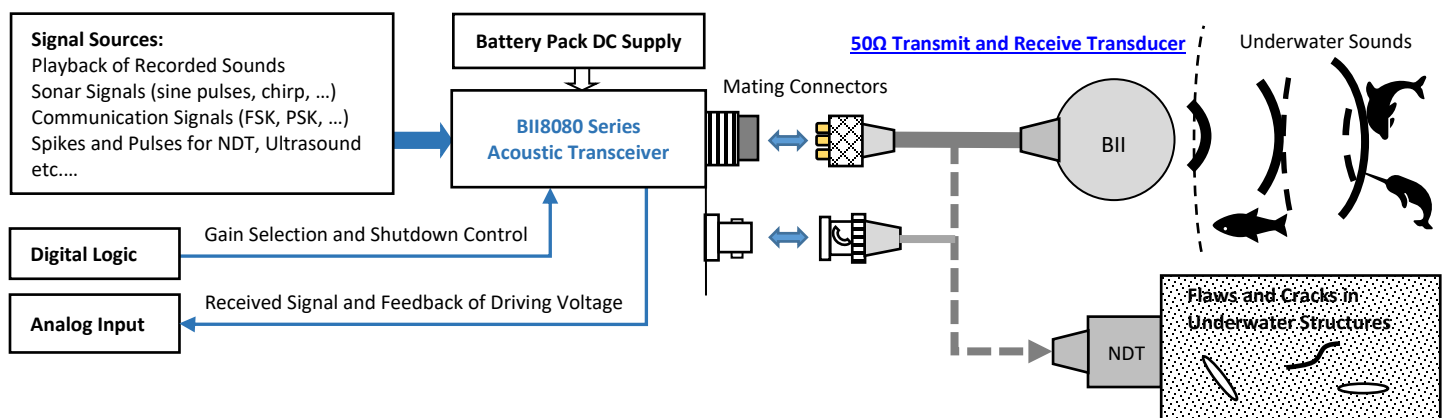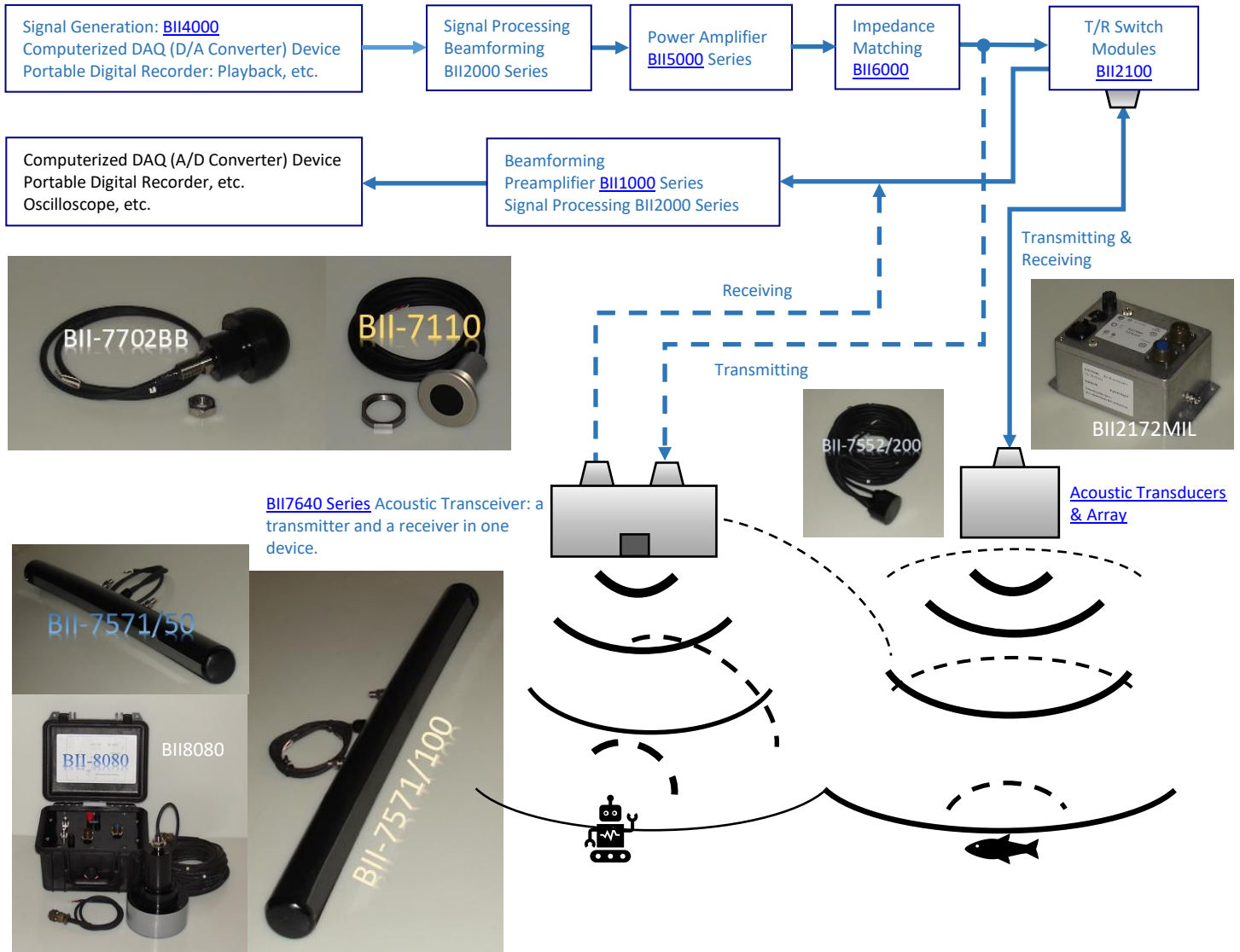
A BII8080 series portable transmit and receive systems are bandpass system and designed optimally for underwater acoustic and NDT ultrasound applications. It integrates a power amplifier, an impedance matching network, a T/R Switch, a digitally programmable gain preamp, and a bandpass filter into a portable water-proof case or a metal enclosure to drive 50 Ω transducers in wideband frequency range around fs (transducer's resonance frequency). With a laptop computer (DSP board or microcontroller) and a DAQ (Data Acquisition Module), BII8080 series functions as a portable underwater acoustic system and/or NDT pulsing system.

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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.
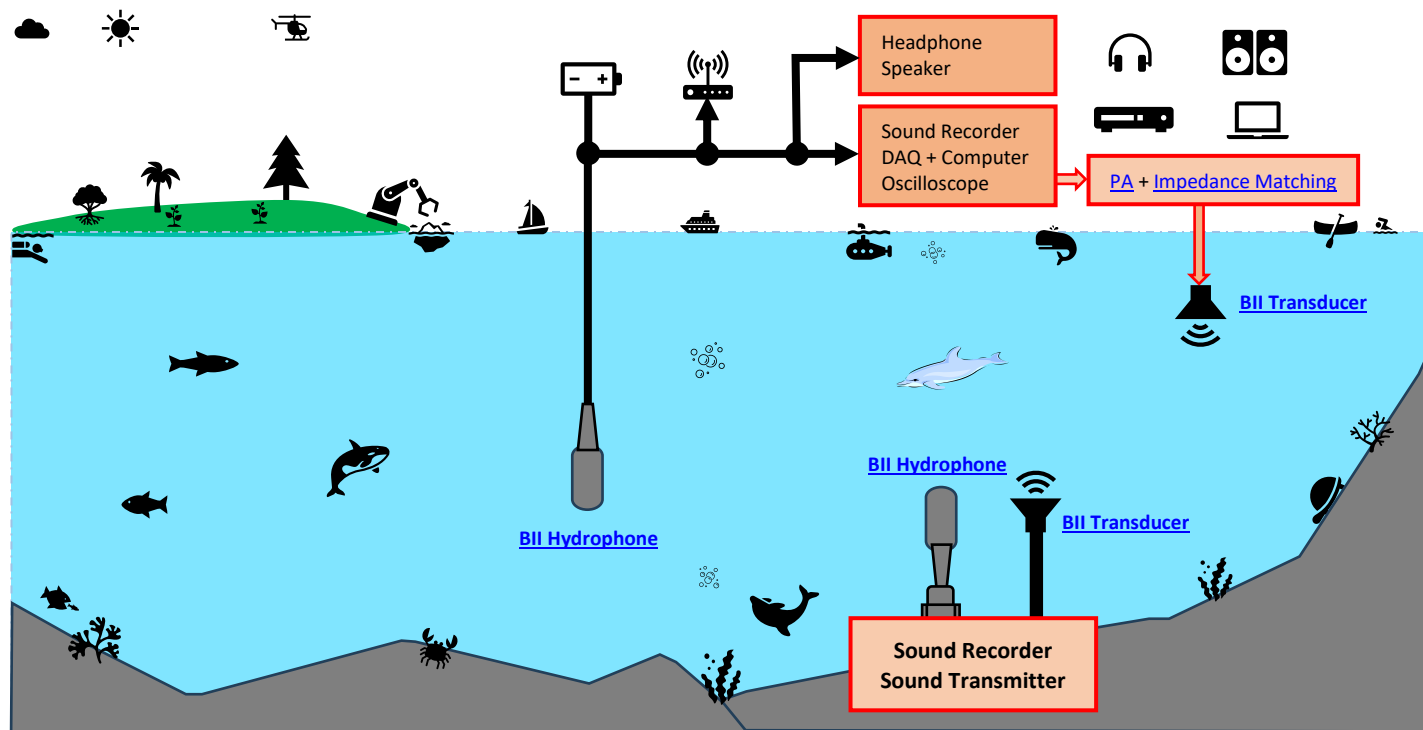


**Typical Applications**

| |
|---|
| 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... |

### Questions

**How do I set up my professional sound recorders to work with BII Hydrophones?**
1. BII hydrophones have their own DC power supply to support **Line Input** of recorders, and **Do NOT** use phantom power 48V which may destroy the hydrophones.
2. **Maximum Input Level (Line Input)** of recorders should be large enough to avoid saturation or clipping during recording.
   **Equivalent Input Noise** of recorders should be low enough for the recorders to be sensitive to weak signal of the interest.
3. **Sampling Rate** of the recorder should be fast enough to avoid missing high frequency sound of the interest. Generally, the **Sampling Rate** should be at least two times greater than the maximum frequency of sound.
4. Calculate the **memory size of data storage** according to sampling rate, resolution, sampling channels, and recording time, and use suitable recording media.
5. Calculate **battery service life** according to battery power and consuming current.
6. When the cable is greater than 5m, **balanced signal or differential signal** is recommended to be in use over the cable.

**How do I playback the recorded sounds in water?**
System Setup: Recorder (Recorded Sounds) with **Line or Phone Output** -> Audio Power Amplifiers -> Impedance Matching Device -> Transducers (Projectors).

**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 Scanning

**Typical Applications**

Scanning Sonar, Obstacle Avoidance, Object/Target Detection and Tracking     Fishery Sonar, Communication     Underwater Robotic and Vehicle (ROV, AUV, UUV)

**BII7646 Series** Underwater Scanning Transducer

The Underwater Scanning Transducer integrates a wide beam projector and a narrow beam low noise directional hydrophone for scanning SONAR. Typical applications are acoustic positioning, tracking, echo locating, and navigation in horizontal or vertical plane in the ocean, rivers, and lakes.

**Tracking, Locating and Navigation:**
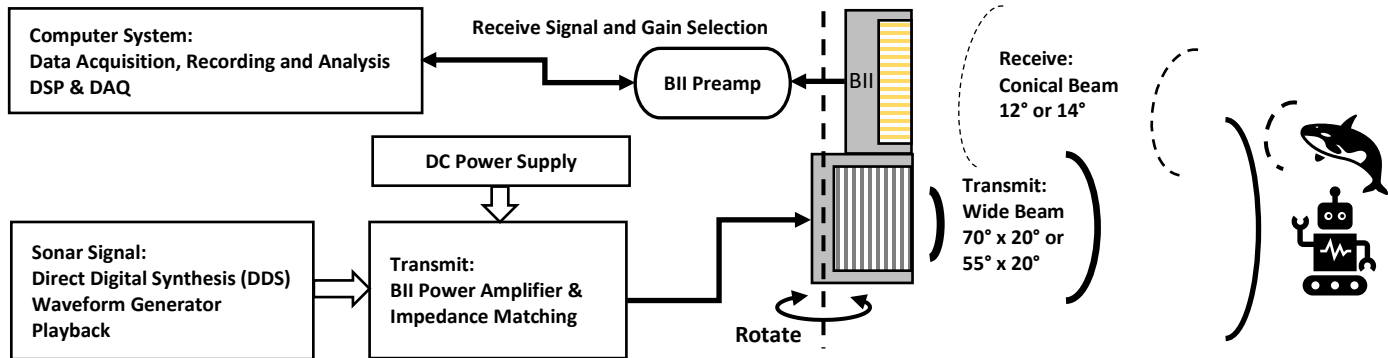


**BII7716 Series** Underwater Scanning Transducer for 360° View Field in Horizontal Plane

The Underwater Scanning Transducer is multi-channel cylindrical array projector, and a directional beam is 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 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:**
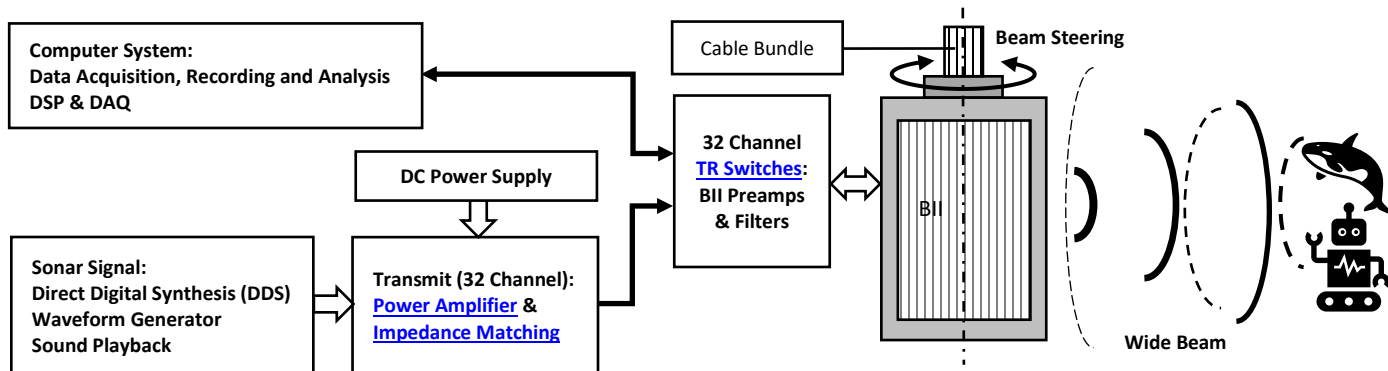


**BII7660 Series** Multibeam Transducer

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. The transmitting array and receiving array in BII7660 series operate independently. The curved transmitting array emits a broad fan-shape beam to insonify the large sector of interest (the field of view), The linear receiving array has fan-shape beams perpendicular to the transmit beam and can be steered electrically to scan the area of interest. Both transmit and receive array are broadband to support broadband Sonar signals (such as FM/Chirp, Ricker etc.). Acoustic sweeping (2D scanning) of the horizon or vertical can be achieved with digital beamforming technology.



**BII MultiBeam Transducer = Curved Array + Linear Array**
The echo intensity from the blue intersection area of the transmit beam (yellow colour) and the 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.

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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.

| Tuned Receiver or Array, Impedance $R_o$ at fs. | → | BII Preamp, Filter, or DAQ. Input Impedance $R_i$ | → | Signal Processor, Data Storage. Digital Recorder, Display. |
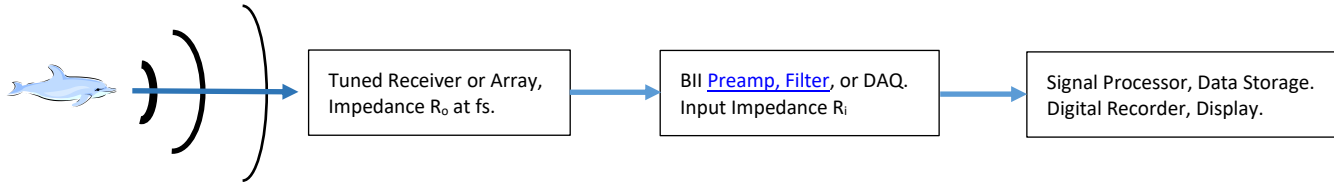
**Three Major Operations of tuned receivers: Impedance matching $R_o = R_i$, Open Circuit $R_i >> R_o$, and $R_o < R_i << \infty$.**

**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:**
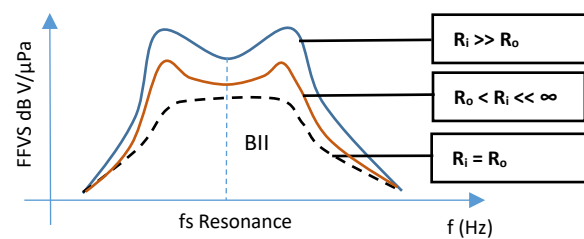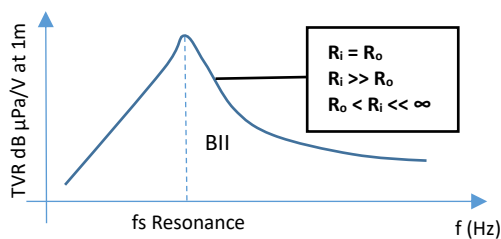


**Tuned Receiver Structure**:
1. Tuning Unit integrated inside receiver housing          2. Receiver + Standalone Tuning Unit

| Receiver + Tuning Unit |

| Receiver | → | Standalone Tuning Unit | → | Preamp, Filter, or DAQ. |

**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.

## 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:**
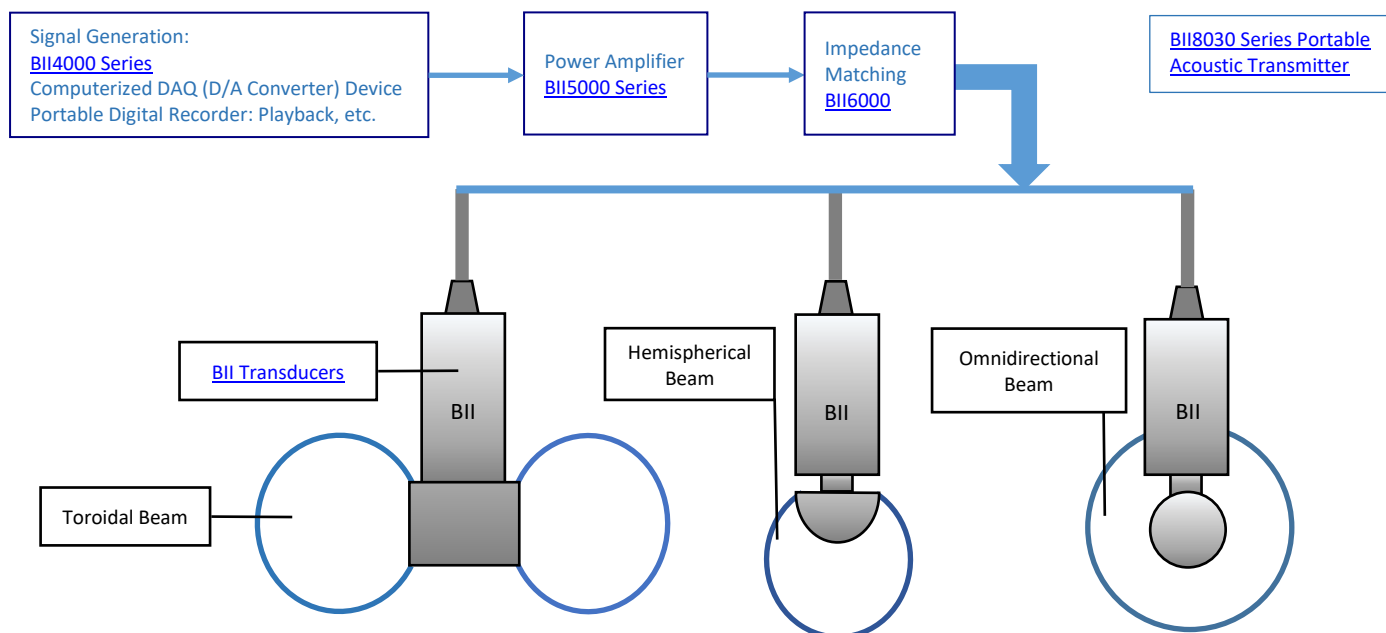


### Repeater and Transponder Setup:

Repeaters and Transponders includes a low noise hydrophone with suitable directivity pattern 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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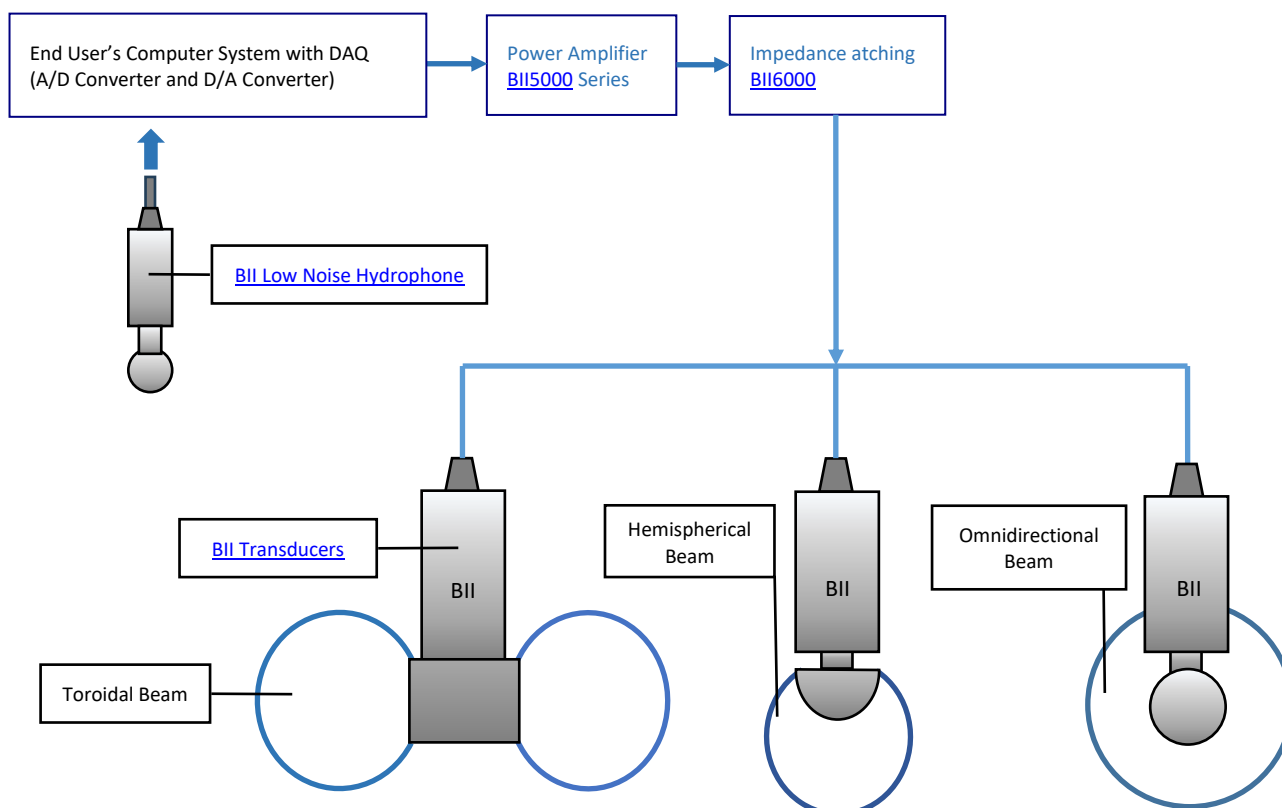
## Acoustical Measurements: Pulsing and Receiving for Physical Acoustics, NDT, and AE

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 = $D^2$/(4λ). |
| Rayleigh Distance = $\pi D^2$/(4λ). | Fraunhofer Zone Distance = 2.3$D^2$/(4λ). | Angle of Divergence = $\sin^{-1}$(1.22λ/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:** First Critical Angle: 15°, compressive wave to shear wave mode conversion. Second Critical Angle: 27°, shear wave to surface wave mode conversion. | **Contact Testing from Plexiglas to Steel:** First Critical Angle: 28°, compressive wave to shear wave mode conversion. Second Critical Angle: 58°, shear wave to surface wave mode conversion. | |

**Block Diagram of System Setup**:

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Trigger

BII4000 Series & BII8010 Series Spike or Tone Burst Generator

DC Power Supply

Oscilloscope Computer + Digitizer

BII2100 Series TR Switch Module

NDT & AE Transducer

Couplant

BII

Exciting Signal and Echoes or Stress Waves

L, S, and Surface wave mode conversion with oblique incidence.

BII NDT

BII-7696    BII-7690

## AE Detection System

**BII7230 Series: AE Sensor for Acoustic Emission Testing.** BII's AE (acoustic emission) sensors with aperture Φ2 to Φ12.7mm detects 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 198°C (388°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**

BII AE Sensor Array

BII

Cracking

Short Cable

Preamps & Filters

Long Cable

Long Cable

| Preamp + Bandpass Filter Standalone or Built inside AE Sensor | Main Amplifier + Bandpass Filter, Standalone. | Third Party's DAQ System: Record, Analysis, Display, etc. |
|---|---|---|

BII-7233

BII7233SE

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## Acoustical Imaging: Microscopy, Holography, and Tomography
**Acoustic Reflection Microscope**



**Acoustic Holography**



Reference Signal $A_r\cos\omega t$

Exciting Signal $A_0\cos\omega t$
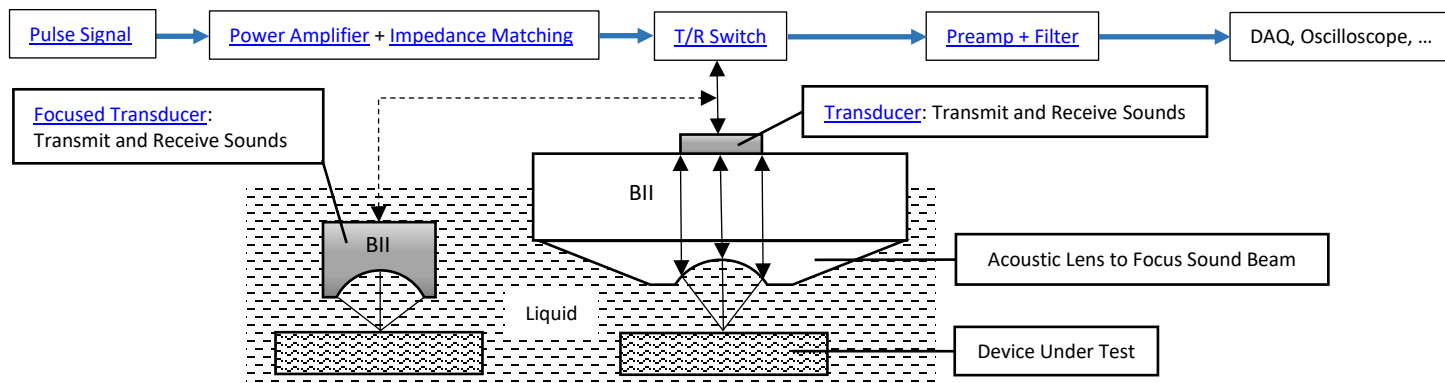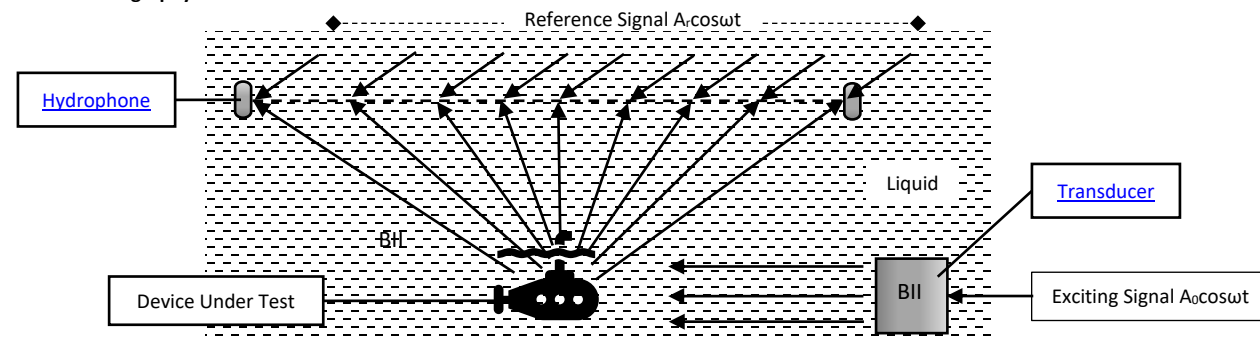
**Acoustic Transmission Tomography**

Source-Receiver Single Pair:
Translational and Rotary Motion around DUT

**Source-Receiver Array Pair: Rotates around DUT**
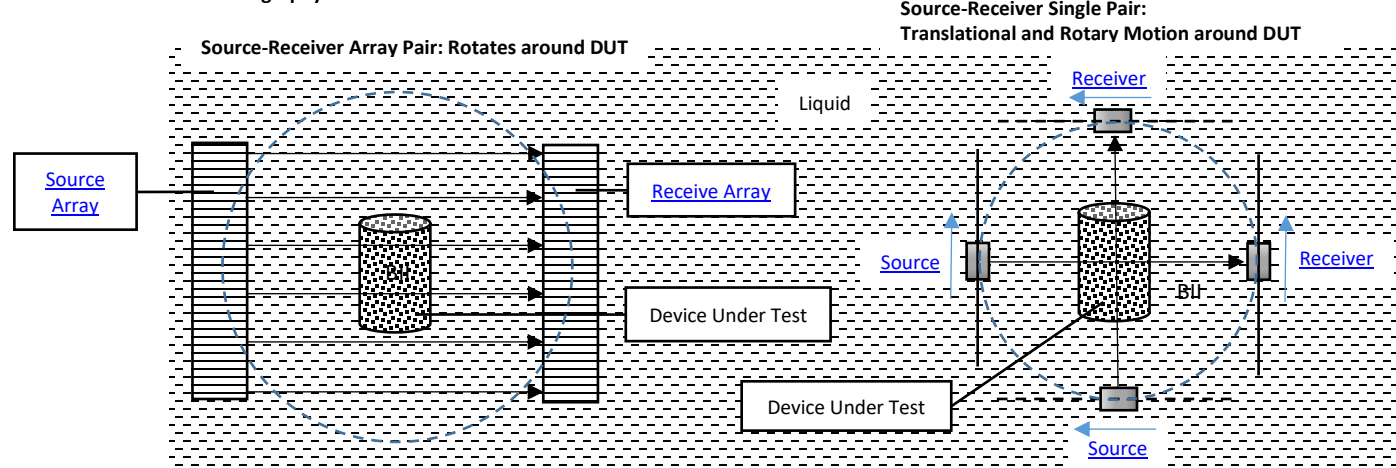


**Underwater Acoustic Tomography: Capturing Acoustic Variability of an Area.**



Underwater Transceiver

Weather

Submersibles

Animals

Fish Shoals

Underwater Transceiver

BII-7642IM

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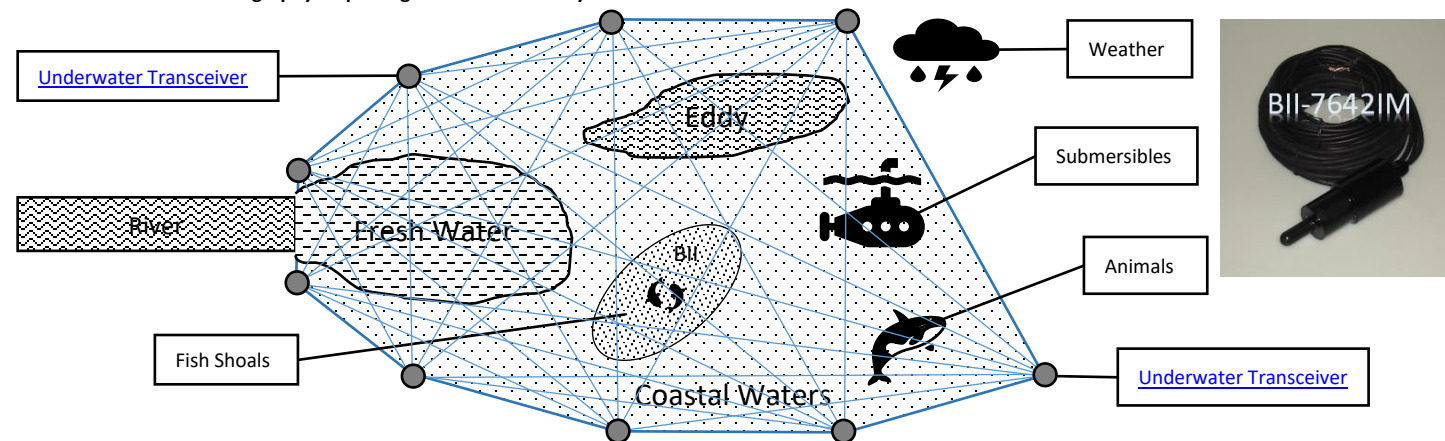
## Ultrasonic Air Transducer: Planar and Electronic Focusing, 30 to 300 kHz, -40°C to 140°C (-40°F to 284°F) is available.

BII's air transducers featuring low to medium Qm 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 | Counting, Monitoring, Remote Control, Alarming, Motion Detection |
| Level Measurement, Speed Measurement, Leak Detection | Automatic Sizing, Sorting & Positioning of Parts, Ultrasonic Testing and Analysis |
| Edge Detection, Web Guiding System, Air-Coupled NDT | Surface/Profile Characterization and Quick Scanning for Quality Control |

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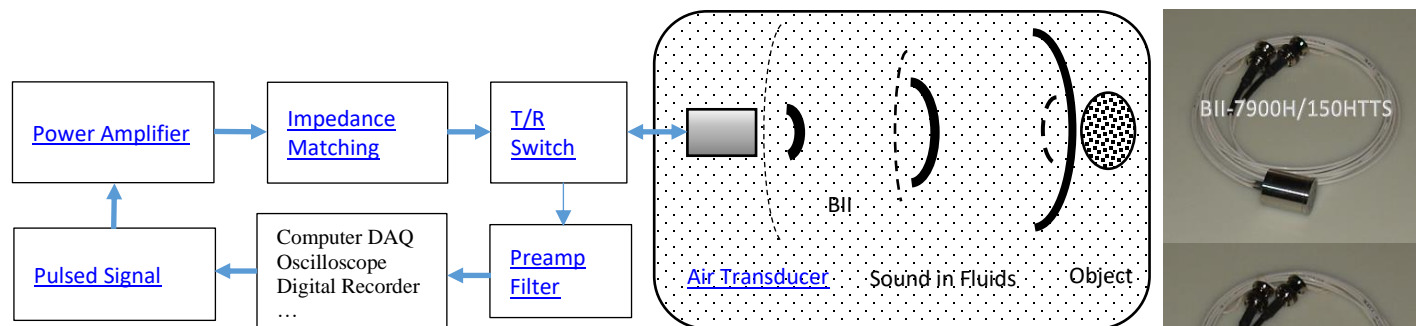


## Pulse-Reflection System in Air and Airlike Fluids
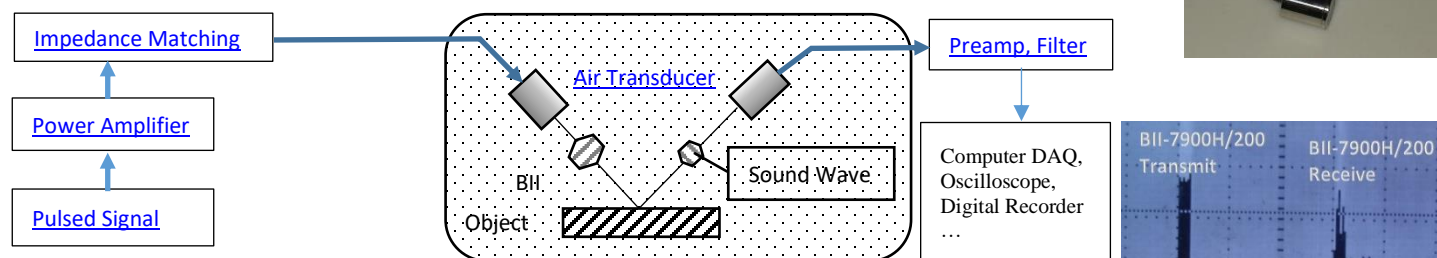


## Pulse Transmission System: Information Transmission through Air, Airlike Fluids and Material.
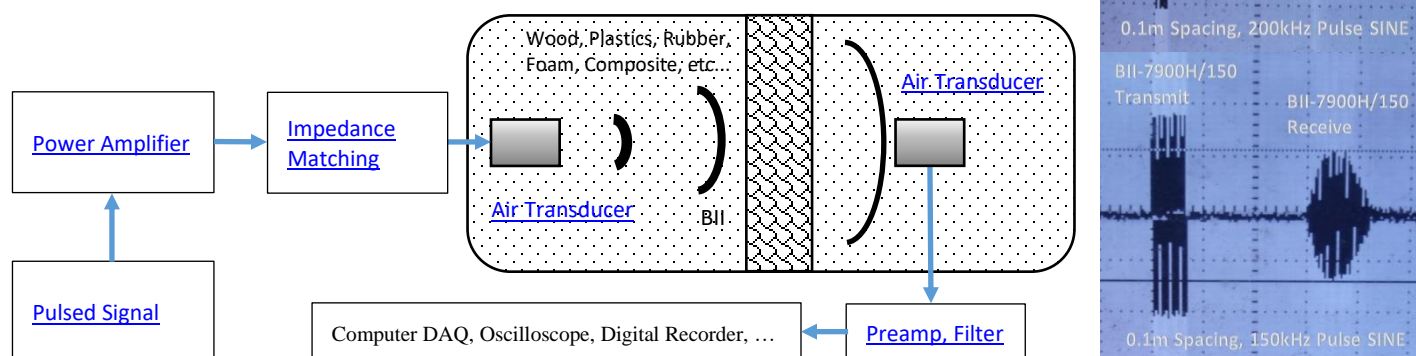


## Air Array Transducer: Electronic Beam Focusing
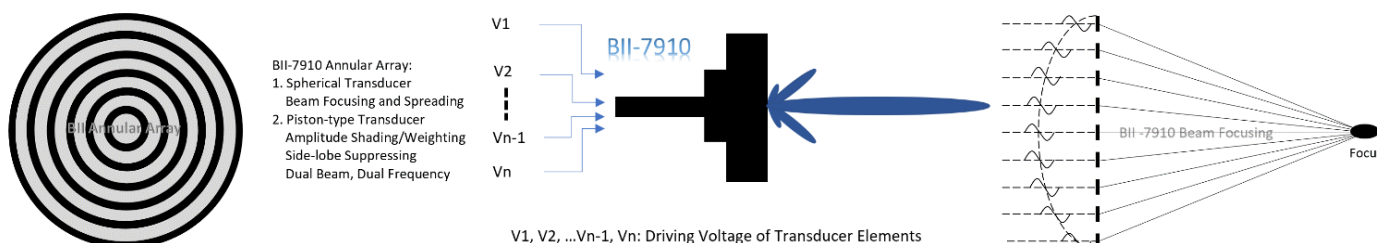


BII-7910 Annular Array:
1. Spherical Transducer
   Beam Focusing and Spreading
2. Piston-type Transducer
   Amplitude Shading/Weighting
   Side-lobe Suppressing
   Dual Beam, Dual Frequency

V1, V2, …Vn-1, Vn: Driving Voltage of Transducer Elements

[Go back to Catalogue](#)

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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.**

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## 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, NDT Ultrasound… |
| 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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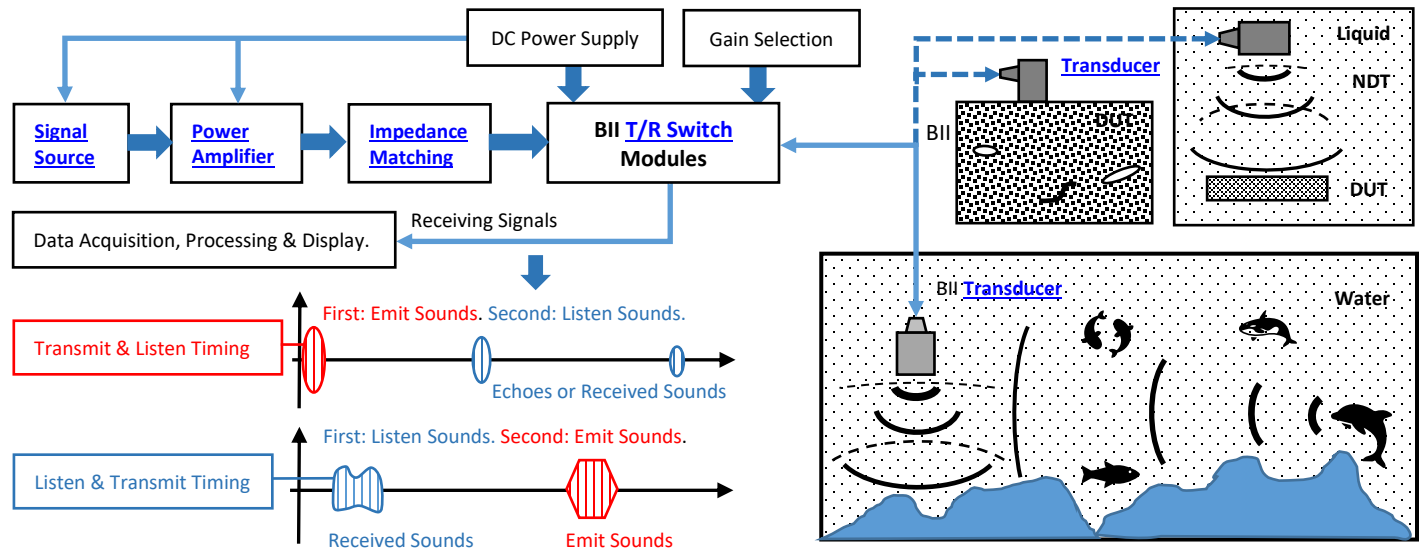
**Piezoelectric Materials and Shapes**

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 Qm (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: (PZT, PT or Lead Metaniobate + Passive Material Matrix.) | Highly anisotropic. High $k_{33}$, $g_{33}$ and $g_h$; low Qm, broadband, high power. -40 to 140 °C (-40 to 284 °F). |
| Hard PZT, Modified $Pb(Ti,Zr)O_3$: | High k, high d, low loss, high power transducers. -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. -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. Great resistance to depoling by electric field. -40 to 300 °C (-40 to 572 °F). |
| Lead Metaniobate PN, Modified $PbNb_2O_6$: | Low Qm, high frequency broadband and pulsing transducers. -100 to 400 °C (-148 to 752 °F). |
| Barium Titanate BT, Modified $BaTiO_3$: | High power SONAR (duty cycle ≤ 1%). Medium $d_{33}$ and $g_{33}$, low $g_{31}$, high N. Great resistance to depoling by compressive stress. -20 to 80 °C (-4 to 176 °F). Lead free. |
| Bismuth Layer Structure BiT, Modified $Bi_4Ti_3O_{12}$: | High frequency transducers. Anisotropic, $k_t/k_p \geq 4$. Low $k_t$ and $k_{33}$, low d constant, medium g constant. -100 to 500 °C (-148 to 932 °F). 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) |



| 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 Vrms. Insulation voltage between windings and core surfaces ≥ 2000 Vrms.
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.
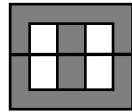
| **Toroid** | **EE** | **Cylinder** | **Plane (PCB Based)** |



### 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:




Embedded BII6000
BII6012MIL
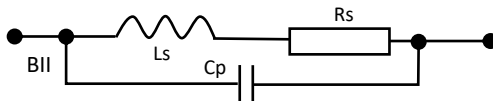
### Typical B-H Curve (Hysteresis)

$Eddy\ Current\ Loss$: $W_{ec} \propto B^2 f^2 A_e^2$
$Hysteresis\ Loss\ W_H \propto B_{max}^n f,\ n = 1.6 \sim 2.0$.
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, mximum $\mu_{max}$ = 7500, $B_s$ = 1.4 T at H = 800 A/m.

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

$Energy\ stored\ in\ magnetic\ field\ w_m = \dfrac{B^2 V_c}{2\mu_r\mu_0} = \dfrac{1}{2}Li^2$

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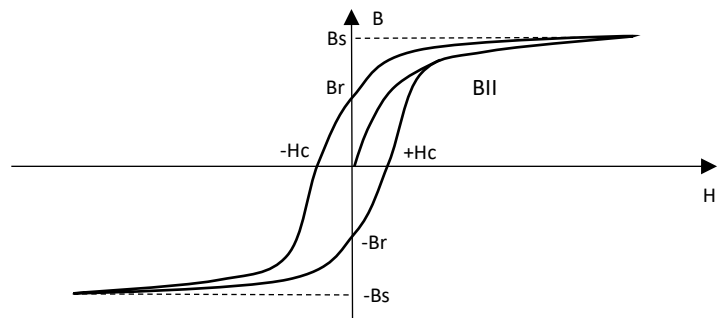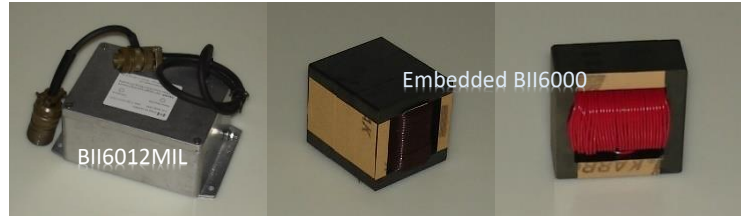


**Magnetic Properties of Typical Ferromagnetic Materials Used at BII, at 25°C unless Specified Otherwise.**

| 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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## Performance and Designs

**Low-Power Acoustical Measurements**

Generally, field-deployed, hand-held, and portable acoustical measuring instruments (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 voltage 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.

| | | BII Hydrophone & Acoustic Sensors no signal conditioning components | | DAQ + Computerized Data Analysis and Storage) |
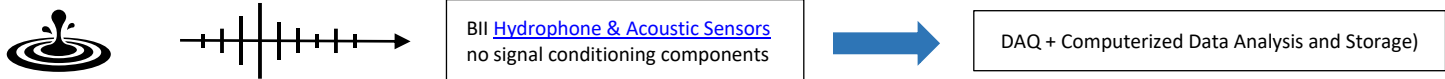
**2. Hydrophones or acoustic sensors with signal conditioning components detect weak sounds.**

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

AE from Material Failure

| | | BII Hydrophone & Acoustic Sensors with Low-Power Preamp & Filter | | DAQ + Computerized Data Analysis and Storage) |
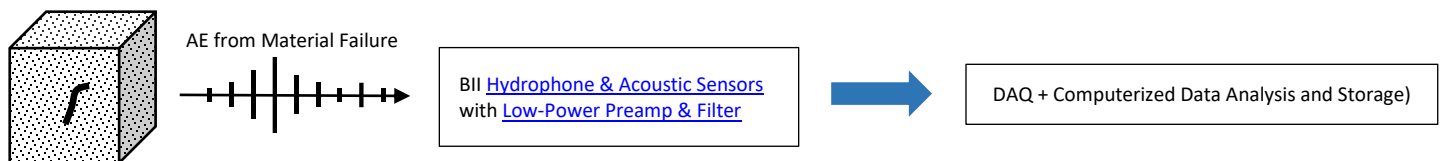
**3. Low-Power Preamp and Filters.**

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. | Single-ended and Differential Output. |
| Wide Supply Voltage: +2.7 to +30 VDC. | Driving Long Cable: 200 m. |
| Low Voltage and Current Noise: 7nV/√Hz, 1.0fA/√Hz, at 1 kHz. | 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.

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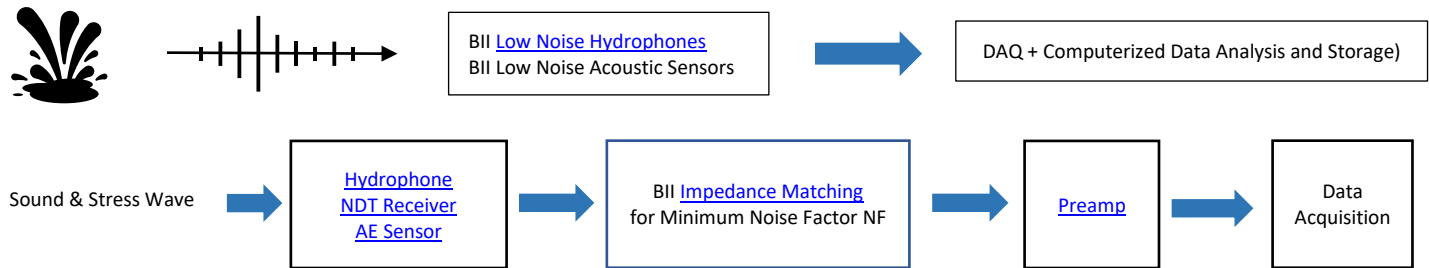
BII7120 Series Omnidirectional Low Noise Hydrophone and BII7079 Directional Low Noise Hydrophone (Acoustic Sensor): Noise Level below Sea State Zero.

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, $V_n^2 = e_n^2 + [ i_n *$ 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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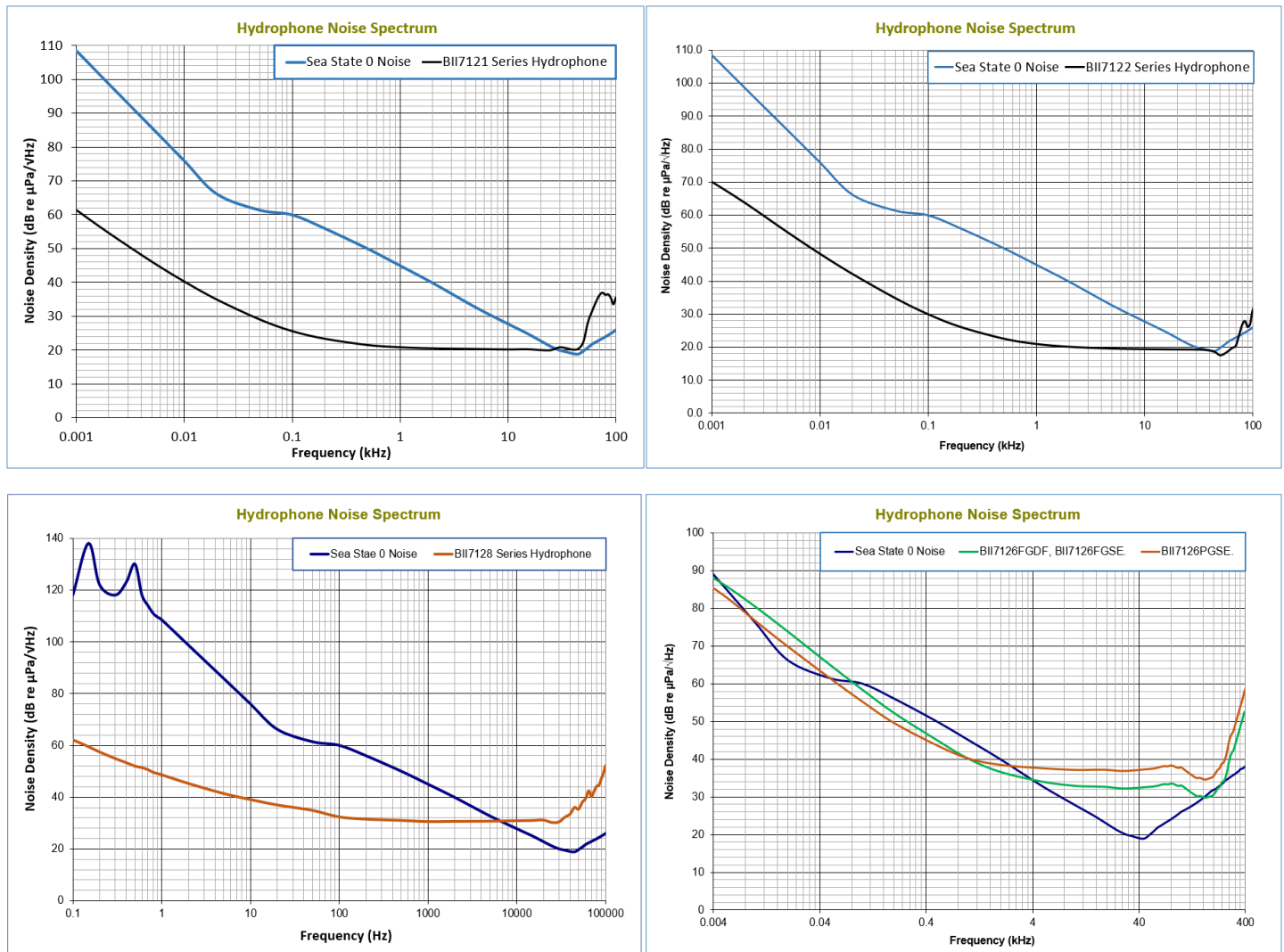
**High-Efficiency Sound Generation**

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** produce 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... Most of these equipment operate in laboratories and factories.

Sounds in water/liquids, air/airlike gases, and solids.

| Signal Generator Sound Playback BII4000 Series | → | Power Amplifiers RF PA Audio PA BII5000 Series | → | Impedance Matching BII6000 | → | |

Transducers & Array, HIFU Transducers, Power Transducers
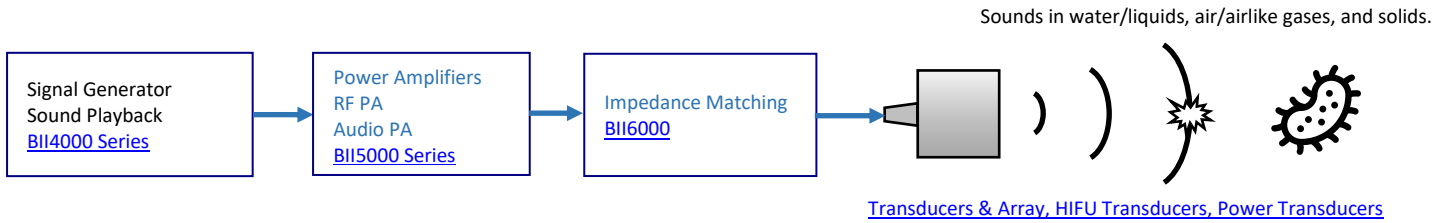
**Overall Conversion Efficiency from Electric Power to Sound Power**

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 $\eta$ = 0.6 to 0.7.

Efficiency of Class D Switching Mode PA $\eta$ = 0.91 to 0.985.

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

**Transducer Efficiency $\eta$** = 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.

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**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**



**Bespoke Directional Response Patterns are available.**
Directivity Pattern: Omnidirectional, Toroidal, Hemispherical, Conical, Cylindrical Sector (Fan-shaped), Spherical Sector, Focusing.

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

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 amplitude shading 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 also 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 1kHz signals underwater with line array, seven BII7010 or BII7140 series hydrophones are used in 0.75m spacing to achieve beam width of 15°. Preamplifiers can also be integrated to drive long cable and weight the signal level of each channel for side lobe suppression.

## Array Patterns:



## Directivity of Array:
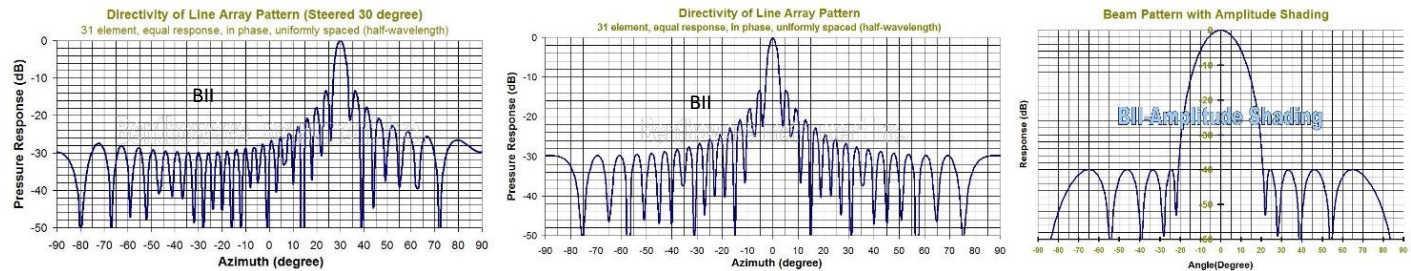


## Technical Notes

| Array Geometry | Array Properties |
|---|---|
| Linear Array:<br>N point element, equal response, in phase, uniformly spaced | $D(\theta) = \sin(\pi dN \sin\theta/\lambda)/(N\sin(\pi d \sin\theta/\lambda))$<br>SNR gain = $10 \cdot \log N$<br>-3dB Beamwidth of Main Lobe = $2 \cdot \arcsin(1.4 \cdot \lambda/(\pi dN))$<br>First Sidelobe: $\theta = \pm\arcsin(1.5\lambda/(dN))$; First Sidelobe: -13.4 dB; Sidelobe Fall-off: -6dB/octave<br>d - Spacing; λ - Wavelength; N - Element Quantity; θ - Angle to normal on the array |
| Linear Array:<br>N point element, triangular weighting, in phase, uniformly spaced | $D(\theta) = [\sin(\pi dN \sin\theta/\lambda)/(N\sin(\pi d \sin\theta/\lambda))]^2$<br>SNR gain = $10 \cdot \log N$; -3dB Beamwidth of Main Lobe = $2 \cdot \arcsin(6.35 \cdot \lambda/(dN))$<br>First Sidelobe: $\theta = \pm\arcsin(3\lambda/(dN))$; First Sidelobe: -26.8 dB<br>Sidelobe Fall-off: -12dB/octave<br>d - Spacing; λ - Wavelength; N - Element Quantity; θ - Angle to normal on the array |
| Dolph-Chebyshev Array | Chebyshev Polynomial:<br>$T_m(x) = \cos(m/\cos(x))$;    $-1 < x < 1$<br>    $= \cosh(m/\cosh(x))$;    $\|x\| \geq 1$<br>$T_0(x) = 1$;<br>$T_1(x) = x$;<br>$T_2(x) = 2x^2 - 1$;<br>$T_3(x) = 4x^3 - 3x$;<br>...<br>$T_{m+1}(x) = 2xT_m(x) - T_{m-1}(x)$;<br>... |
| Planar/Conformal Array: Identical Elements | $g(u) = \sum(i(n) \cdot \exp(jkndu))$<br>$g(u) = f(u) \cdot e(u)$;   $u = m \cdot \lambda/d$; Pattern Multiplication<br>g(u)-Radiation/Receiving Pattern of the Array<br>f(u)-Array Pattern or Array Factor<br>e(u)-Element Pattern or Element Factor<br>d-interelement distance; λ-Wavelength; m = ...,-2,-1,0,1,2,...<br>i(n)-Element n; k-wave number; u=sinθ |

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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**

| Signal Generator Computer + DAQ Microcontroller | → | BII Power Amplifier | → | Impedance Matching for Maximum Power Delivery | Cable → | SONAR Projector, NDT, HIFU,Power Transducer | → | Sound & Stress Wave Electromechanical Coupling Vibration & Deformation |
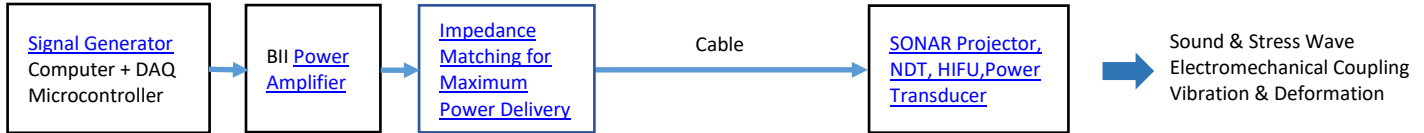
a. Driving voltage of transducer is limited by voltage ratings of both cables and transducers.
b. Grounding are necessary for operating safety.
c. Impedance mismatch exists between cable and transducer. The mismatch can be ignored in low frequency range when cable length is much less than electromagnetic wavelength.
d. This setup is popular for 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. The disadvantage is that each transducer needs a bespoke impedance matching device to match the impedance requirements of the power amplifier. That is, the exchangeability among parts is poor.

**(2). 50Ω or 100Ω Impedance Matching**

| Signal Generator Computer + DAQ Microcontroller | → | BII Power Amplifier | → | Impedance Matching to Drive 50Ω or 100Ω Load | 50Ω Coax or Shielded Cable → | 50Ω or 100Ω SONAR Projector, NDT, HIFU, Power Transducer | → | Sound & Stress Wave Electromechanical Coupling Vibration & Deformation |

| Signal Generator Computer + DAQ Microcontroller | → | BII Power Amplifier Acoustic Transmitter Acoustic Transmitter and Receiver Driving 50Ω or 100Ω Load. | 50Ω Coax or Shielded Cable → | 50Ω or 100Ω SONAR Projector, NDT, HIFU, Power Transducer | → | Sound & Stress Wave Electromechanical Coupling Vibration & Deformation |

The exchangeability among parts is excellent for easy maintenance, fast system recovery, lower cost, etc.

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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

| Hydrophones AE Sensors | → | BII Preamplifiers Driving cable up to 1 km. | Twisted Pairs, 50Ω Coax, Shielded Cable, Shielded Cable with Twisted Pairs → | Signal Processing System |


BII7002 50m RG58/BNC
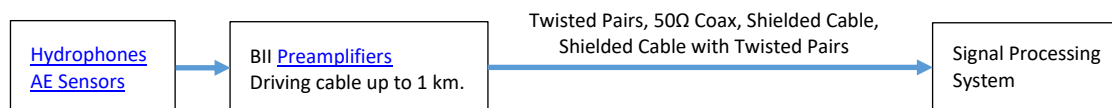
BII preamps provide flexible and bespoke cable driving solutions with current, single-ended voltage, or differential voltage to drive Twisted Pairs, 50Ω Coax, Shielded Cable, Shielded Cable with Twisted Pairs.

**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 or RG178 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.


BII7013 20m RG174/BNC

### Sound Radiation

| Signal Generator Computer + DAQ Microcontroller | → | BII Power Amplifier | → | Impedance Matching to Drive 50Ω or 100Ω Load | 50Ω Coax or Shielded Cable → | 50Ω or 100Ω SONAR Projector, NDT, HIFU, Power Transducer | → | Sound & Stress Wave Electromechanical Coupling Vibration & Deformation |

| Signal Generator Computer + DAQ Microcontroller | → | BII Power Amplifier Acoustic Transmitter Acoustic Transmitter and Receiver Driving 50Ω or 100Ω Load. | 50Ω Coax or Shielded Cable → | 50Ω or 100Ω SONAR Projector, NDT, HIFU, Power Transducer | → | Sound & Stress Wave Electromechanical Coupling Vibration & Deformation |

### Sound Radiation and Detection: SONAR and NDT

| Signal Generator Computer + DAQ Microcontroller | → | BII Power Amplifier | → | Impedance Matching to Drive 50Ω or 100Ω Load | 50Ω Coax or Shielded Cable → | 50Ω or 100Ω Transducers with T/R Switch | ↔ | Sound & Stress Wave Electromechanical Coupling Vibration & Deformation |

Receiving Gain Selection

Received Signal, 50Ω Coax, Shielded Cable, Twisted Pairs.


BII7521 30m SC Cable/WL
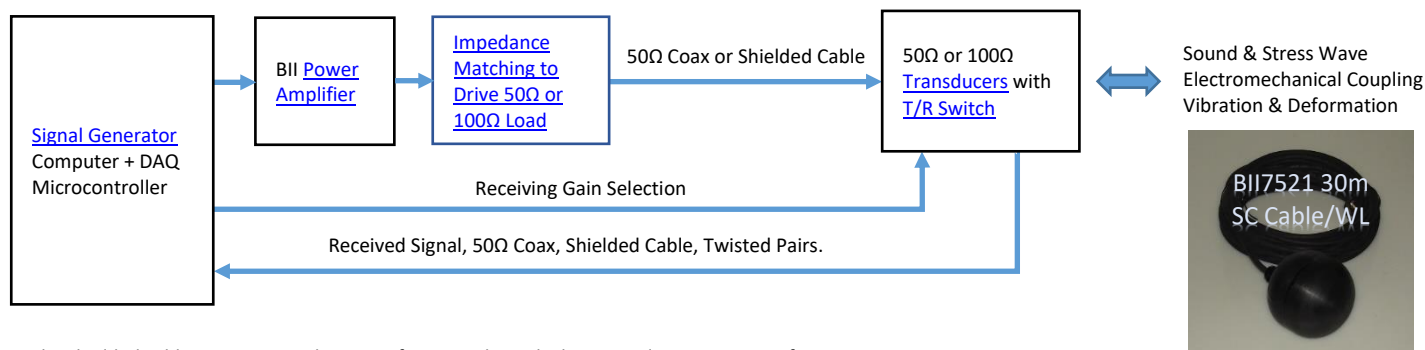
1. The shielded cable or coax provide means for grounding which is critical to operating safety.
2. EMI generated by conductors is reduced by grounded shielding.
3. Magnetic flux generated by a twisted pair will cancel each other.
4. Maximum transmitting power is limited by voltage and current ratings 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 Ω$^{-1}$). $G_p$ = $G_{max}$ at $f_s$. $R_{TL}$: 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. 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 ≥ Pulse Width*(1-D)/D.

Off-time ≥ 98 (Seconds) when PW=2 seconds.
Off-time ≥ 49 (Seconds) when PW=1 second.
Off-time ≥ 4.9 (Seconds) when PW=100 ms.
Off-time ≥ 490 (ms) when PW=10 ms.
Off-time ≥ 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 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**

**Receiving Sensitivity:**

(Number) V/μPa = ((Number)*1000000) V/Pa = (20*log(Number)) dB V/μPa = (20*log(Number) + 120) dB V/Pa

(Number) dB V/μPa = ((Number) + 120) dB V/Pa = $10^{Number/20}$ V/μPa = $10^{Number/20}*1000000$ V/Pa

**Transmitting Voltage Response:**

(Number) μPa/V@1m = (20*log(Number)) dB μPa/V@1m = (20*log(Number) - 120) dB Pa/V@1m

(Number) dB μPa/V@1m = $(10^{Number)/20}$ μPa/V@1m = $(10^{(Number/20}$ /1000000) Pa/V@1m

**Impedance and Admittance**

$$Impedance\ Z = R + jX = \frac{G}{G^2+B^2} - \frac{jB}{G^2+B^2};$$

$$Admittance\ Y = G + jB = \frac{R}{R^2+X^2} + \frac{jX}{R^2+X^2}$$

$$|Z| = \frac{1}{|Y|} = \sqrt{R^2 + X^2} = \frac{1}{\sqrt{G^2+B^2}};$$

$$Impedance\ Phase\ \theta = \tan^{-1}\frac{X}{R} = -\tan^{-1}\frac{B}{G}$$

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

**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. |
| | 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. |
| | $P_{in}$: Input Electrical Power. η: Electroacoustic Efficiency. DI: Directivity Index. |
| **Input Power:** | $P_{in} = V_{rms}^2 * G$. G: Parallel Conductance of Transducer. |
| **Acoustic Far Field:** | ≥ Area/λ (Planar), ≥ (Length*Length)/λ and ≥ Length (Line or thin cylinder). |
| **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: $f_{-3dB} = 1/(2\pi R_i C_h)$. |
| | $R_i$: Input Resistance or Impedance of a Preamp or A/D Converter. |
| | $C_h$: 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. |
| | $C_h$: 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. |
| | Absorption Coefficient (≤50 kHz): α (dB/km)) = 1.0936 [0.1*f²/(1 + f²) + 40*f²/(4100 + f²)]. 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. |
| | $I_{rms}$: 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. |
| | C: Channel Capacity. B: Channel Bandwidth. SNR: Signal-to-Noise Ratio. |
| **Constants:** | Free Dielectric $\varepsilon_o$ = 8.842 x $10^{-12}$ C/mV. |
| | Sound Speed in Sea Water: C = 1449.2+4.6T-0.055T²+0.00029T³+(1.34-0.010T)*(S-35)+0.012z (m/s). |
| | T: Temperature, °C. S: Salinity, parts per thousand of dissolved weight of salts. z: Depth, meter. |
| | Sound Speed in Fresh Water: C = 1481 m/s. Density of Sea Water: 1026 kg/m³. Fresh Water: ρ = 998 kg/m³. |

| Ocean Sound Sources | Frequency Range | | Ocean Sound Sources | Frequency Range |
|---|---|---|---|---|
| Vessel Traffic: | 5 to 500 Hz | | Drill Ship: | 10 to 20,000 Hz |
| Air-gun (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).
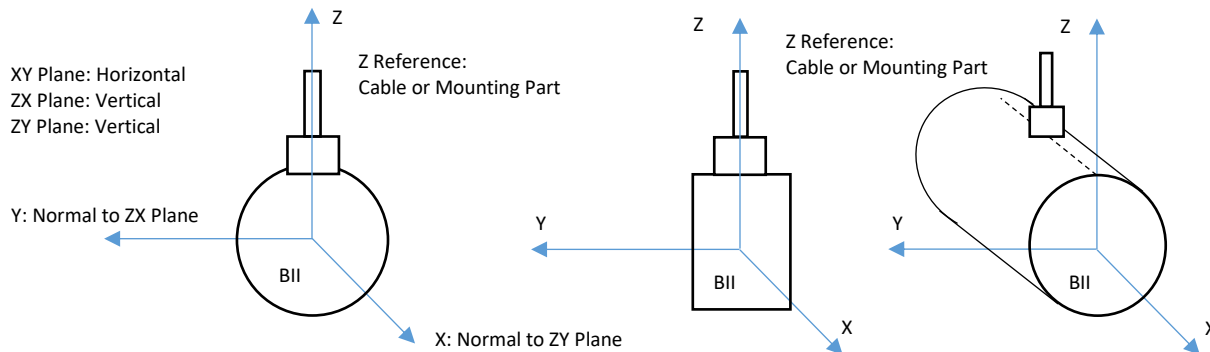**Impedance Measurement**: Z-Ɵ, R-X, G-B, Equivalent Circuit Model.
**Power**: Efficiency, Power Factor, Quality Factor (Bandwidth).
**Environmental Testing**: Pressure, Thermal (Temperature), Electric Field (or Voltage Rating).
**Calibration Methods**: BII uses primary methods (or reciprocal calibration) and secondary method (or comparison calibration) from 26 Hz to 10 MHz.

### Hydrophone and Transducer (Projector) Orientation



XY Plane: Horizontal
ZX Plane: Vertical
ZY Plane: Vertical

Y: Normal to ZX Plane

X: Normal to ZY Plane

Z Reference: Cable or Mounting Part

### 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. The variation of a BII reference hydrophone used in comparison calibration ≤ ± 0.2 dB in five years. BII does not have suggestions on recalibration of these standard 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 the transducers after one-year field use.

### Does BII Provide Calibration Service?

Yes, BII provides calbration 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: $D = dT + \varepsilon^T E$ and $S = s^E T + dE$

Thermodynamics of Ferroelectric/Piezoelectric Medium: Gibbs Functions $G = U - S*T - E*D - H*B - \sigma*\theta$.

Energy Loss Density per Hysteresis Loop of Ferroelectric/Piezoelectric Materials = $\int DdE$.

Piezoelectric Strain Constant d, Polarization P, Dielectric Constant $\varepsilon$ and Electrostrictive Constant q: $d \approx 2q*\varepsilon*P$.

Dielectric Susceptibility $\chi$, Internal Field Constant $\gamma$, Polarizability $\alpha$, Entity Density N: $\chi = N*\alpha/(\varepsilon_0*(1-N*\alpha*\gamma))$.

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).



$$Energy\ Loss\ Density\ per\ Loop = \int DdE$$

Gibbs Functions $G = U - S*T - E*D - H*B - \sigma*\theta$



**D-E Loop (Hysteresis)**: Dependence on Frequency, Temperature, Pressure, Electric Field Level, and Poling.
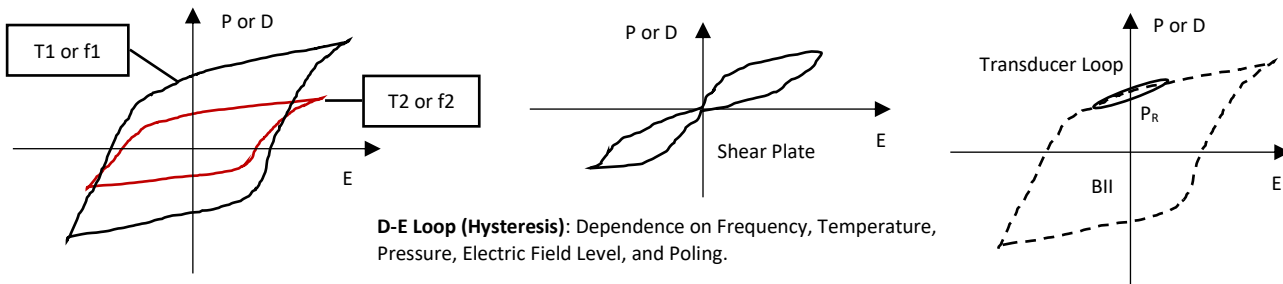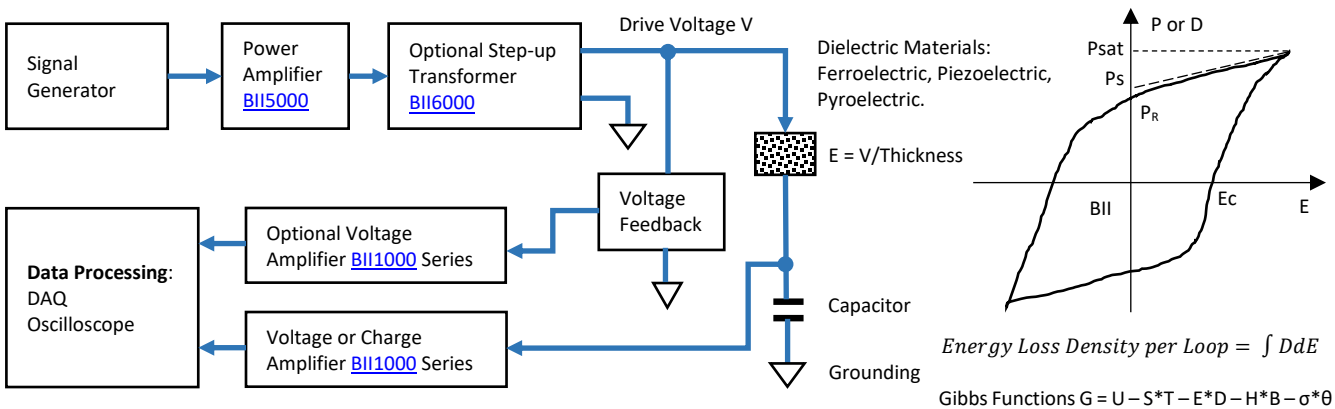
**Direct Measurement of Piezoelectric Constants.** With standard test weights and BII amplifiers, a low-cost simple quasi-static absolute measurement system can be set up to measure piezoelectric strain and/or voltage constants with reasonable accuracy: $d_{31}$, $d_{33}$, $d_h$, $g_{31}$, $g_{33}$ and $g_h$. 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.
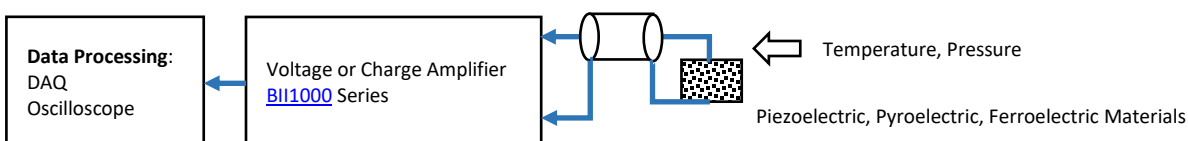


**Impedance Spectroscopy.** A customized impedance measurement system can be configured with BII's electronic components to study the material response to the applied electric field from 1 Hz to 10 MHz. The impedance of a material is computed over a range of frequencies with measured V and I. Material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

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Signal Generator → Power Amplifier BII5000 → Optional Step-up Transformer BII6000

Drive Voltage V

Ferroelectric and Piezoelectric Materials
E = V/Thickness

Voltage Feedback

Data Processing:
DAQ
Oscilloscope

Optional Voltage Amplifier BII1000 Series

I-to-V Amplifier Bespoke BII1000 Series

Current I

Grounding

$$\varepsilon_r''(\omega)$$

$$\leftarrow \omega$$

BII

$$\varepsilon_r'(\omega)$$

$$\varepsilon_{r\infty}'(\omega) \qquad \varepsilon_{rs}'(\omega)$$

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

$$\omega_r: Relaxation\ Frequency$$

Impedance = V/I = $Z*\cos\theta + jZ*\sin\theta$.     Dissipation Factor D = Loss Tangent $\tan\delta = \cot\theta$.
Quality Factor Q = $\tan\theta$.   I = $(j\omega\varepsilon' + \omega\varepsilon'')*C_0/\varepsilon_0*V$.   $\tan\delta = \varepsilon''/\varepsilon'$.   Power Factor = $\cos\theta$.

**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:**

Signal Generator → Power Amplifier BII5000 → Step-up Transformer BII6000 → Drive Voltage at 1kHz → Material Sample ← Mechanical Stress Variation Temperature Variation

Data Analysis: Dissipation Factor tanδ Permittivity ε ← Sampling Data DAQ Modules ← I-to-V Amplifier Bespoke BII1000 Series ← Impedance Bridge
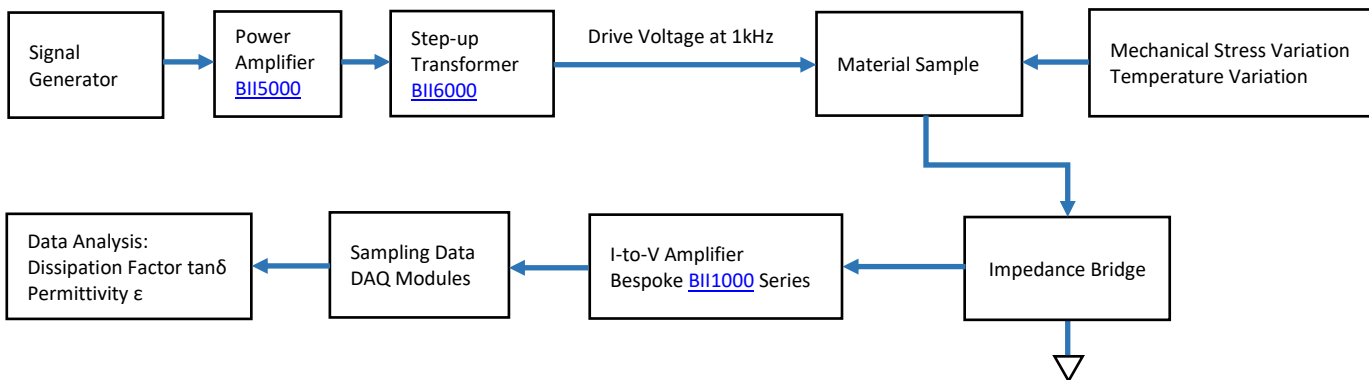
**Low Field and Ageing Measurement:**

Mechanical Stress Variation Temperature Variation → Material Sample → LCR Meter or Impedance Analyzer

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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.

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

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## Ordering Information

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

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.

There is **HOW To Order** in product datasheets which contain detailed information on how to order standard and custom-fit products.

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

| Part Number | -Mounting Part | -Cable Length in Meter | -Cable Type | -Connector Type |
|---|---|---|---|---|
| Example: | Description | | | |
| BII7xxx-FH-6m-RG174-BNC | BII7xxx Hydrophone, Free Hanging, 6m RG174 Coax, Male BNC. | | | |
| BII7xxx-HT-FH-6m-RG178-SMC | BII7xxx Hydrophone, Service Temperature: -10 °C to 120 °C, or 14 °F to 248 °F. Free Hanging, 6m RG178 Coax, SMC (Plug, Female Socket). | | | |

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

| Part Number | -Preamp Gain, dB | -Output Type | -HPF/LPF -3dB Filter Frequencies | -Mounting | -Cable Length in meter | -Cable | -Connector |
|---|---|---|---|---|---|---|---|
| Example of Part Number: | | | Description | | | | |
| BII7xxxFG-26dB-SE-0.3kHz-FH-10m-SC-BNC/BS | | | BII7xxxFG Hydrophone, 26dB Preamplifier, Single Ended Output, 0.3kHz High Pass Filter, Free Hanging, 10m Shielded Cable, Connector: Male BNC for Signals, Battery Snap for +9VDC Batteries. | | | | |
| BII7xxxPG-0/20/40/60dB-DF-10Hz/100kHz-FH-20m-SC-WL/XLR/BS | | | BII7xxxPG Hydrophone, 0/20/40/60dB Programmable Preamplifier, Differential Output, 10Hz to 100kHz Band Pass Filter, Free Hanging, 20m Shielded Cable, Connector: Wire Leads for Sensitivity Selection, XLR Plug for Signals, Battery Snap for +9VDC Batteries. | | | | |

### 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.

#### How to Order

| Part Number | -Mounting Part | -Cable Length in Meter | -Cable Type | -Connector Type |
|---|---|---|---|---|
| Example: | Description | | | |
| BII7xxx-FH-6m-SC-UMC | BII7xxx Transducer, Free Hanging, 6m Shielded Cable, Male Underwater Mateable Connector. | | | |
| BII7xxx-HT-FH-6m-RG178-SMC | BII7xxx Transducer, Service Temperature: -10 °C to 120 °C, or 14 °F to 248 °F. Free Hanging, 6m RG178 Coax, SMC (Plug, Female Socket). | | | |
| BII7xxxIM-FH-10m-RG58-BNC | BII7xxxIM Transducer, Built-in Impedance Matching Network to 50Ω at fs, Free Hanging, 10m RG58 Coax, Male BNC. | | | |
| BII7xxx-IM8Ω-FH-10m-SC-WL | BII7xxx Transducer, Built-in Impedance Matching Network to 8Ω at fs, Free Hanging, 10m Shielded Cable, Wire Leads. | | | |
| BII7xxx-TS-IM8Ω-FH-10m-SC-WL | BII7xxx Transducer, Built-in Temperature Sensor, Built-in Impedance Matching Network to 8Ω at fs, Free Hanging, 10m Shielded Cable, Wire Leads. | | | |

#### How to Order Transducers with T/R Switches. 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.

| Part Number | -Appendage | -Receive Gain | -HPF/LPF | -Mounting | -Cable Length | -Cable Type | -Connector for signals of Transmit/Receive/DC Supply/Temperature |
|---|---|---|---|---|---|---|---|
| BII75xx | Default: **TRIM50Ω** | Default: **40 dB** | -3dB Receive bandpass Frequencies. | Default: **FH**. | Default: **10m.** | Default: **SC or Coax** | Default: **WL**. |
| Example: | | | Description | | | | |
| BII75xx-TR-IM50Ω-40dB-100Hz/100kHz-BFMSS-10m-SC-MIL/XLR/BS | | | BII75xx Transducer, Built-in T/R Switch, Built-in Impedance Matching Network as 50Ω load at fs, Receive Gain: 40dB, Receive Bandpass Filter: 100Hz to 100kHz. Bolt-fastening Mounting (Stainless Steel), 10m Shielded Cable, MIL-5015 Connector for Transmit Signal, XLR for Receive Signal, 9V Battery Snap for DC Supply. | | | | |
| BII75xx-TS-TR-IM50Ω-40dB-100Hz/100kHz-BFMSS-10m-SC-MIL/XLR/BS/TRS | | | BII75xx Transducer, Built-in Temperature Sensor, Built-in T/R Switch, Built-in Impedance Matching Network as 50Ω load at fs, Receive Gain: 40dB, Receive Bandpass Filter: 100Hz to 100kHz. Bolt-fastening Mounting (Stainless Steel), 10m Shielded Cable, MIL-5015 Connector for Transmit Signal, XLR for Receive Signal, 9V Battery Snap for DC Supply, TRS for Temperature Signal. | | | | |
| BII75xx-TR-IM50Ω-40dB-0.3MHz/10MHz-FH-10m-RG58-BNC/BNC/BS/TRS | | | BII75xx Transducer, Built-in T/R Switch, Built-in Impedance Matching Network as 50Ω load at fs, Receive Gain: 40dB, Receive Bandpass Filter: 0.3MHz to 10MHz. Free Hanging, 10m RG58 Cable, BNC Male Connector for Transmit Signal, BNC Male for Receive Signal, 9V Battery Snap for DC Supply, TRS for Temperature Signal. | | | | |

#### Cable and Connector Information for High Power Signals (from Power Amplifier and to Transducers). Non-UL Uses.

| | Wire and Cable Types | Ratings of Voltage, Current or Power, and Temperature. |
|---|---|---|
| Cable Options: | AWG18 Wires (**WR**) | 3000 Vrms, 10 Arms. |
| | Two Conductor Shielded Cable (**SC**) | 600 Vrms, 5 Arms. |
| | Two Two-conductor Shielded Cable Bundle (**2SC**) | 600 Vrms, 10 Arms. |
| | High Temperature Shielded Cable (**HTSC199**) | 600 Vrms, 6 Arms, up to +199°C or 390 °F, Non-waterproof. |
| | Coax RG58 (50Ω) (**RG58**) | 1400 Vrms, 4 Arms. |
| | Coax RG174/U (50Ω) (**RG174**) | 1100 Vrms, 1.6 Arms. |

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| | | |
|---|---|---|
| | Coax RG178B/U (50Ω) (**RG178**). | 750 Vrms, 0.86 Arms, up to +200°C or 390°F. |
| | **Connector Type** | **Ratings of Voltage, Current or Power, and Temperature.** |
| Connector Options: | 1. Wire Leads (**WL**) | Used for Cables or Wires. |
| | 2. 50Ω BNC (**BNC**), Bayonet Lock. Panel Mount or In-line.<br>In-line BNC: Input uses Pin, output uses Socket.<br>Panel Mount BNC: Both Input and Output use BNC Jacks. | 500Vrms, 316W.<br>Used for Grounded Signal with Metal Enclosures or Coax Cables. |
| | 3. MIL-5015 Type Connector (**MIL**), Thread Fastening.<br>Panel Mount or In-line. Input uses Pin, output uses Socket. | 500Vrms, 13 A; Up to +125°C or 257°F, or,<br>900Vrms, 13 A; Up to +125°C or 257°F.<br>Used for Metal Enclosures or Shielded Cables. |
| | 4. XLR Connector (**XLR**), Positive Latchlock.<br>Panel Mount or In-line. Input uses Pin, output uses Socket. | 133Vrms, 15 A; -25°C to +75°C or -13°F to +167°F.<br>Used for Metal Enclosures or Shielded Cables. |
| | 5. Underwater Mateable Connector (**UMC**), Thread Fastening.<br>Panel Mount or In-line. Input uses Pin, output uses Socket. | 600Vrms, 10A. Waterproof, IP68.<br>Used for Metal Enclosures or Shielded Cables. |
| | 6. Sheathed Banana Jack. Panel Mount or In-line. | 1000V CAT III/600V CAT IV, 25A. IEC61010-031 rated.<br>**NOT USED in this device.** |
| | 6. SMA (Plug, Male Pin) (**SMA**). Thread Fastening. In-line. | Voltage Rating: 335 VRMS Continuous. (Max. Diameter Φ9.24 mm).<br>Up to 155°C or 311°F. |
| | 7. SMC (Plug, Female Socket) (**SMC**). Thread Fastening. In-line. | Voltage Rating: 335 VRMS Continuous. (Max. Diameter Φ6.4 mm).<br>Up to 155°C or 311°F. |
| | 8. LEMO (Plug Male Pins) (**LEMO**). Push-Pull Fastening.<br>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 Wrms to 3 kΩ transducer 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$_L$ = 1732Vrms/3000Ω = 0.57733 A$_{rms}$.
Therefore, AWG18 Wire and Wire leads are suitable.

**Case 2.** Deliver 500 Wrms to 300 Ω transducer 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$_L$ = 387.3Vrms/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 Wrms to 50 Ω transducer 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$_L$ = 122.5Vrms/50Ω = 2.45A$_{rms}$.
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.

## Abbreviation List for Ordering

| Principal Parameters | | |
|---|---|---|
| **DRx**: 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°x250° in XY and ZX plane, frequency dependent. | |
| **HSPH:** | Beam generated by hemispherical transducer. Generally, -3dB Beam Width at fr: 360°x70° 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 Δθ:** | -3dB conical Beam Width Δθ in ZX and ZY plane, in °, generated by transducers of circular plate or convex shell. | |
| **Δθ$_H$ × Δθ$_V$:**<br>(Planar) | -3dB fan-shaped Beam Width, generated by transducers with rectangular (or square) apertures. Δθ$_H$ is in ZX plane (Along-track, Along-length or Horizontal Plane) and Δθ$_V$ is in ZY plane (Cross-track, Cross-length or Vertical Plane), such as -3dB Along-Length x Cross-Length Beam Width = 5° x 50°. | |
| **Δθ$_H$ × Δθ$_V$:**<br>(Curved) | -3dB fan-shaped Beam Width, generated by transducers with cylindrical curve apertures. Δθ$_H$ is in ZX plane (Along-curve or Horizontal Plane) and Δθ$_V$ 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** | | | |
| **FG**: Fixed Gain Preamp | **PG**: Programmable Gain Preamp | **HPF**: High Pass Filter | **LPF**: Low Pass Filter |
| **BPF**: Band Pass Filter | **SE**: Single Ended Output/Unbalanced | **DF**: Differential Output/Balanced | |
| **Mounting Parts:** Detail information at Mounting Parts. | | | |
| **Cable: -4° to 140° F (-20° to 60° C) Typically** | | | |
| **WR**: Wires | **MiniCoax**: Coax (ΦD=1.4mm) | **RG178**: RG178B/U 50Ω Coax, -70°C To +200°C | |
| **RG174**: RG174/U 50Ω Coax | **RG58**: RG58 50Ω Coax (see Note 1) | **SCB**: Shielded Cable Bundle | |
| **WCB**: Wire/Cable Bundle | | | |
| **SC26**: Shielded Cable with Polyurethane Jacket, ΦD = 2.6 mm. Temperature: -40 to 70 °C, Voltage: ≤ 150 V. | | | |
| **SC32**: Shielded Cable with Twisted Pair and Teflon (PTFE) Jacket, ΦD=3.2 mm (SC32), up to 200°C. Not water-proof. | | | |
| **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. -50 °C to +90 °C, ≤ 600 Vrms. | | | |
| **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. | | | |
| **SC**: 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). Uses: Water Depth ≤ 3000 m; Max. Operating Voltage: 300 Vrms or 600 Vrms available, Max. 10 A. | | | |

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| | |
|---|---|
| **Shielded Cable with Twisted Pair (SCTP):** Recommended for hydrophone (receiver) without preamplifier. | |
| **Cable Jacket:** PVC, Polyurethane, EPDM rubber, FEP, PTFE, etc... | |

**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 is. 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.

**High Temperature Cables**

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

**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. Dry Use ONLY.

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

**HTSC199**: High Temperature Shielded Cable: -65° to 390° F (-54° to 199° C), Maximum 600VAC.

**HTUSC**: High Temperature Unshielded Cable: -40° to 840° F (-40° to 449° C), Maximum 600VAC. Dry 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. |
| **SBJ or SBP**: Sheathed Banana Jack or Plug. | **SMA:** Plug, Male Pin, 50Ω. | **SMC**: Plug, Female Socket, 50Ω. |
| **LEMO**: PLUG 3 Contacts, Socket or Pin. | Reserved. | **TRS**: 3.5mm or 1/8" TRS Plug or Jack. |
| **XLR3/4/6**: XLR Receptacle with 3/4/6 Male Pins. | **5015**: MIL-5015 style Circular Connector, Socket or Pin. | **SP**: Solder Pins. |
| **BS**: +9V Battery Snap. | **UMC**: Underwater Mateable Connector (See Note 2). | **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 | XLR3/4/6 | MIL-5015 | 9V Battery Snap | Underwater Connector |
|---|---|---|---|---|---|---|---|---|---|
| **Biggest Size:** | Φ14.3 | Φ9.24 | Φ6.4 | Φ9.5 | Φ10.5 | Φ20.2 | Φ30 | Φ13 | Φ21.5 or Φ35 |

**Note 1: RG58 Coax with BNC connector.** Available lengths: 1m, 2m, 3m, 5m, 10m, 15m, 20m, 30m. Please choose cable length which is much less than the Electromagnetic wavelength λ≈c/f. c: speed of light in Vacuum.

**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.

| | |
|---|---|
| **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. |

**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 198°C (14°F to 390°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 |

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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| -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 198 °C, or 248 to 390 °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.

**Underwater Transducer (Projector and Hydrophone) Handling**
Warning: Wrongful handling may damage the transducer and hydrophone beyond repair.
1. Do not drive the 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 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.

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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 a DC Power Supply for BII Devices**

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).

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.

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, Navigation. | Ultrasonic (Ultrasound, AE, NDT) Testing, Material Characterization. |
| Seafloor-mapping, Sub-bottom/Sediment Profiler, Acoustic Image. | Low Noise Ultrasonic Preamplifier, Ultrasonic Instrumentation, Pulse Amplifier. |
| Target Strength Testing, Towed Array, Sonobuoy, Bottom Moored Systems. | Sonic Cavitation Noise, Hand-held, Portable, Battery-operated Systems. |

### How to choose the BII preamps?

❖ Detecting low frequency signals of f ≤ 50 to 100 kHz:  low $i_n$ preamp. Detecting high frequency signals of f > 50 to 100 kHz: low $V_n$ preamp.
❖ Detect low frequency sounds: Differential or Single-ended Input. Detect high frequency ultrasounds in MHz range: Single-ended Input.
❖ High-frequency signals over 50Ω coax (long or short): Single-ended Output. Signals over short shielded-cables: Differential or Single-ended Output.
❖ Low-frequency signals over long shielded-cables or twisted-pairs: Differential Output.

| Preamplifier | Type | Gain Type | Maximum Cable Length | Features |
|---|---|---|---|---|
| » BII1030 | Voltage Amplifier | Variable | 1000m or RG58 Coax | 1.8 nV/√Hz, 0.8 fA/√Hz, 30 Hz to 20 MHz, 0 to 80 dB Variable Gain. |
| » BII1040 | Voltage Amplifier | Fixed | 200m or RG58 Coax | 3nV/√Hz, 4fA/√Hz, 1Hz to 18MHz, 40dB Gain, Single Ended or Differential Output. |
| » BII1050 | Voltage Amplifier | Fixed | 305m or RG58 Coax | 1nV/√Hz, 0.8fA/√Hz, 0.01Hz to 10MHz, 20 to 80dB Gain, Single Ended or Differential Output. |
| » BII1060 | Voltage Amplifier | Fixed | 1000m | 0.01Hz to 550kHz, 40 to 60dB Gain, 40µA, +2.7VDC, Single Ended or Differential Output. |
| » BII1080 | Voltage Amplifier | Fixed | 200m | 5.2nV/√Hz, 3.1fA/√Hz, 20 to 80dB Gain, 0.1Hz to 4.5MHz, Single-ended or Differential Input. |
| » BII1090 | Voltage Amplifier | Digitally Programmable | 1000m or RG58 Coax | 1.0nV/√Hz, 0.8fA/√Hz, 0.02Hz to 8MHz, Digitally Programmable Gains: 0, 20, 40, 60, 80dB. Single Ended or Differential Output. |
| » BII2000 | AGC Amplifier | Automatic | 200m | -20 to 80 dB Automatic Gain Control, 100 Hz to 1 MHz Bandwidth. |

### Noise Figures of Typical Low Noise Preamps.
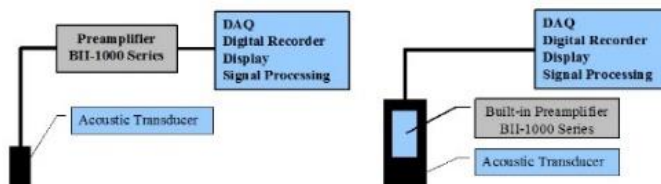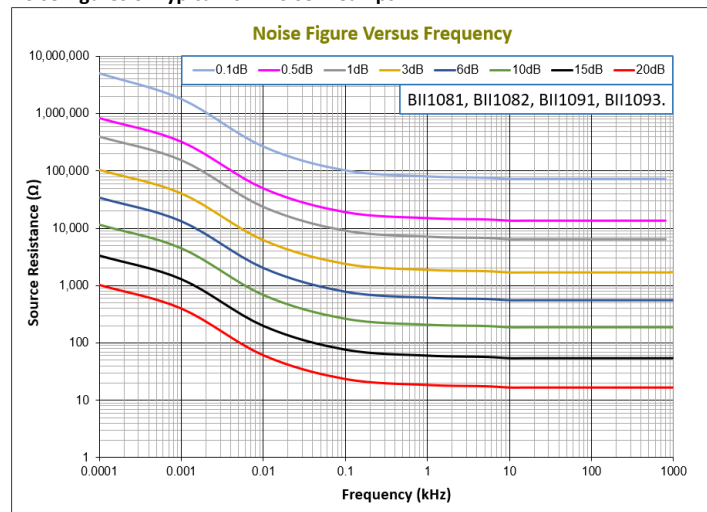


### Attenuate Output of a Hydrophone or Preamp to Meet Input Level of a DAQ (Data Acquisition Board/Module, A/D Converter.)



Single-Ended DAQ

$Vi = Vo * R2/(R1+R2)$.
$R1 \geq 1\ k\Omega$.

Differential Input of DAQ

$Vi = Vo * R2/(R1+R2+R3)$.
$R1=R3 \geq 1\ k\Omega$.

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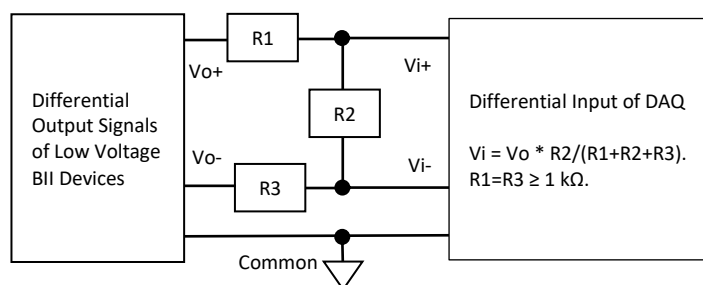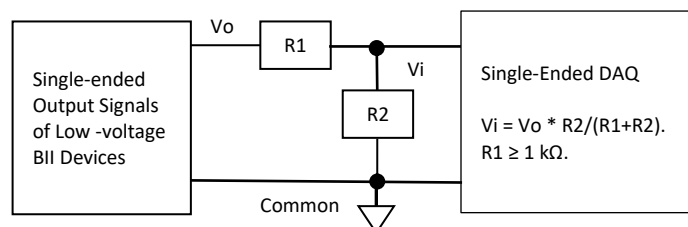
## Power Amplifiers for SONAR, NDT, HIFU & Dielectric Material Test

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. They can also be used to provide low and/or high electric field (with BII6000 step-up transformer) for dielectric materials characterizations such as P/E or D/E hysteresis, dielectric constant and loss, and their field-level and frequency dependence (Measurement of ferroelectric and piezoelectric materials).

BII5110 series switching amplifiers have valuable features of high power capability, low power consumption, high efficiency, wide bandwidth and small size for battery-powered acoustic instruments such as sonobuoy, underwater pinger, transponder, acoustic release, etc...

| Typical Applications | |
|---|---|
| Sub-bottom Profiler, Sea-floor Mapping, Depth Sounder | 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 |

**SYSTEM CONFIGURATION**
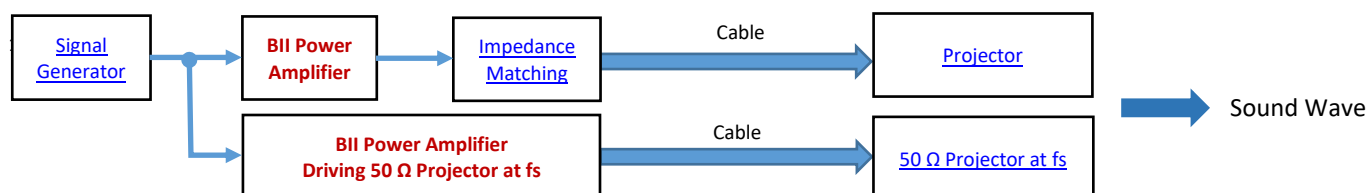


| Power Amplifier | Output Power | Bandwidth | Source Level in Water | Quiescent Current | Type | Package |
|---|---|---|---|---|---|---|
| » BII5000 | 32 Watt | 350Hz to 150kHz | 184.0+DI, dB µPa*m | 100mA active 10µA shutdown | Linear | PCB |
| » BII5010 | 118 or 235 Watt | 0.1 to 15MHz | 191.5+DI, dB µPa*m | 15mA | Linear, Pulse | Metal Enclosure |
| » BII5020 | 86 Watt | 150Hz to 500kHz | 187.0+DI, dB µPa*m | 36mA active 16mA shutdown | Linear | PCB Metal Enclosure |
| » BII5040 | 31.3 Watt | 0.1 to 10MHz | 182.7+DI, dB µPa*m | 53mA active 0.8mA shutdown | Linear | PCB Metal Enclosure |
| » BII5060 | 208 to 415 Watt | 135Hz to 100kHz | 196.0+DI, dB µPa*m | 59mA Active 24mA Shutdown | Linear | PCB, IP68, Metal Enclosure |
| » BII5100 | 309 Watt 1050 Watt | 1kHz to 1MHz 1kHz to 100kHz | 194.2+DI, dB µPa*m 200.6+DI, dB µPa*m | 13mA | Switch Mode (Class D) | PCB |
| » BII5110 | 355 Watt | 1kHz to 3MHz | 194.8+DI, dB µPa*m | 1mA and 2mA | Switch Mode (Class D) | PCB Metal Enclosure |
| » BII5120 | 138 Watt | 20Hz to 3MHz | 189.2+DI, dB µPa*m | 65mA Active 6mA Shutdown | Linear | PCB, IP68, Metal Enclosure |

**Source Level** of a transducer is calculated with efficiency 0.7 in water. **DI** is Directivity Index of the transducer, in dB.

**Measure Differential Output of BII Power Amplifiers**
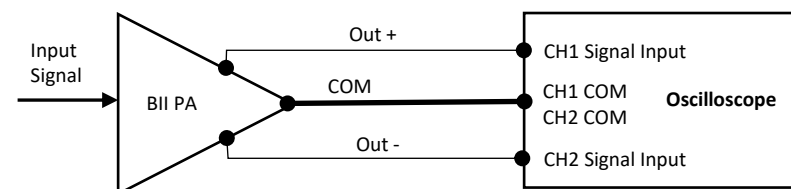


Warning: Outputs of the Power amplifier are differential, DO NOT Connect Out + or Out - to any COM.

**Measure Single Ended Output of BII Power Amplifiers**
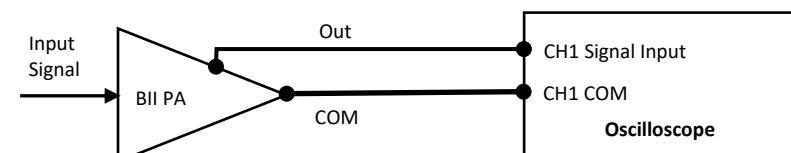


**Warning**:
1. Outputs of the power amplifier is high voltage, choose suitable oscilloscope probe with correct attenuation and voltage rating.
2. for operating safety, ensure proper grounding, and shut down power supply of the device before handing the cables, wirings and hookup, etc.

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## 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.

### Typical Applications
❖ Impedance matching between Amplifiers (Power Amplifier and Preamplifiers) and Piezoelectric Transducers.
❖ Wideband Step-up and Step-down Transformers for Study of Materials.

### System Configuration

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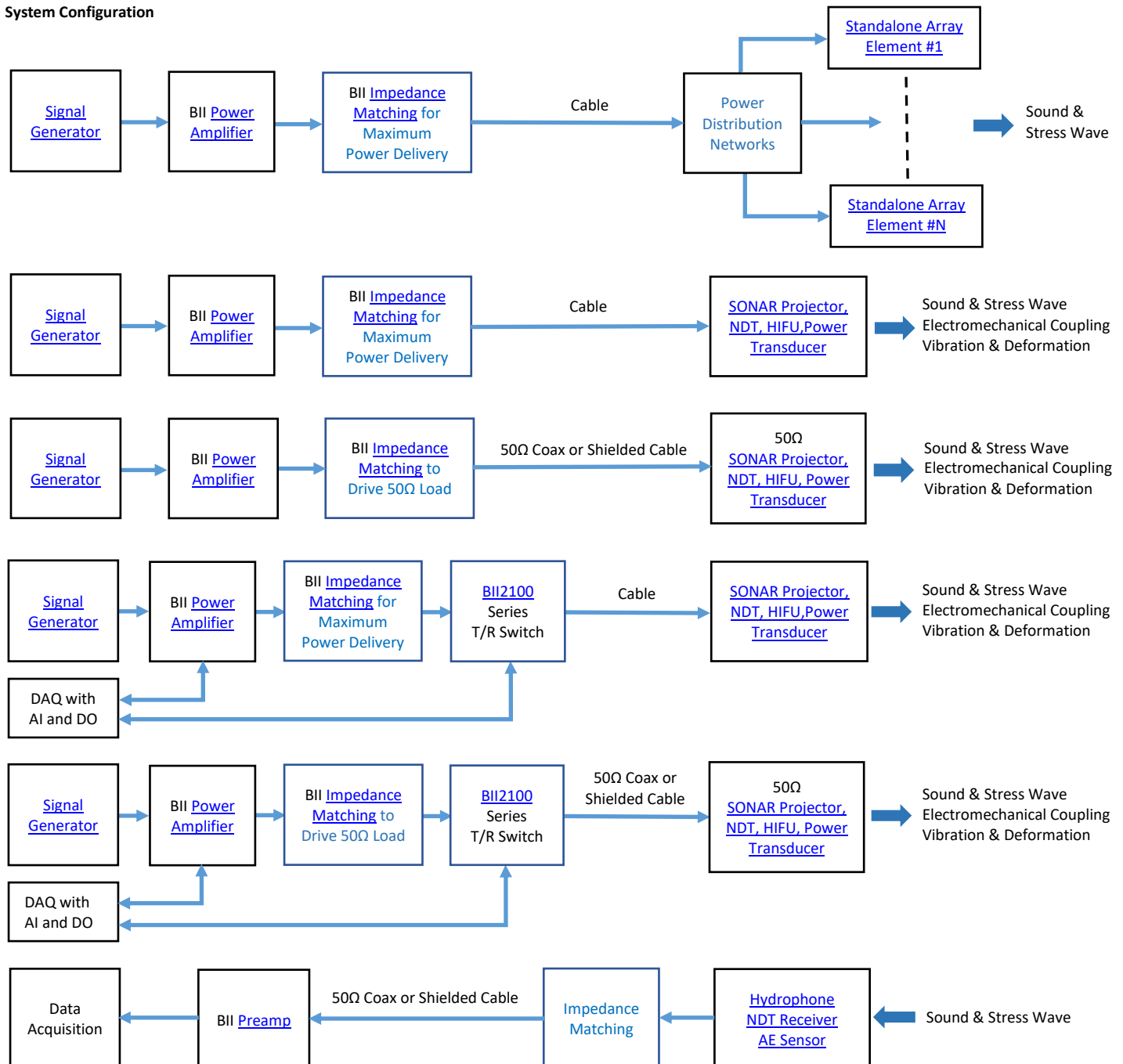
## Transmit and Receive System: SONAR & Ultrasound

BII T/R Switching Modules provide integrated solutions 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, a T/R switch, a bandpass filter, and a low noise DPGA preamplifier (Digitally Programmable Gain 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 Sounder (Navigation/Object Avoidance, Depth/Distance Sounder, Wave-height Sensor), Target Strength Measurement, Sub-bottom Profilers, Side-scan SONAR, Fishery SONAR, Transponders, Positioning, Beacon, Communication and Telemetry, Artificial Acoustic Target, Acoustic Speedometers (Doppler SONAR), Sound Velocity Profiler, Marine Bioacoustics, Acoustic Deterrent Devices, Ocean Current Profiling, Flow Meter, NDT (Non-destructive Test), Diagnostic Ultrasounds, Ultrasonic Test and Analysis, Material Study.

| T/R Switch Modules | Frequency Range | Receiving Gain Range | Gain Control | Built-in Impedance Matching |
|---|---|---|---|---|
| BII2100 Series | 2 kHz to 350 kHz or 10 MHz. | 20, 40, 60, 80dB, and 20, 50 dB. | Digital, TTL/CMOS | No |
| BII2110 Series | 2 kHz to 1 MHz. | -20 to 80 dB. | None, AGC | No |
| BII2170 Series | 2 kHz to 350 kHz or 10 MHz. | 20, 40, 60, 80dB, and 20, 50 dB. | Digital, TTL/CMOS | Yes |

### Transmitting and Receiving System Configuration with BII2170 T/R Switching Modules



### System Block Diagram

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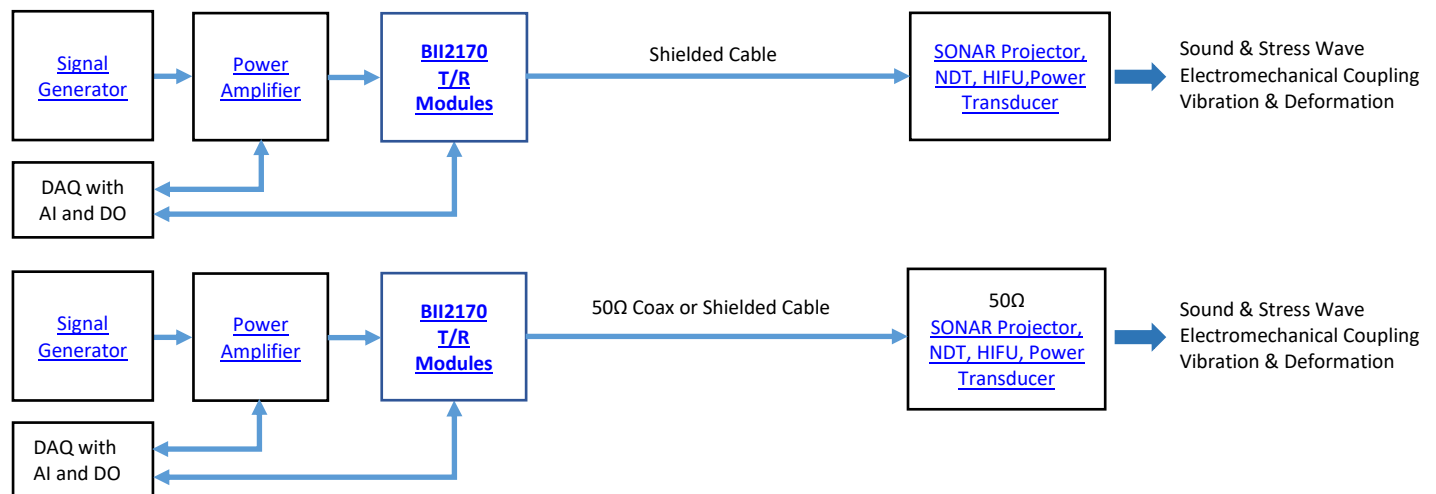
benthowave.com
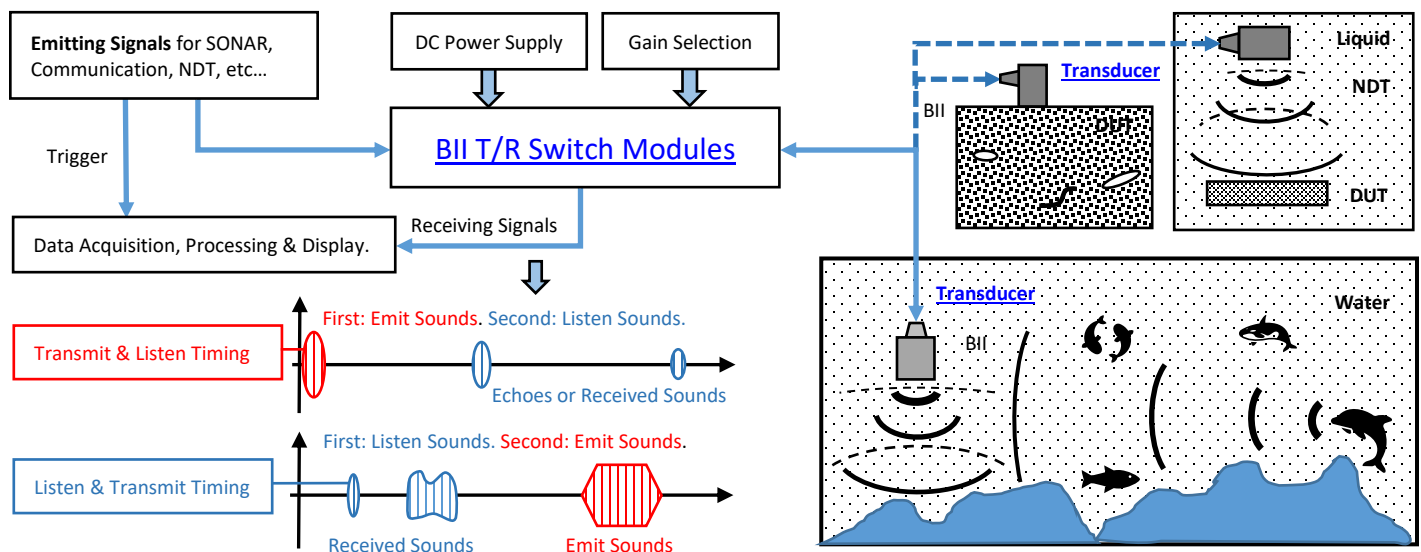
## Wiring Information

**Wirings of BII Hydrophones (Sound Receiver)**

This document contains following wiring information of BII hydrophones and Pressure Transducers:

1. Hydrophone (Sound Receiver) Wiring to DAQ (Data Acquisition).
2. Hydrophone (Sound Receiver) Wiring with Built-in Preamplifier.
3. Hydrophone (Sound Receiver) Wiring without Built-in Preamplifier.

**1. Hydrophone (Sound Receiver) Wiring to DAQ Hardware.**

    BII: Benthowave Instrument Inc.; DAQ: Data Acquisition Hardware; AI: Analog Input; CH: Channel; GND: Ground.

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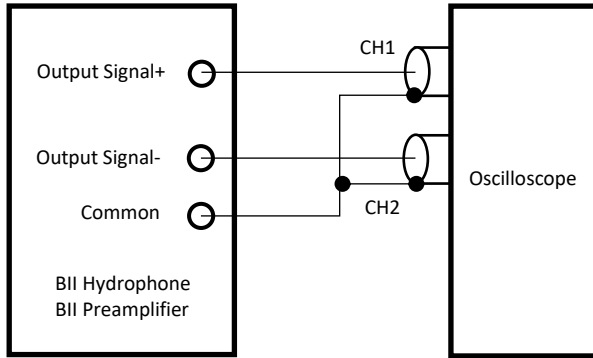


**BII's Differential Output to Differential Input of a DAQ**

If input impedance of a DAQ device is greater than 100MΩ, use following wiring with one 100kΩ to 1MΩ resistor.
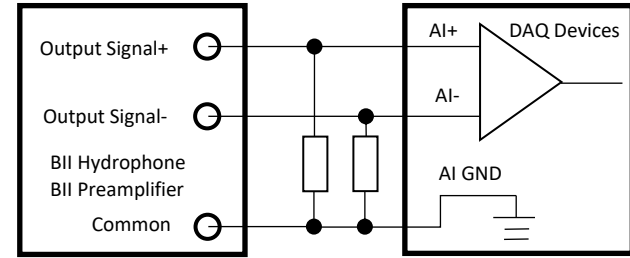


**BII's Single-Ended Output to Single-Ended Input of a DAQ**

If input impedance of a DAQ device is greater than 100MΩ, use following wiring with one 100kΩ to 1MΩ resistor.
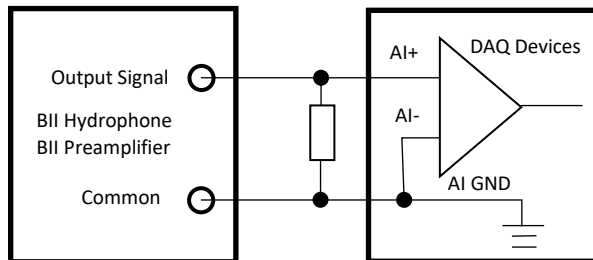


**BII's Single-Ended Output to Differential Input of a DAQ**
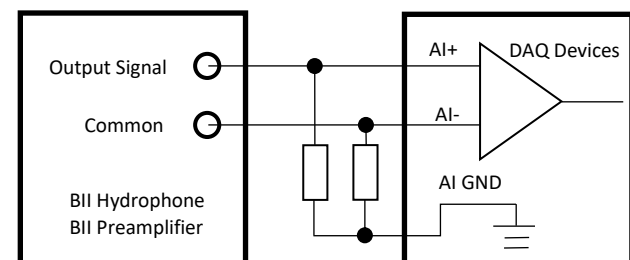


**BII's Differential Receiver to Differential Input of a BII Preamp**



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



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



## 2. Hydrophone (Sound Receiver) Wiring with Built-in Preamplifier

BII manufactures single-power-supply preamplifiers and split-power-supply preamplifiers with single-ended output and differential output, please double check the specification of preamplifiers before powering the hydrophone to avoid damaging the hydrophones.

**Wiring Information of Hydrophones with Fixed-gain Preamps:**

| Two-Wire Hydrophone | Two Conductor Shielded Cable | | | Coax + BNC Male | |
|---|---|---|---|---|---|
| +VDC and Signal | White or Red | | | Center Conductor | |
| Signal Common | Black | | | Shield | |
| Shielding | Shield (Connected to Common inside hydrophone or floating) | | | Shield | |

| Wiring of Single Ended Output: | Wire Leads | BNC Male/SMA/SMC, 9V Battery Snap | Underwater UMC4P or XLR4 Connector | XLR3 Plug and 9V Battery Snap | TRS Plug and 9V Battery Snap |
|---|---|---|---|---|---|
| +VDC | Red | Female Snap | Pin 3 | Battery Female Snap | Battery Female Snap |
| Common | Black | Male Snap | Pin 1 | Battery Male Snap | Battery Male Snap |
| Signal | White | Center Pin or Contact | Pin 2 | XLR Pin 2 | TRS Tip |
| Signal Common | Blue, Green, or Yellow | BNC/SMA/SMC Shield | Pin 4 | XLR Pin 1 and Pin 3 | TRS Ring and Sleeve |
| Shielding | Shield | N/A | N/A | XLR Metal Shell | N/A |
| Wiring of Differential Output: | Wire Leads | Underwater or XLR4 Connector | | XLR3 + 9V Battery Snap | TRS + 9V Battery Snap |
| +VDC | Red | Pin 3 | | Battery Female Snap | Battery Female Snap |
| Common | Black | Pin 1 | | Battery Male Snap | Battery Male Snap |
| Signal+ | White | Pin 2 | | XLR Pin 2 | TRS Tip |
| Signal- | Blue, Green or Yellow | Pin 4 | | XLR Pin 3 | TRS Ring |
| Signal Common | N/A | N/A | | XLR Pin 1 | TRS Sleeve |
| Shielding | Shield | N/A | | XLR Metal Shell | N/A |

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

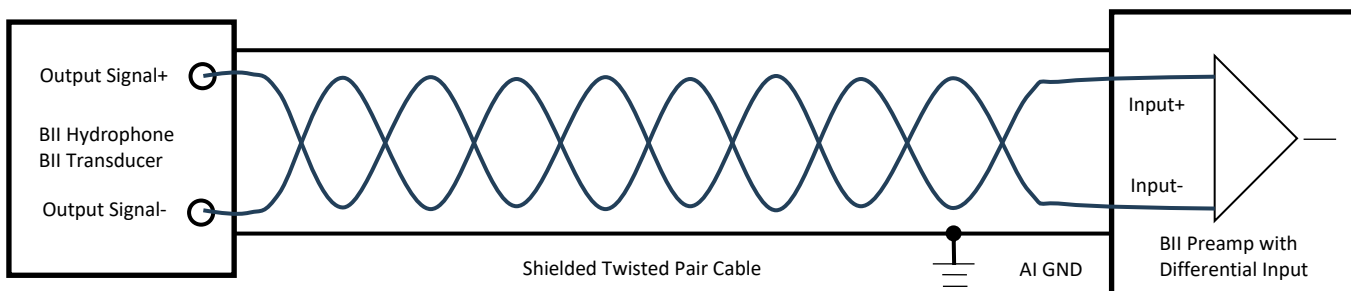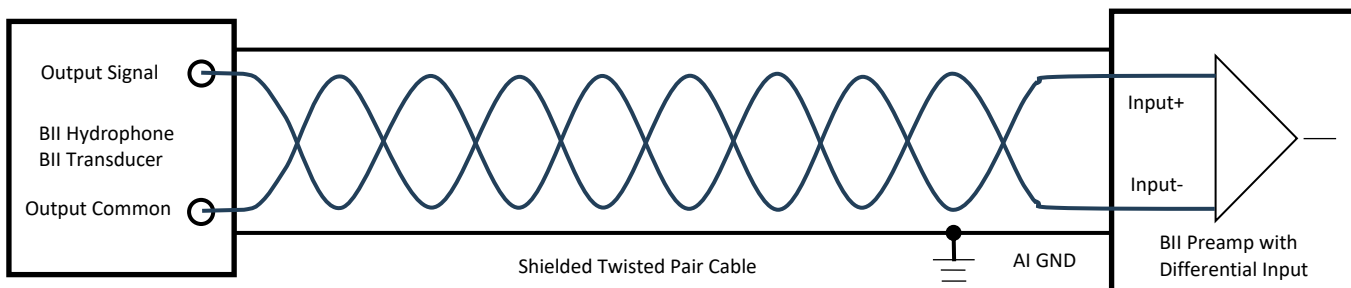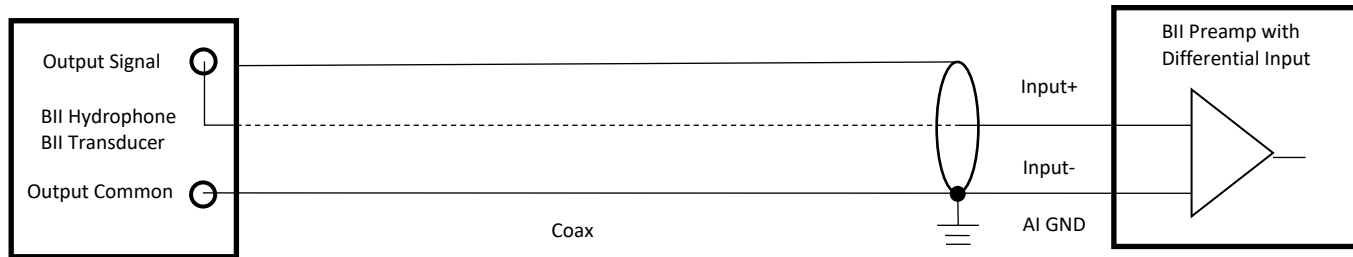| Wiring of Single Ended Output: | Wire Leads | 9V Battery Snap and BNC Male/SMA/SMC | Underwater UMC6P or XLR6 Connector | XLR3 Plug + 9V Battery Snap | TRS Plug + 9V Battery Snap |
|---|---|---|---|---|---|
| +VDC | Red | Battery Female Snap | Pin 3 | Battery Female Snap | Battery Female Snap |
| Common | Black | Battery Male Snap | Pin 1 | Battery Male Snap | Battery Male Snap |
| Digital Common | Black | Black | Pin 1 | Black | Black |
| Digital A1 (Gain Selection) | Yellow or Brown | Yellow or Brown | Pin 5 | Yellow or Brown | Yellow or Brown |
| Digital A0 (Gain Selection) | Blue | Blue | Pin 6 | Blue | Blue |
| Output Signal | White | BNC/SMA/SMC Center | Pin 2 | XLR Pin 2 | TRS Tip |
| Output Signal Common | Green | BNC/SMA/SMC Shield | Pin 4 | XLR Pin 1 and Pin 3 | TRS Ring and Sleeve |
| Shielding | Shield | Shield | N/A | XLR Metal Shell | N/A |
| Wiring of Differential Output: | Wire Leads | Underwater UMC6P or XLR6 Connector | | XLR3 Plug + 9V Battery Snap | TRS Plug + 9V Battery Snap |
| +VDC | Red | Pin 3 | | Battery Female Snap | Battery Female Snap |
| Common | Black | Pin 1 | | Battery Male Snap, XLR Pin 1. | Battery Male Snap, TRS Sleeve. |
| Digital Common | Black | Pin 1 | | Black | Black |
| Digital A1 (Gain Selection) | Yellow or Brown | Pin 5 | | Yellow or Brown | Yellow or Brown |
| Digital A0 (Gain Selection) | Blue | Pin 6 | | Blue | Blue |
| Output Signal + | White | Pin 2 | | XLR Pin 2 | TRS Tip |
| Output Signal - | Green | Pin 4 | | XLR Pin 3 | TRS Ring |
| Shielding | Shield | N/A | | XLR Metal Shell | N/A |

**Selecting Sensitivity FFVS of Two-bit Digitally Programmable**

| FFVS Selection Wire A1 | FFVS Selection Wire A0 | Hydrophone Sensitivity at 1kHz | Hydrophone Sensitivity at 1kHz |
|---|---|---|---|
| 0 (Logic Low) | 0 (Logic Low) | xxx + 0dB V/µPa | xxx + 20dB V/µPa |
| 0 (Logic Low) | 1 (Logic High) | xxx + 20dB V/µPa | xxx + 40dB V/µPa |
| 1 (Logic High) | 0 (Logic Low) | xxx + 40dB V/µPa | xxx + 60dB V/µPa |
| 1 (Logic High) | 1 (Logic High) | xxx + 60dB V/µPa | Xxx + 80dB V/µPa |

**Wiring Information of Hydrophones with One-bit Programmable Gain Preamps:**

| Wiring of Differential Output: | Wire Leads | Underwater UMC6P or XLR6 Connector | XLR3 + 9V Battery Snap | TRS + 9V Battery Snap |
|---|---|---|---|---|
| +VDC | Red | Pin 3 | Battery Female Snap | Battery Female Snap |

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| Common | Black | Pin 1 | Battery Male Snap, XLR Pin 1. | Battery Male Snap, TRS Sleeve. |
|---|---|---|---|---|
| Digital Common | Yellow or Brown | Pin 5 | Yellow or Brown | Yellow or Brown |
| Digital A0 (FFVS Selection) | Blue | Pin 6 | Blue | Blue |
| Output Signal+ | White | Pin 2 | XLR Pin 2 | TRS Tip |
| Output Signal - | Green | Pin 4 | XLR Pin 3 | TRS Ring |
| Shielding | Shield | N/A | XLR Metal Shell | N/A |
| **Wiring of Single-Ended Output:** | **Wire Leads** | **Underwater UMC6P or XLR6 Connector** | **XLR3 + 9V Battery Snap** | **TRS + 9V Battery Snap** |
| +VDC | Red | Pin 3 | Battery Female Snap | Battery Female Snap |
| Common | Black | Pin 1 | Battery Male Snap, XLR Pin 1. | Battery Male Snap, TRS Sleeve. |
| Digital Common | Yellow or Brown | Pin 5 | Yellow or Brown | Yellow or Brown |
| Digital A0 (FFVS Selection) | Blue | Pin 6 | Blue | Blue |
| Output Signal | White | Pin 2 | XLR Pin 2 | TRS Tip |
| Output Signal Common | Green | Pin 4 | XLR Pin 3 | TRS Ring |
| Shielding | Shield | N/A | XLR Metal Shell | N/A |
| **Selecting Sensitivity of One-bit Digitally Programmable** | | | | |
| **FFVS Selection Wire A0** | **Hydrophone Sensitivity FFVS at 1kHz.** | | | |
| 0 (Logic Low) | xxx + 20 dB V/µPa | | | |
| 1 (Logic High) | xxx + 50 dB V/µPa | | | |

**3. Hydrophone (Sound Receiver) Wiring without Built-in Preamplifier**

| **Wiring of Differential Output:** | **Wire Leads** | **Underwater Connector UMC3P** | **LEMO Connector** | **TRS Plug (Balanced Mono)** | **XLR3 (Balanced Audio)** |
|---|---|---|---|---|---|
| Signal + | White or Red | Pin 2 | Contact 2 | Tip, Positive/Hot | Pin 2, Positive/Hot. |
| Signal - | Black | Pin 1 | Contact 1 | Ring, Negative/Cold | Pin 3, Negative/Cold. |
| Common & Shielding | Shield | Pin 3 | Contact 3 | Sleeve, Ground/Common | Pin 1, Shield/Ground. |
| **Wiring of Single Ended Output:** | **Wire Leads** | **Underwater Connector UMC3P** | **BNC/SMA/SMC** | **Coax with Wire Leads** | **TRS Unbalanced mono** |
| Signal | White or Red | Pin 2 | Center Contact | Coax Center Contact | Tip |
| Signal Common | Black | Pin 1 | Shield | Coax Shield | Ring & Sleeve |
| Shielding | Shield | Pin 3 | Shield | Coax Shield | Ring & Sleeve |
| **Underwater Projector Application**: for 50Ω BNC/SMA/SMC connector, it is buyer's sole responsibility to make sure that the BNC/SMA/SMC shield of the signal source is firmly grounded for operating safety before hooking up transducer/hydrophone to the signal source. Coax with BNC/SMA/SMC is not intended for hand-held use at voltages above 30Vac/60Vdc. | | | | | |

## Wirings of BII Transducers (Projectors)

BII transducers and projectors take differential (bridge) driving signals and single ended driving signals. This document contains following wiring information of BII Transducers and Projectors:
1. Electrical Wiring of BII Transducers without T/R Switch.
2. Electrical Wiring of BII Transducers with T/R Switch and Two Shielded Cables.

DANGER! HIGH VOLTAGE on the cable and wires of the transducers and projectors.
DO NOT TOUCH THE DEVICE, ITS WIRES AND CABLES BEFORE THE POWER SUPPLY IS SHUT DOWN.
All exposed bare wires, metal wires, wire leads and solders should be water-proofed (withstanding the pressure rating if any), and insulated with insulation material.
Insulation voltage must be greater than 1500 VDC and 1000 Vrms AC.
The cable shields should be grounded for operating safety. The wires should be shielded with shielding and grounded.

**1. Electrical Wiring of BII Transducer without T/R Switch**

| **Transmitting Wiring with Single Ended Driving Signal.** for multiple arrays inside a transducer, the cables will be labelled with #1, #2, #3, #4, #5 …. | | | | | |
|---|---|---|---|---|---|
| **Transducer Wiring:** | **Two Conductor Shielded Cable** | **Coax, BNC, SMC, or SMA** | **Underwater Connector UMC3P** | **MIL-5015 Connector** | **XLR3** |
| Signal: | White or Red | Center Contact | Contact 2 | Contact C | Pin 2 |
| Signal Common: | Black | Shield | Contact 1 | Contact B | Pin 3 |
| Shielding and Grounding | Shield | Shield | Contact 3 | Contact A | Pin 1 |
| **Transmitting Wiring with Differential Driving Signal.** for multiple arrays inside a transducer, the cables will be labelled with #1, #2, #3, #4, #5 …. | | | | | |
| **Wiring:** | **Two Conductor Shielded Cable** | **Underwater Connector UMC3P** | **MIL-5015 Connector** | **XLR3 Receptacle with 3 Pins.** | |
| Transmitting Signal + | White or Red | Contact 2 | Contact C | Pin 2 | |
| Transmitting Signal - | Black | Contact 1 | Contact B | Pin 3 | |
| Shielding and Grounding | Shield | Contact 3 | Contact A | Pin 1 | |

**2. Electrical Wiring of BII Transducers with T/R Switch and Two Shielded Cables**

| **Transmitting Wiring with Single Ended Driving Signal.** | | | | | |
|---|---|---|---|---|---|
| **Transducer Wiring:** | **Two Conductor Shielded Cable** | **Coax, BNC, SMC, or SMA** | **Underwater Connector UMC3P** | **MIL-5015 Connector** | **XLR3** |
| Signal: | White or Red | Center Contact | Contact 2 | Contact C | Pin 2 |
| Signal Common: | Black | Shield | Contact 1 | Contact B | Pin 3 |
| Shielding and Grounding | Shield | Shield | Contact 3 | Contact A | Pin 1 |

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**Transmitting Wiring with Differential Driving Signal.**

| Wiring: | Two Conductor Shielded Cable | Underwater Connector UMC3P | MIL-5015 Connector | XLR3 Receptacle with 3 Pins. |
|---|---|---|---|---|
| Transmitting Signal + | White or Red | Contact 2 | Contact C | Pin 2 |
| Transmitting Signal - | Black | Contact 1 | Contact B | Pin 3 |
| Shielding and Grounding | Shield | Contact 3 | Contact A | Pin 1 |

**Wiring Information of Two-bit Programmable Gain T/R Switch:**

| Wiring of Single Ended Output: | Wire Leads | 9V Battery Snap and BNC Male/SMA/SMC | Underwater UMC6P or XRL6 Connector | XLR3 + 9V Battery Snap | TRS Plug + 9V Battery Snap |
|---|---|---|---|---|---|
| +VDC | Red | Battery Female Snap | Pin 3 | Battery Female Snap | Battery Female Snap |
| Common | Black | Battery Male Snap | Pin 1 | Battery Male Snap | Battery Male Snap |
| Digital Common | | Black | | Black | Black |
| Digital A1 (Gain Selection) | Yellow or Brown | Yellow or Brown | Pin 5 | Yellow or Brown | Yellow or Brown |
| Digital A0 (Gain Selection) | Blue | Blue | Pin 6 | Blue | Blue |
| Output Signal | White | BNC/SMA/SMC Center | Pin 2 | XLR Pin 2 | TRS Tip |
| Output Signal Common | Green | BNC/SMA/SMC Shield | Pin 4 | XLR Pin 1 and Pin 3 | TRS Ring and Sleeve |
| Shielding | Shield | Shield | N/A | XLR Metal Shell | N/A |
| **Wiring of Differential Output:** | **Wire Leads** | **Underwater or XLR6 Connector** | | **XLR3 + 9V Battery Snap** | **TRS Plug + 9V Battery Snap** |
| +VDC | Red | Pin 3 | | Battery Female Snap | Battery Female Snap |
| Common | Black | Pin 1 | | Battery Male Snap, XLR Pin 1. | Battery Male Snap, TRS Sleeve. |
| Digital Common | | | | Black | Black |
| Digital A1 (Gain Selection) | Yellow or Brown | Pin 5 | | Yellow or Brown | Yellow or Brown |
| Digital A0 (Gain Selection) | Blue | Pin 6 | | Blue | Blue |
| Output Signal + | White | Pin 2 | | XLR Pin 2 | TRS Tip |
| Output Signal - | Green | Pin 4 | | XLR Pin 3 | TRS Ring |
| Shielding | Shield | N/A | | XLR Metal Shell | N/A |

**Selecting Sensitivity FFVS of Two-bit Digitally Programmable**

| FFVS Selection Wire A1 | FFVS Selection Wire A0 | Receiving Sensitivity at 1kHz | Receiving Sensitivity at 1kHz |
|---|---|---|---|
| 0 (Logic Low) | 0 (Logic Low) | xxx + 0dB V/µPa | xxx + 20dB V/µPa |
| 0 (Logic Low) | 1 (Logic High) | xxx + 20dB V/µPa | xxx + 40dB V/µPa |
| 1 (Logic High) | 0 (Logic Low) | xxx + 40dB V/µPa | xxx + 60dB V/µPa |
| 1 (Logic High) | 1 (Logic High) | xxx + 60dB V/µPa | Xxx + 80dB V/µPa |

**Wiring Information of One-bit Programmable Gain T/R Switch:**

| Wiring of Differential Output: | Wire Leads | Underwater UMC6P or XLR6 Connector | XLR3 + 9V Battery Snap | TRS + 9V Battery Snap |
|---|---|---|---|---|
| +VDC | Red | Pin 3 | Battery Female Snap | Battery Female Snap |
| Common | Black | Pin 1 | Battery Male Snap, XLR Pin 1. | Battery Male Snap, TRS Sleeve. |
| Digital Common | Yellow or Brown | Pin 5 | Yellow or Brown | Yellow or Brown |
| Digital A0 (FFVS Selection) | Blue | Pin 6 | Blue | Blue |
| Output Signal+ | White | Pin 2 | XLR Pin 2 | TRS Tip |
| Output Signal - | Green | Pin 4 | XLR Pin 3 | TRS Ring |
| Shielding | Shield | N/A | XLR Metal Shell | N/A |
| **Wiring of Single-Ended Output:** | **Wire Leads** | **Underwater or XLR6 Connector** | **XLR3 + 9V Battery Snap** | **TRS + 9V Battery Snap** |
| +VDC | Red | Pin 3 | Battery Female Snap | Battery Female Snap |
| Common | Black | Pin 1 | Battery Male Snap, XLR Pin 1. | Battery Male Snap, TRS Sleeve. |
| Digital Common | Yellow or Brown | Pin 5 | Yellow or Brown | Yellow or Brown |
| Digital A0 (FFVS Selection) | Blue | Pin 6 | Blue | Blue |
| Output Signal | White | Pin 2 | XLR Pin 2 | TRS Tip |
| Output Signal Common | Green | Pin 4 | XLR Pin 3 | TRS Ring |
| Shielding | Shield | N/A | XLR Metal Shell | N/A |

**Selecting Sensitivity of One-bit Digitally Programmable**

| FFVS Selection Wire A0 | Receiving Sensitivity FFVS at 1kHz. | |
|---|---|---|
| 0 (Logic Low) | xxx + 20 dB V/µPa | xxx + 30 dB V/µPa |
| 1 (Logic High) | xxx + 50 dB V/µPa | xxx + 70 dB V/µPa |

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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. |
| Connectors | Excellent adhesion and water-proof sealing with marine epoxy, polyurethane, and rubber potting compounds. |
| 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. ||
| **Repair Processes** ||
| **Surface Preparation:** | Clean surface area of dirt, grease, oil, or loose debris. For best results use a detergent or degreaser such as Isopropyl Alcohol to first clean the surface, then roughen surface with file or coarse sandpaper to provide the best repair. |
| **Weighting, Mixing and Curing:** | Following instruction of the potting compounds.<br>Note: some potting compounds might need primer to achieve better adhesion on rubber housing and cable. |
| It is strongly recommended to cure the compounds with temperature less than or equal to 60°C or 140°F. ||

**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. **Threadlockers** are recommended to prevent threaded fasteners from loosening due to shock and vibration. Threadlockers is 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 air transducers and shallow-water (<100 m) transducers. Specify this customization when ordering.

Maximum diameters of typical free-hanging mounting parts (mm):
Plastics: Φ16, Φ21, Φ25, Φ37 …
Stainless Steel: Φ22.
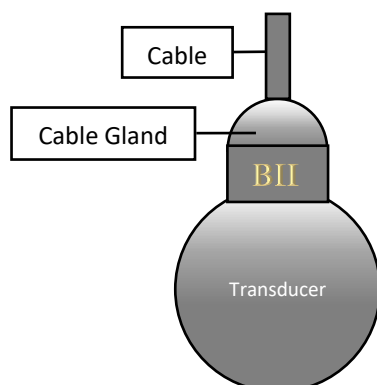




**BII7011/BII7012 Hydrophones: Default Free Hanging with Smooth Domes.**
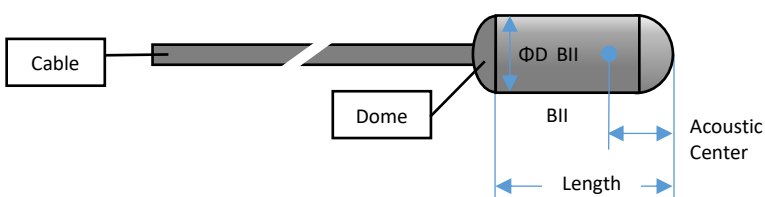
**BII7011/BII7012 Hydrophones: Free Hanging wih Short Length.**
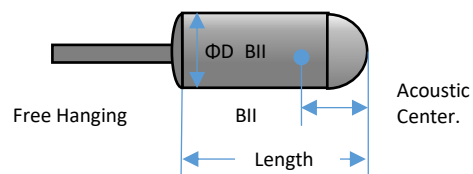


The hydrophone body has streamlined hemispherical domes which minimize the drag forces and the hydrodynamic noise caused by the hydrophone in motion or the flow past the hydrophone.

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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.
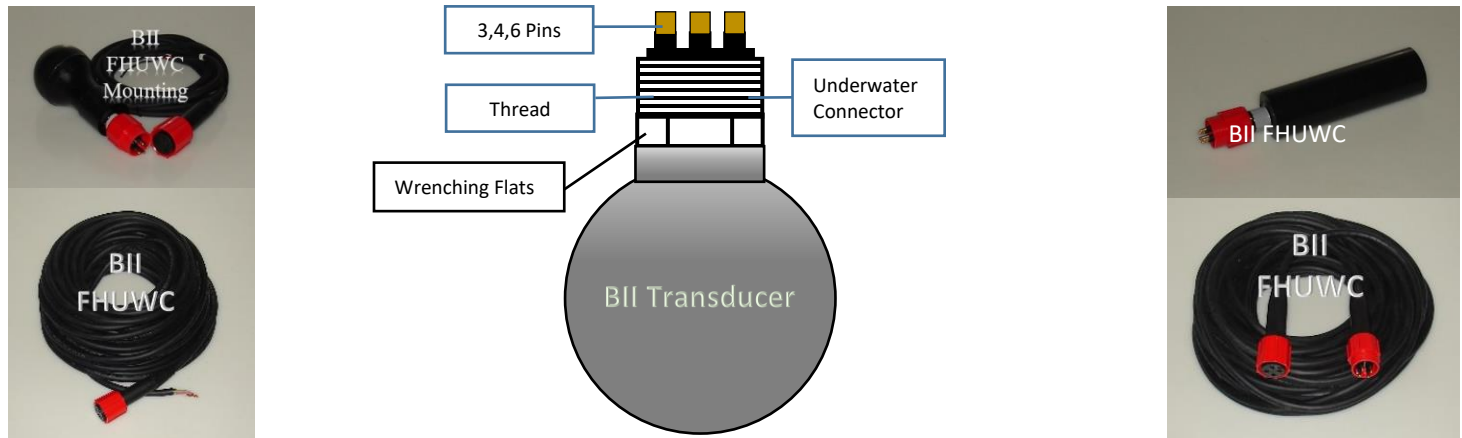


**Free Hanging with Underwater Connector (FHUWC) and Accessories**
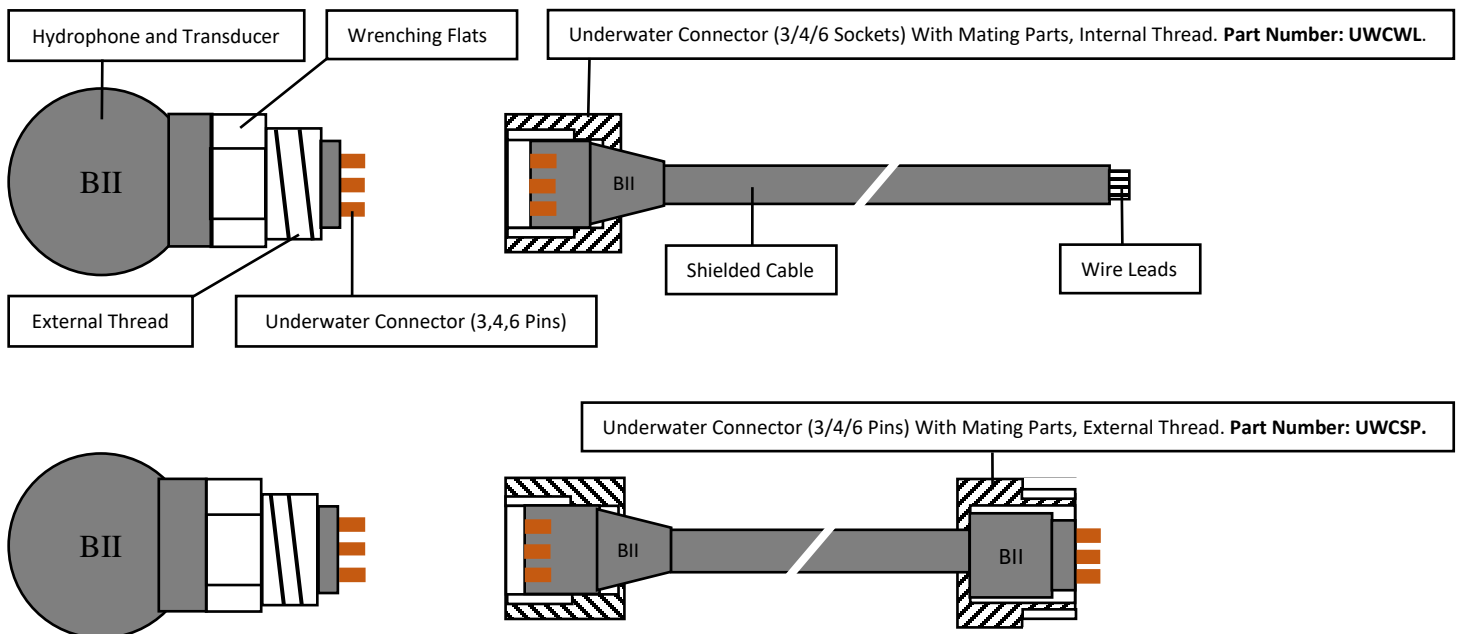


| Underwater Connector and Accessories: Hookup to Data Acquisition System, Cable Extension, etc. | |
|---|---|
| **Part Number:** | **Description** |
| FHUWC-3P | An Underwater Connector (3 Pins, External Thread) are encapsulated on Transducers/Hydrophones. |
| FHUWC-4P | An Underwater Connector (4 Pins, External Thread) are encapsulated on Transducers/Hydrophones. |
| FHUWC-6P | An Underwater Connector (6 Pins, External Thread) are encapsulated on Transducers/Hydrophones. |
| UWCWL: | Underwater Connector with Socket insert and Internal-Thread Mating Parts, customized-length shielded cable, Wire Leads |
| UWCSP: | Underwater Connector with Socket insert and Internal-Thread Mating Parts, customized-length shielded cable, Underwater Connector with Pin insert and External-Thread Mating Parts. |
| The mating connector installed on buyer's devices can be purchased from BII or the local suppliers in buyer's country. Please contact BII for more information. | |

**Hydrophone: Free-hanging with Underwater Connector (FHUWC), 3 Pins (No Preamplifier), 4 Pins (Fixed Sensitivity), and 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-M10x14 |
|---|---|---|---|
| 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. | | | |
| **Threadlockers 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.

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Cable or Wires

Lock Nut

Threads

Flat

BII

Mounting Wall
With Thru-hole

Dry Spaces,
Inside Submersibles.

Wrenching Flats: 19mm
Wrench Height < 6mm.

O-ring

Water. Outside Submersibles.

**Metric Thread Installation without Nut and Washer**
Refer to Thread Sealing Tips.
It is buyer's responsibility and liability to take measures (such as threadlockers etc…) at buyer's cost to prevent the installation from being loose or detached.

Mounting Wall
With M10x1.5 Thread

Cable or Wires

Threads

BII

Dry Spaces,
Inside Submersibles.

Wrenching Flats: 19mm

O-ring

Water. Outside Submersibles.

Mounting Wall
With M10x1.5 Thread

Cable or Wires

Thread

BII

Dry Spaces,
Inside Submersibles.

Wrenching Flats: 19mm
Wrench Height < 6mm.

O-ring

Water. Outside Submersibles.

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

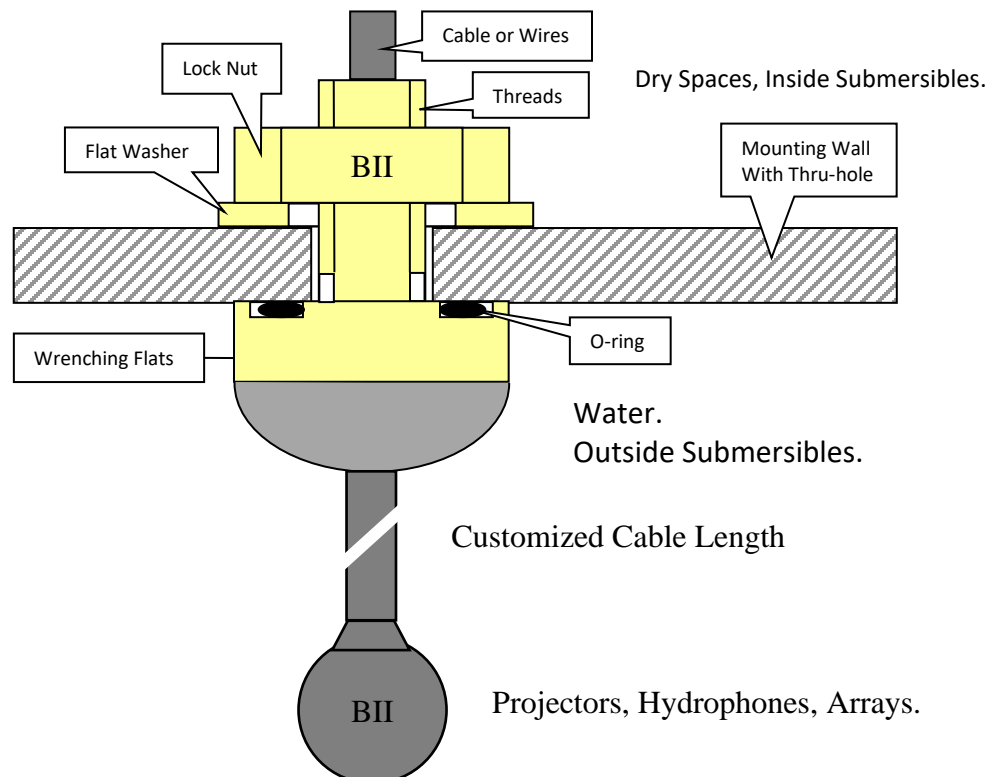| Part Number: | THFH-M10 | THFH-7/16" | THFH-1/2" | THFH-5/8" | THFH-1" |
|---|---|---|---|---|---|
| Thread (Right Hand): | M10x1.5x22 | 7/16"-20x22 UNF-2A | 1/2"-13x22 UNC-2A | 5/8"-18x27 UNF-2A | 1"-14x25.4 UNS-2A |
| Application: | | Projector or Hydrophone | | Arrays | |
| Material: | Stainless 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. | | | | | |
| Threadlockers 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



THFH Mounting

**Installation:**



Dry Spaces, Inside Submersibles.

Water.
Outside Submersibles.

Customized Cable Length

Projectors, Hydrophones, Arrays.

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

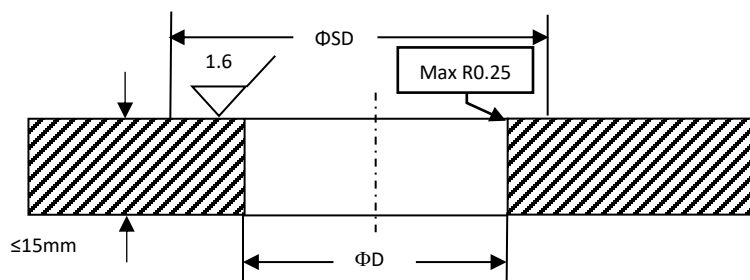| Part Number: | THM-7/16" | THM-1/2" | THM-5/8" | THM-1" |
|---|---|---|---|---|
| Thread (Right Hand): | 7/16"-20x22 UNF-2A | 1/2"-13x22 UNC-2A | 5/8"-18x27 UNF-2A | 1"-14x25.4 UNS-2A |
| Application: | Projector or Hydrophone | | Arrays | |
| Material: | Stainless Steel | Anodized Aluminum | Stainless 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. | | | | |
| Threadlockers are recommended to prevent threaded fasteners from loosening due to shock and vibration. NOT provided by BII. | | | | |

**Recommended Mounting hole Size**



**Transducer/Hydrophone Installation:**



**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".**

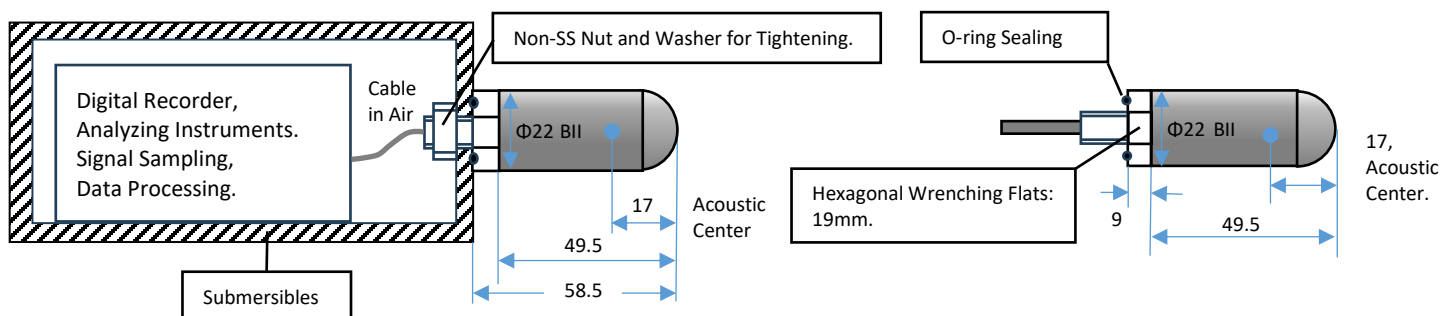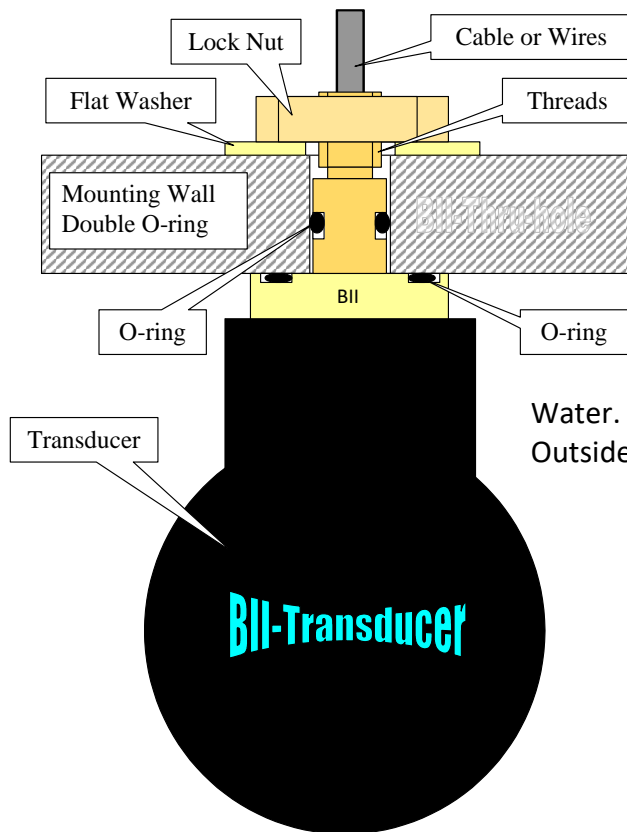| Maximum Depth: 2500 m. | Thread: 7/16"-20x25 UNF-2A (Right Hand). | Maximum Diameter: Φ25 mm | Fastening Torque: ≤30 Nm. |
|---|---|---|---|
| O-rings (012 and 015), flat washer and nut are included. | | Thickness of Mounting Wall: 8 to 18 mm. | |
| Service Temperature: | 1. Default: -40 to 140 °F 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. | | | |
| Threadlockers 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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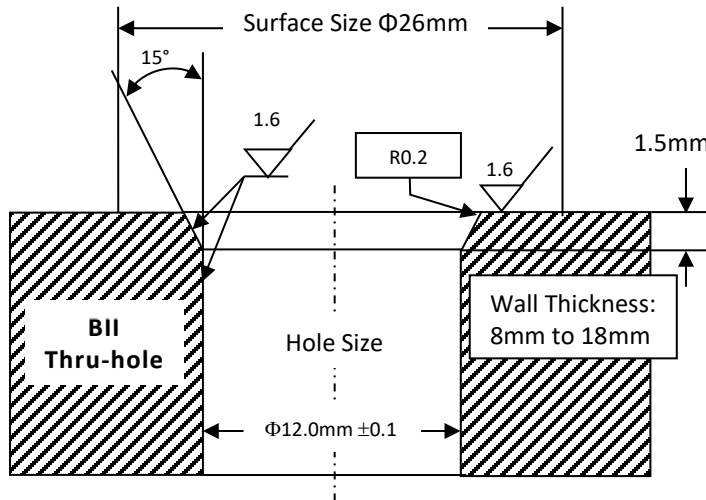
## Bolt-Fastening Mount (Dimension Unit: mm)

| Part Number | BFM-M6 | BFM-7/16" | BFM-5/8" | BFM-FH | BFMP-M12 | BFMP-NPT3/8" |
|---|---|---|---|---|---|---|
| Application: (Portable Apparatus) | Small Device, Array Element. | Single Device, Array Element. | Single Device, Array Element. | Large Heavy 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"-16x1.25 | M12x1.5x8mm | NPT3/8"x15mm |
| Maximum Diameter: | Φ9.25 | Φ22 | Φ27 | Φ38 | Φ20.5 | Φ24 |
| Maximum Depth: | 2000 m | 2000 m | 2000 m | 500 m | 300 m | 300 m |
| Accessories: | Flat Washer and Nut | | | Nut and washers | Lock nut Height: 5mm | Lock nut Height: 5mm |
| | Flat washer: included ONLY for heavy transducer (weight > 5 kg). | | | | | |
| 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 | ≤ 8 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 | Φ12.1 to Φ13.0 mm | Φ17.0 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. | | | -4 to 176 °F or -20 to 80 °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. | | | | | | |
| Threadlockers are recommended to prevent threaded fasteners from loosening due to shock and vibration. NOT provided by BII. | | | | | | |

**Bolt Fastening Mounting**



**Mounting Hole**



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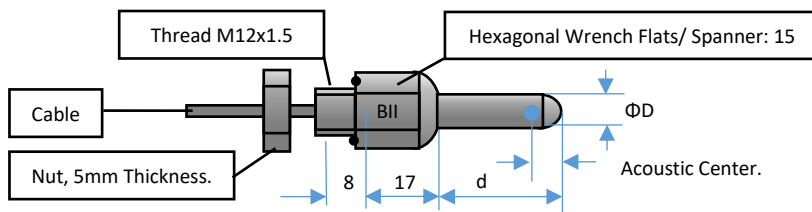


Bolt-Fastening Mount (Plastics) (**BFMP-M12x1.5**)
**Thread**: M12x1.5, Lock nut: included.
**Maximum Depth**: 300 m.
**Mounting Hole**: Φ12.1 to Φ13.0 mm.
**Fastening Torque**: ≤ 1.5 Nm.
**Mounting Wall Thickness**: ≤ 3 mm.

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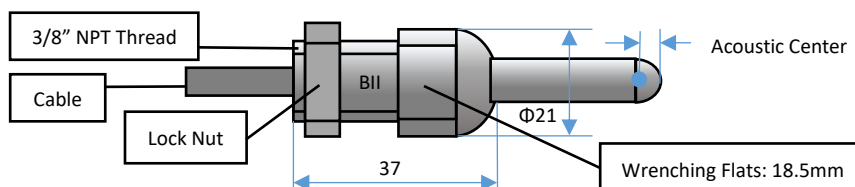


Bolt-Fastening Mount (Plastics) (**BFMP-NPT3/8"**)
**Thread**: NPT-3/8", Lock nut: included.
**Maximum Depth**: 300 m.
**Mounting Hole**: Φ17.0±0.1 mm.
**Fastening Torque**: ≤ 2.5 Nm.
**Mounting Wall Thickness**: ≤ 10 mm.

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



SS Nut and Washer for Tightening.

Frames/Fixtures/Jigs for Mounting

Digital Recorder,
Analyzing Instruments.
Signal Sampling,
Data Processing.

Cable in Water

Φ22 BII

17  Acoustic Center

49.5

58.5

Hexagonal Wrenching Flats: 19mm.

Φ22 BII

17, Acoustic Center.

9

49.5
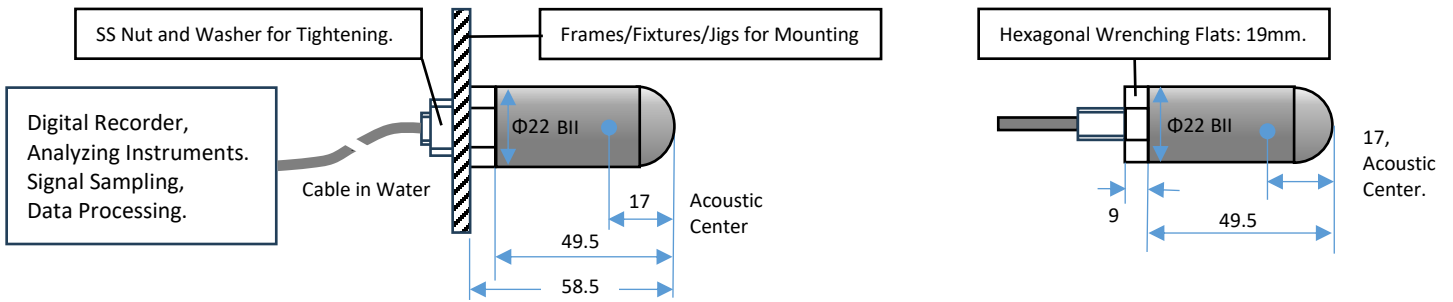
## Bolt-Fastening Mounting with Free Hanging BFM-FH
**Line (Rectangular) Array Overal Size (Dimensional Unit: mm).** following transducer structures are for illustration ONLY.



Cable

3.5" or 89mm

7" or 178mm

2 x 3/8"-16 x 1.25" 316 SS

BII

ΦD=Φ42, Φ48, Φ60, or Φ89mm
Determined by aperture size.

Radiation & Receiving Face

Front View

Line Arrays inside Housing

2 x 3/8"-16 x 1⅛"
316 SS Screw

Cable

BII

Line Arrays

Right View

Acoustic Window

BII

Aperture Length + 25 to 35 mm

Bottom View
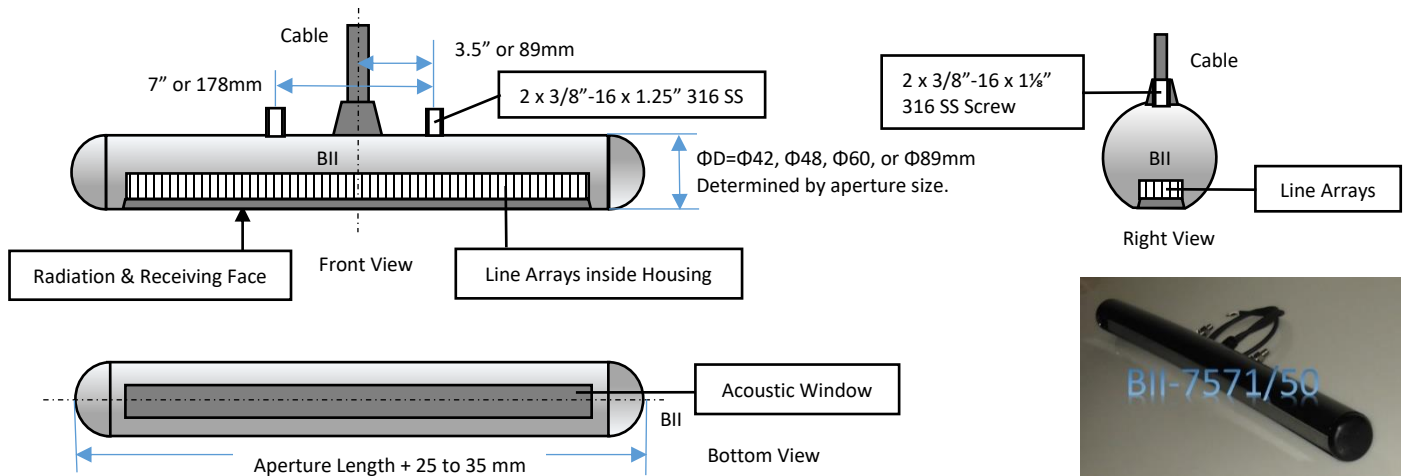
**Spherical, Hemispherical, Cylindrical and Planar Transducers with BFM-FH (Bolt Fastening Mounting with Free Hanging).**



Cable

Transducer
ΦD ≥ 2"

2 x 3/8"-16 x 1.25"
316 SS Screw

BII

32mm

Top View

BII

Front View

3/8"-16 x 1.25"
316 SS Screw

Cable

Transducer
ΦD < 2"

BII

Top View

BII

Front View

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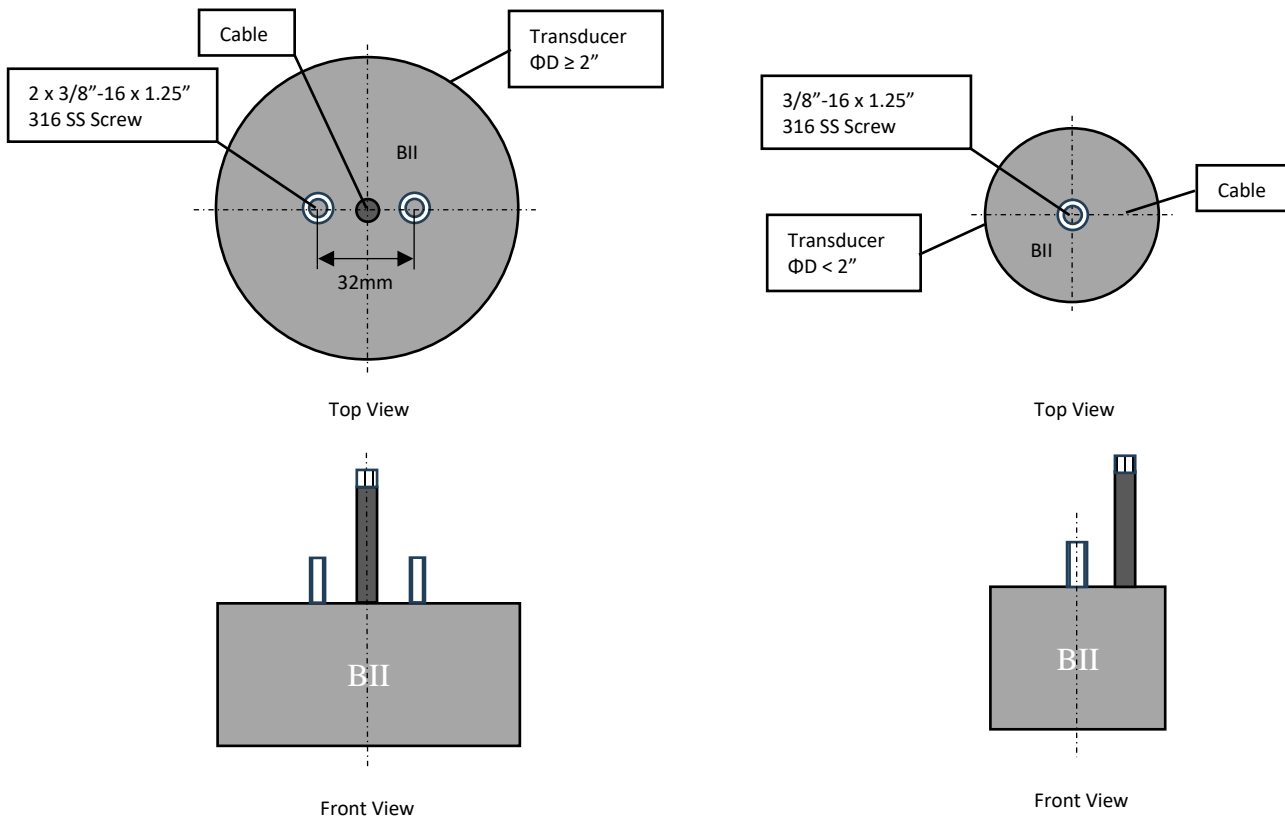
## Bolt-Fastening Front Mount (Dimension Unit: mm)

| 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. | | |
| Threadlockers 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)



ΦOD

Hydrophone/Transducer:
No Preamp, diameter ΦOD ≤ 14mm.

Threads 5/8"-18x22 mm UNF (Right Hand)

Lock Nut

Mounting Wall With Thru-hole

Flat Washer

BII

Shielded Cable

BII-7013 BFFMRA

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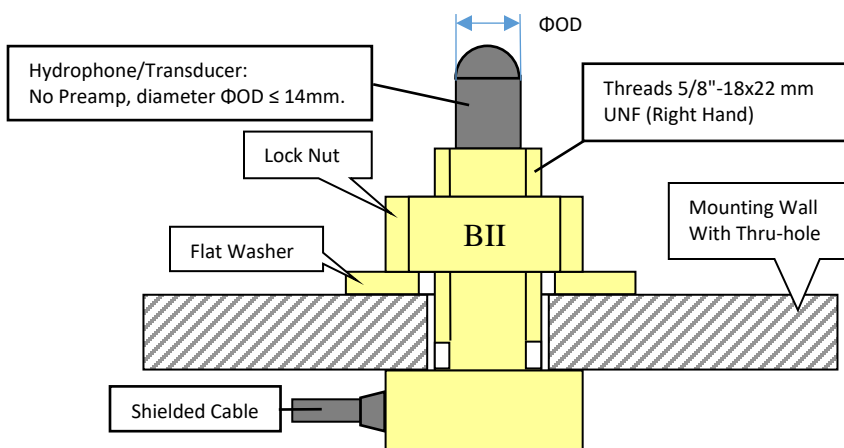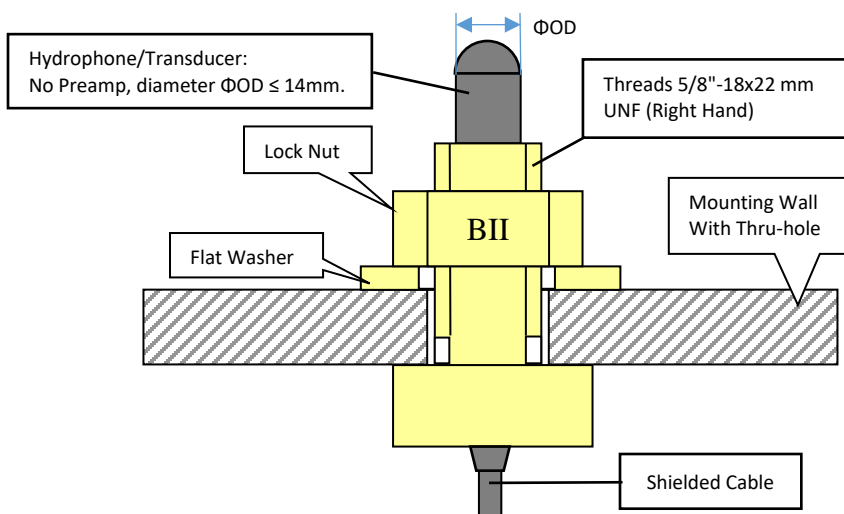Mounting Thickness: ≤12.7mm.

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

ΦOD

Hydrophone/Transducer:
No Preamp, diameter ΦOD ≤ 14mm.

Threads 5/8"-18x22 mm UNF (Right Hand)

Lock Nut

Mounting Wall With Thru-hole

BII

Flat Washer

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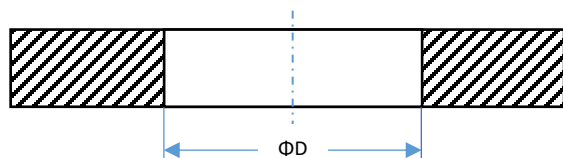
Sensing Element ≤ Φ14mm.
Mounting Hole: Φ16.0±0.1mm.
Fastening Torque: ≤30Nm.
Mounting Thickness: ≤12.7mm.

### Mounting Hole

ΦD

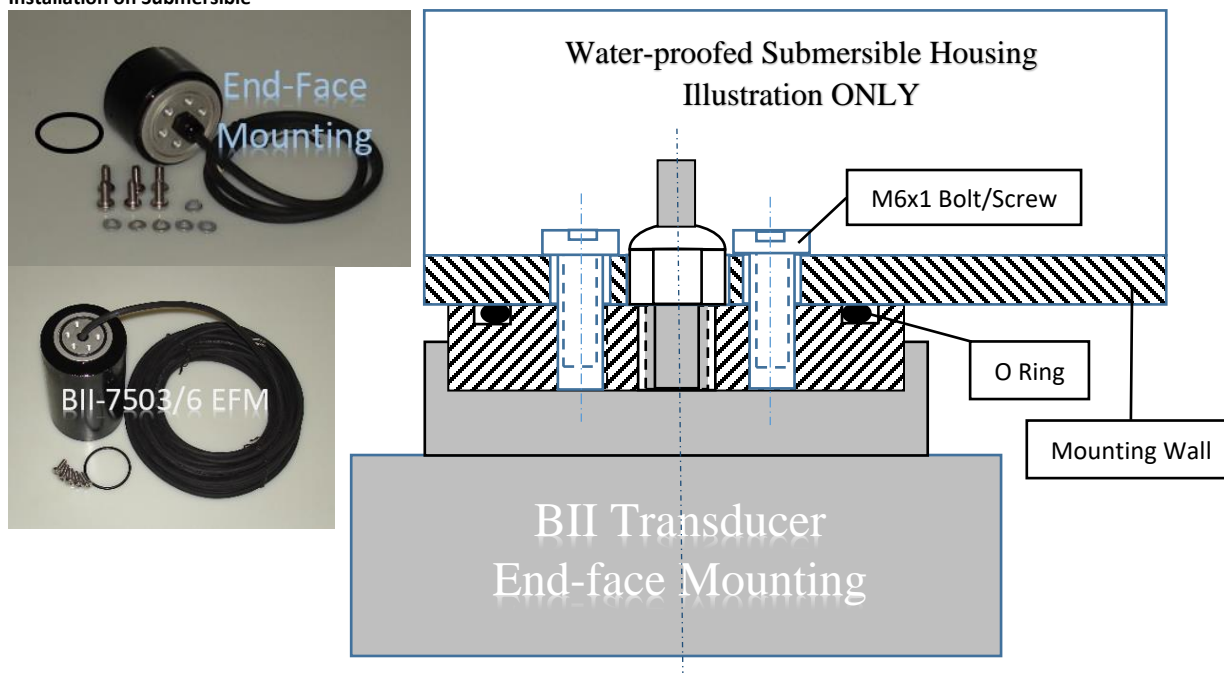# Benthowave Instrument Inc.

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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. | |
| Theaded 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 thichness 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 | |
| Threadlockers 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**



6 M6x1x12.7 Threaded Holes, Equal Spacing on 31mm PCD (Pitch Circle Diameter).

Warning: Depending on the thickness of mounting wall, proper screw length should be used at buyer's cost. If screw length was too long, internal part of the transducer would be damaged when tightening; if screw length was too short, thread of the End-face part would be damaged by transducer weight or tightening torque. Mounting wall thickness T should be: 3.5 mm < T < 8 mm for M6x1x16 Screws.

**Installation on Submersible**

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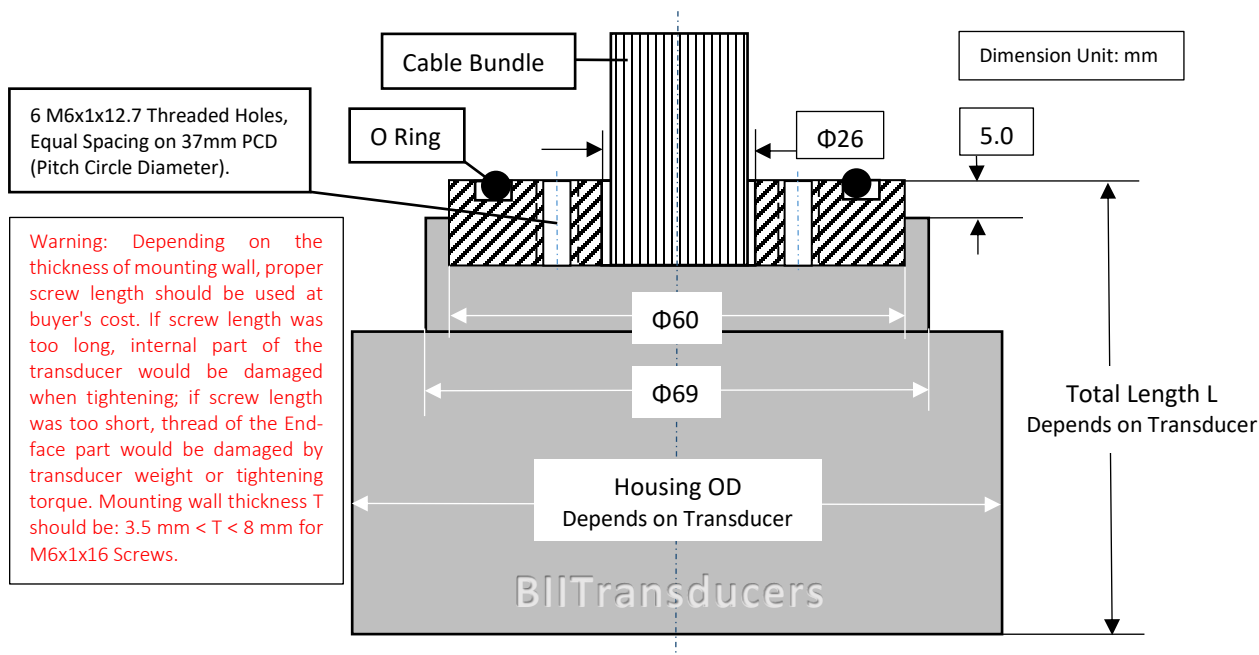
**BII**
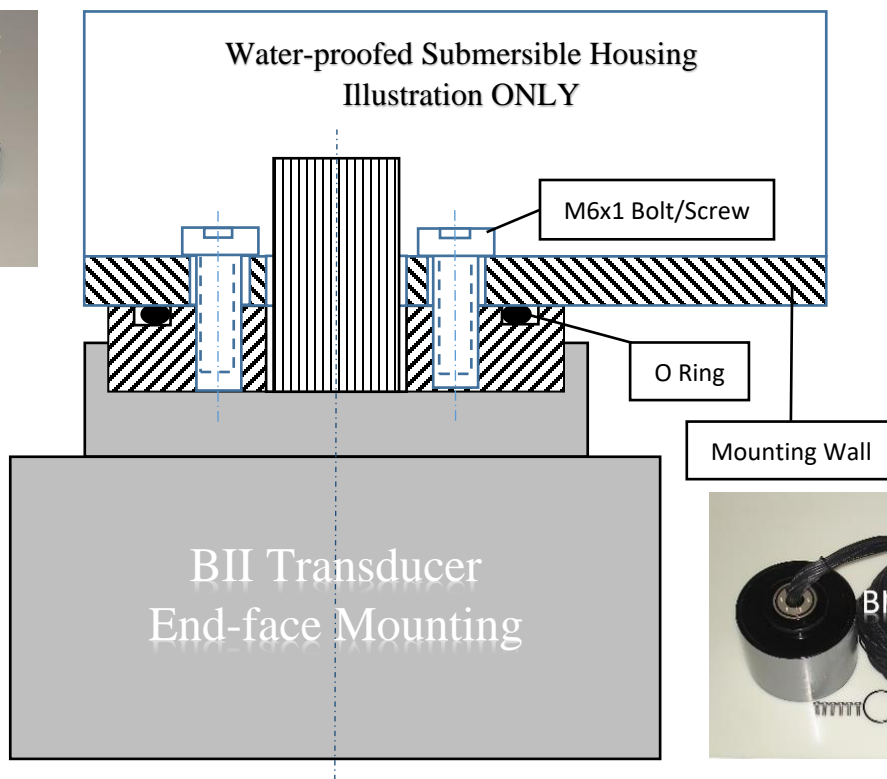SE=SL-TL+AG-NL

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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.

Cable Bundle

O Ring

Φ26

Dimension Unit: mm

5.0

6 M6x1x12.7 Threaded Holes, Equal Spacing on 37mm PCD (Pitch Circle Diameter).

Warning: Depending on the thickness of mounting wall, proper screw length should be used at buyer's cost. If screw length was too long, internal part of the transducer would be damaged when tightening; if screw length was too short, thread of the End-face part would be damaged by transducer weight or tightening torque. Mounting wall thickness T should be: 3.5 mm < T < 8 mm for M6x1x16 Screws.

Φ60

Φ69

Total Length L
Depends on Transducer

Housing OD
Depends on Transducer

BIITransducers

**Installation on Submersible**

BII End-face Mounting

Water-proofed Submersible Housing
Illustration ONLY

M6x1 Bolt/Screw

O Ring

Mounting Wall

BII Transducer
End-face Mounting

BN-7716/50
EFMM

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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. | | | | | |
| Threadlockers are recommended to prevent threaded fasteners from loosening due to shock and vibration. NOT provided by BII. | | | | | |

**Flange Mounting**
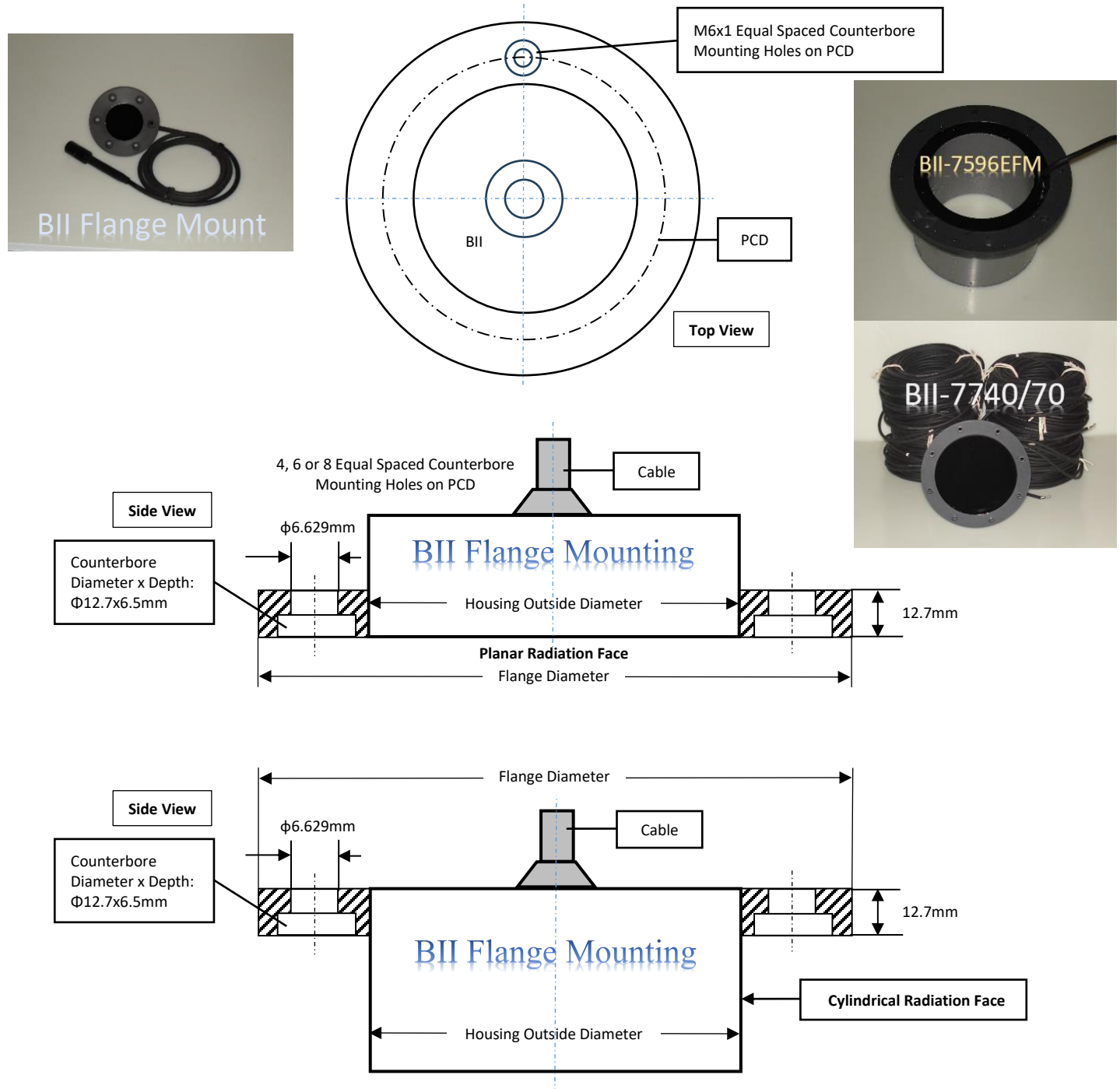


| Part Number | Flange Diameter (mm) | Pitch Circle Diameter PCD (mm) | Housing Outside Diameter (mm) | M6x1 Mounting Hole Number on PCD | Flange Thickness (mm) |
|---|---|---|---|---|---|
| FGM-Φ220 | Φ220 | Φ195 | Φ168 | 8 | 12.7 |
| FGM-Φ190 | Φ190 | Φ165 | Φ141 | 8 | 12.7 |
| FGM-Φ165 | Φ165 | Φ140 | 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 |

Go back to Catalogue

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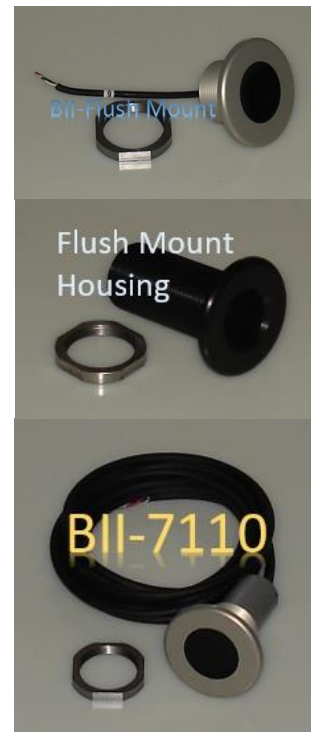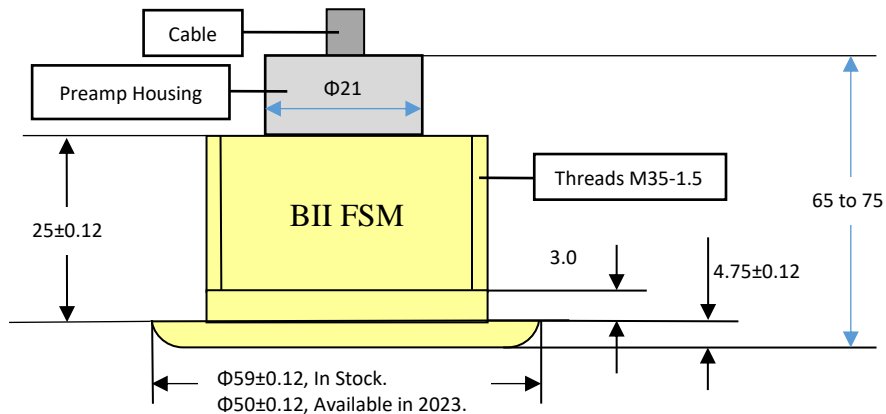
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## Flush Mount (Marine Sealant or Gasket) (FSM) (Dimension Unit: mm)

| 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-M55 | ≤ Φ47 mm | Anodized Aluminum | M55x1.5 | 29.75, 50. | Φ70 | ≤ (L − 13) | ≤ 30 Nm |
| FSM-M70 | ≤ Φ62 mm | Anodized Aluminum | M70x1.5 | 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. |
| **Threadlockers 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):**
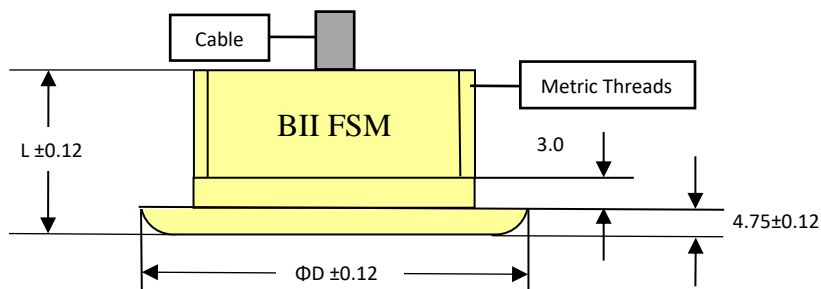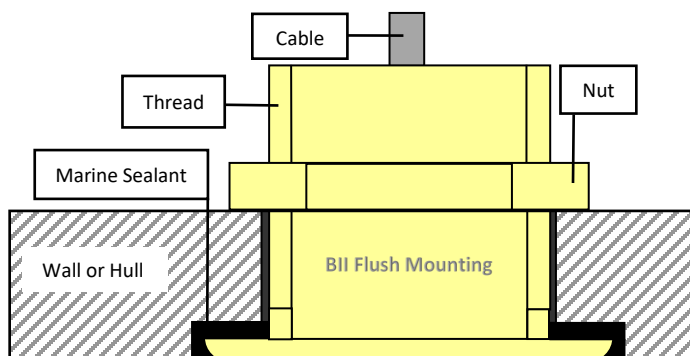


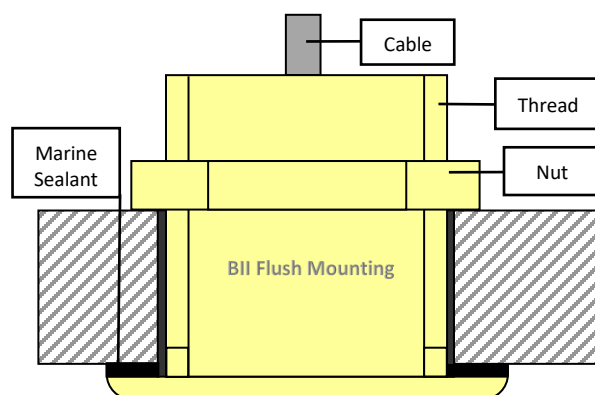**Flush Mounting Parts for Hydrophones with Built-in Preamp, Physical Size (Dimensional Unit: mm):**



**Installation/Mounting**

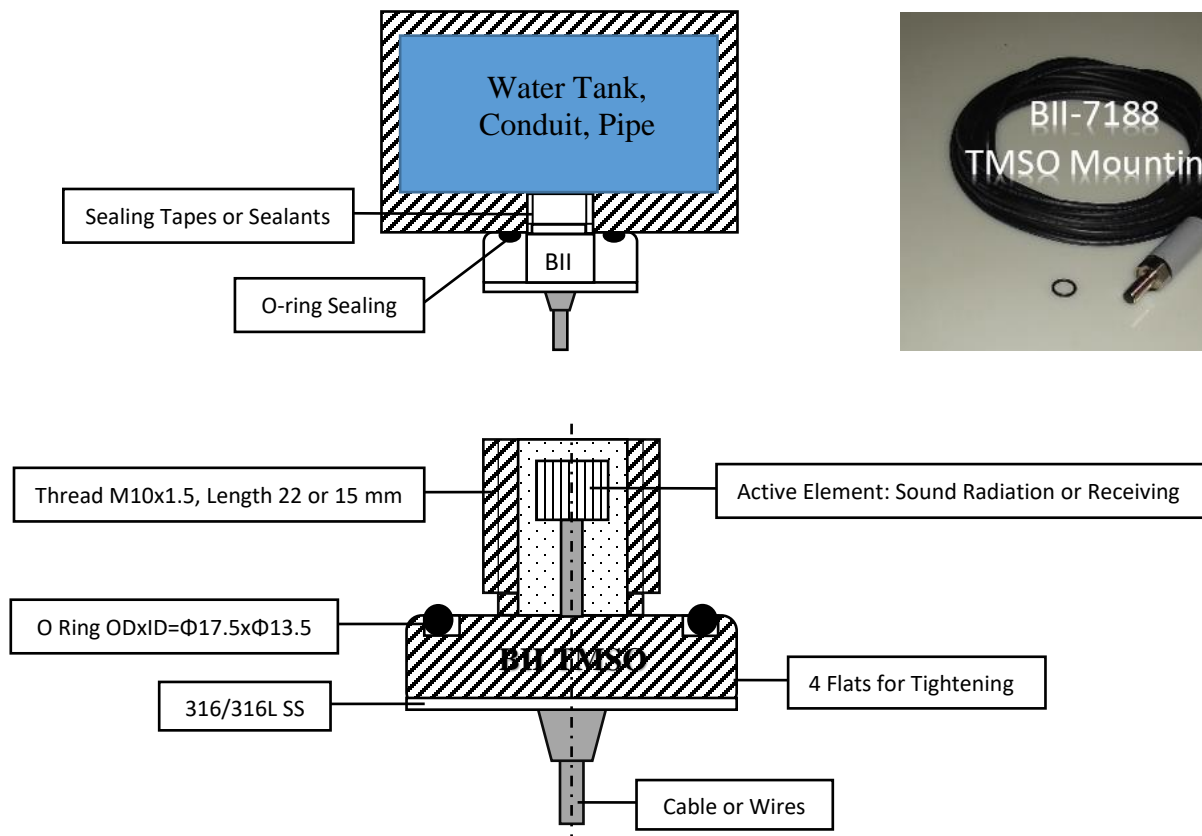**Flush Mounting with Counterbore Hole.**



**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. | |
| | 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. | |
| | 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. | |
| | 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. | |
| Threadlockers 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.
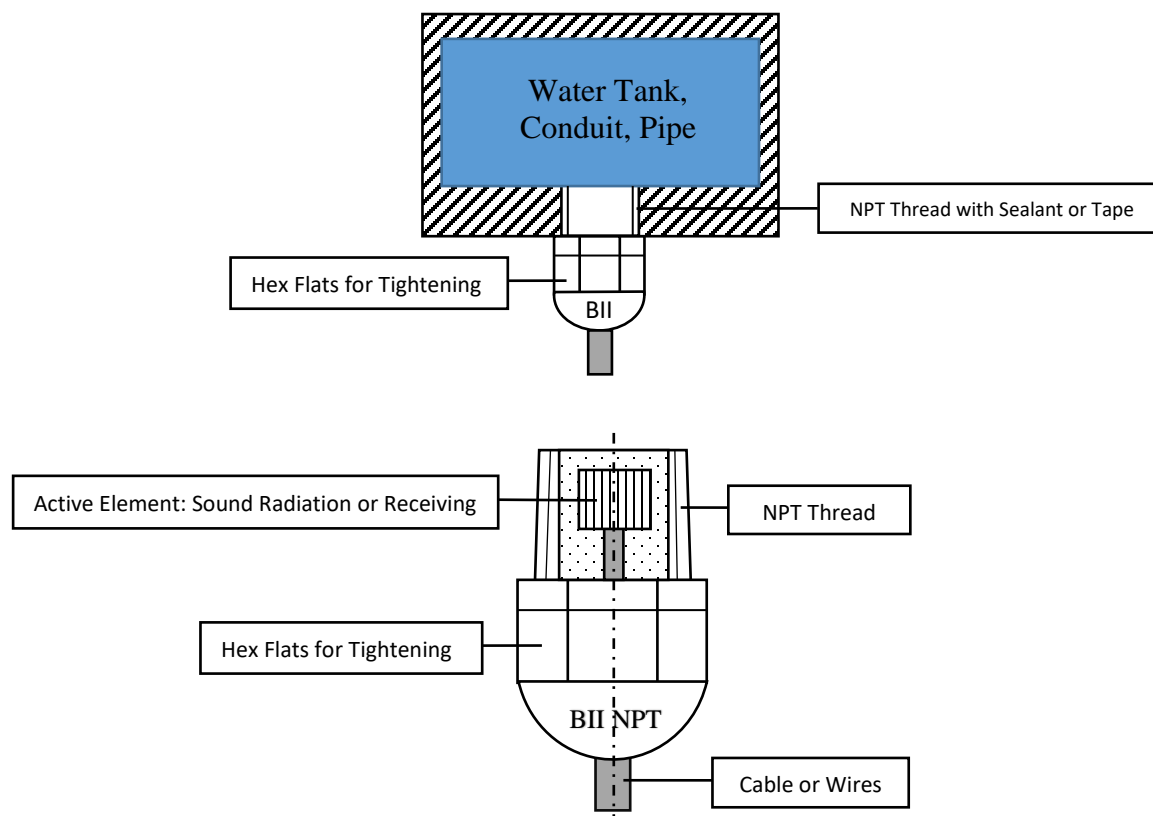
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## NPT Thread Mounting (NPT) (Dimension Unit: mm)

| 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. | |
| | 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. 1. Default: BII does not provide sealant. 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. |
| Threadlockers 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.
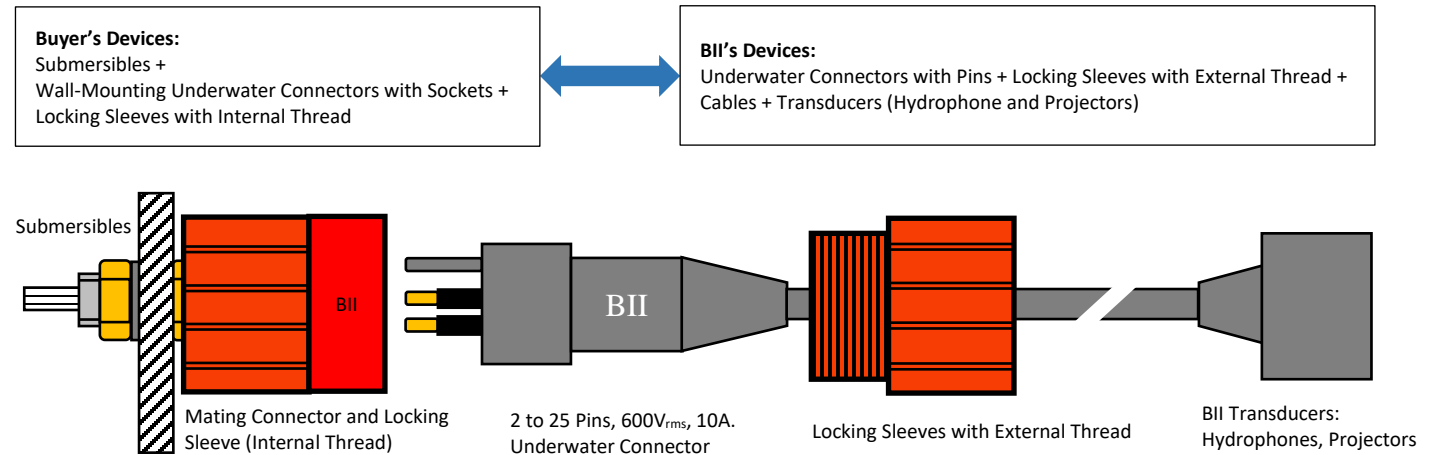
**Thread (NPT) Mount**

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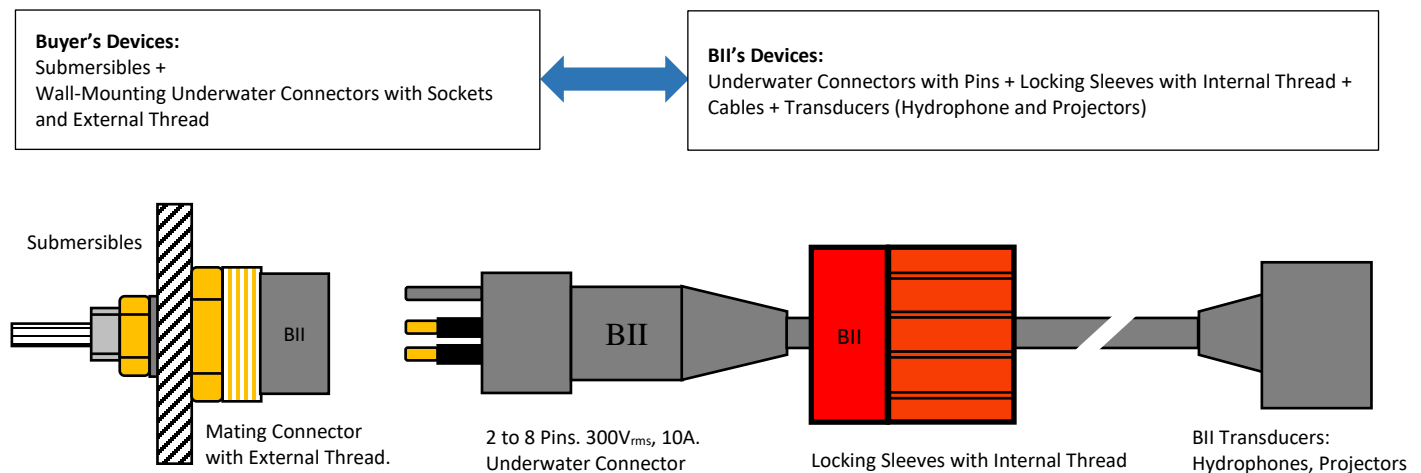
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## Underwater Connector Assembly

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…
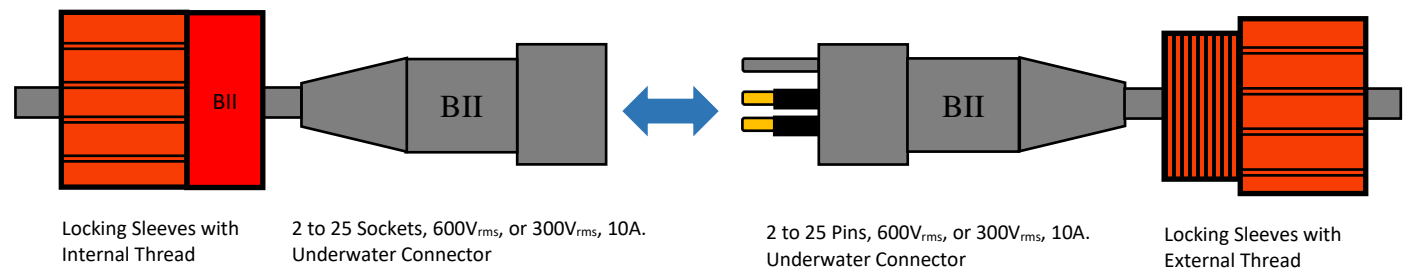
### 1. Standard Circular Series Underwater Connectors

**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)

Submersibles

Mating Connector and Locking Sleeve (Internal Thread)

2 to 25 Pins, 600V$_{rms}$, 10A. Underwater Connector

Locking Sleeves with External Thread

BII Transducers: Hydrophones, 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)

Submersibles

Mating Connector with External Thread.

2 to 8 Pins. 300V$_{rms}$, 10A. Underwater Connector

Locking Sleeves with Internal Thread

BII Transducers: Hydrophones, Projectors

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

Locking Sleeves with Internal Thread

2 to 25 Sockets, 600V$_{rms}$, or 300V$_{rms}$, 10A. Underwater Connector

2 to 25 Pins, 600V$_{rms}$, or 300V$_{rms}$, 10A. Underwater Connector

Locking Sleeves with External Thread



BII-7623DP

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

| Harmonized System (HS) Code Reference of BII (Benthowave Instrument Inc.) Products | | | |
|---|---|---|---|
| Description of BII Products | HS Code | Description of BII Products | HS Code |
| Hydrophone as Parts and Accessories for Underwater (Oceanography) Acoustic Instruments | 90159000 | Power Amplifier as Parts and Accessories for Acoustic Instruments | 85184000 |
| Underwater Transducer as Parts and Accessories for Underwater (Oceanography) Acoustic Instruments | 90159000 | Electronic Preamplifier as Parts and Accessories for Acoustic Instruments | 85185000 |
| High Intensity Focused Ultrasound Transducer as Parts and Accessories for Acoustic Instruments | 90279000 | 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 | 85185000 |
| Non-Destructive Testing Transducer as Parts and Accessories for Acoustic Measuring Instruments | 90279000 | Pulsed Signal Generator as Parts and Accessories for Acoustic Measuring Instruments | 85432000 |
| Acoustic Emission Transducer as Parts and Accessories for Acoustic Measuring Instruments | 90279000 | Signal Pulser & Receiver as Parts and Accessories for Acoustic Measuring Instruments | 85432000 |
| Ultrasonic Air Transducer as Parts and Accessories for Acoustic Instruments | 90279000 | ~~Underwater Sound Recorder for Measuring and Analyzing Underwater Sounds~~ | ~~90278900~~ |
| Impedance Matching Transformer as Parts and Accessories for Acoustic Instruments | 85043100 | ~~Scientific Echo Sounder as Rangefinder in Oceanography~~ | ~~90151000~~ |

## Sales and Technical Support

Selecting products, request quotes and technical support: **info@benthowave.com**

Please email your information, inquiries, questions and sales documents in plain text or PDF, other types of files as email attachments might be deleted automatically. The information, such as BII's quote or invoice number, detailed description on products and/or applications, your country/company name, are helpful and necessary during sales and technical support.

**Buyer's Email Account**: Please use formal email account of your company, organization, and entity, and avoid using third-party's email servers (accounts) which may reject sender's emails because of different server settings such as preventing spoofing and scam.

If a buyer decides to use third-party email provider to contact BII, the buyer must set up or do authentication following Email provider's process to make sure you can receive emails from www.benthowave.com and above-mentioned email. Otherwise, our company email may be returned to us and you can not receive our response.

**Commercial Information**: DO NOT email or send any confidential information such as trade secrets and Intellectual Property to BII. BII does not manufacture customized products which utilize buyer's intellectual properties.

**"Ship to" Address Format:** Contact Person's Name, Company/Organization Name (and branch or department if any), Street Number and Name, City, Province or State, Postal Code, Country, Phone Number and E-mail Address, **VAT** (Value Added Tax Identification) **Number**, **EORI Number** (EU, Northern Ireland, Norway and Switzerland). Please use "," or ";" to clearly separate address information.

**Consignee and End User:** In most cases, consignee and end user are same person, company, research center, or entity. If an end user has a representative/consignee to purchase goods from BII, the representative/consignee should be in end user's country.

**USA Buyers**: For shipments to the United States of America with a value of 2,500 USD or more, if the Recipient is a company: Customs authorities require an **Employer Identification Number (EIN)**.

**Consignees/Buyers in EU, Northern Ireland, Norway, and Switzerland**: Beginning March 1, 2023, the European Union (EU) Import Control System 2 (ICS2) requirements come into effect to strengthen safety and security measures at customs. As a result, BII is required to provide to the courier EORI number (Economic Operator Registration and Identification number of VAT-registered businesses. Private individuals may also need an **EORI number** to ship or receive packages. In Norway it's known as an 'Organization number', while in Switzerland it's referred to as the 'Unique Identification (UID) number'.) in Recipient Tax ID/Customer Reference field of a shipping application and on the Commercial Invoice before arrival at customs in the EU, Northern Ireland, Norway, and Switzerland. EU countries are Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, and Sweden.

## 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 once BII creates waybill label. New online updates from courier website will be about 5 to 24 hrs later.

**Shipping 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 with BII's courier account.  2. **FOB**, ship with buyer's courier account.  3. **EXW-Ex Works**, Buyer's Freight Forwarder picks up goods (Package) at BII.

**Shipping Package:** Cartons, maximum weight: 30 kg of each carton package.

## Sales Tax and Custom Brokerage Services

No Canadian sales tax to international customers. GST or HST is applicable to Canadian customers ONLY.

**For international customers:** Consignee is responsible to import customs clearance, and pay import duties, tariffs, brokerage fees, taxes imposed by consignee's country and other costs related to shipment.

1. If consignee uses Carrier's brokerage services for customs clearance, the carrier pays import taxes on behalf of consignee. The consignee should repay or reimburse the carrier and pay the brokerage charges (if any) at time of delivery. The consignee may contact carrier's local customer service on how to repay or reimburse the carrier.

2. If consignee has his own custom broker for customs clearance, consignee should notify the broker to do customs clearance of the shipment once BII emails consignee the shipment information.

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

**Payments:** Refer to the payment terms in official quotation.

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**Hours of Operation**
9:00a.m. to 5:00p.m., Monday to Friday.
Closed on Saturday, Sunday, and Statutory 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 is severe weather 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/consignees all over the world and BII ships products directly to buyers/consignees all over the world. Except Canada, BII does NOT have any branch and/or sales representative in any other country.
1. First, buyer/consignee specifies the products in detail by referring to **<How to Order>** in respective datasheet. Email BII consignee's complete address with Postal Code and phone number, and payment methods (USA & Canada: Cheque, Bank Draft or Wire Transfer; Other Countries: Wire Transfer through Bank). **BII does not accept credit card payment**.
2. BII issues official quote to buyer which enclose BII's sales terms and conditions. Buyer/consignee reads the quote in depth. Contact BII for any question and update.
3. Buyer places order with email confirmation or purchase order.
4. BII issues Proforma Invoice to buyer, which encloses BII's bank information. Buyer starts to make payment to BII, and BII prepares to manufacture buyer's order.
5. BII manufactures, tests, and calibrates the products.
6. BII prepares export documents and complete export declaration to Canadian Customs.
7. BII ships goods to buyer with DHL, UPS, FedEx, or Buyer's Freight forwarder, and notifies buyer with waybill/tracking number and/or commercial invoice.
8. Buyer tracks the shipment online at carrier's website, complete the import customs clearances at buyer/consignee's country, and pay the taxes and or duties, if any, imposed by buyer/consignee's country.
   a. Generally (for most of buyers), the courier will conduct customs clearance on behalf of buyer/consignee, the buyer/consignee just need to provide necessary information to courier and pay taxes and/or duties, if any, to courier before delivery.
   b. If buyer/consignee has his/her own customs brokers, the buyer/consignee should notify the customs broker to conduct customs clearance once BII emails the shipping information to buyer/consignee.
9. Buyer/Consignee receives the shipment.

**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.
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.

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**Careers at BII**

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. 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. |

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**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.

# BII
SE=SL-TL+AG-NL

# Benthowave Instrument Inc.
Acoustic Solutions for SONAR, HIFU, NDT, AE, Physical Acoustics, Imaging, Material Study …

benthowave.com

## 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 Offcial Address>**. (www.benthowave.com. Contact: info@benthowave.com.)

**<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.

| This Authorization is valid till <input a date here>. Validity of one year ONLY starting from the issue date of this authorization. | | |
|---|---|---|
| **Authorization Signature:** | **Company:**<br>**Benthowave Instrument Inc.** | |
| **Name:** | **Title:**<br>Sales Manager | |
| **Date:** | **Telephone:**<br>BII Phone Number | **Email:**<br>info@benthowave.com |