



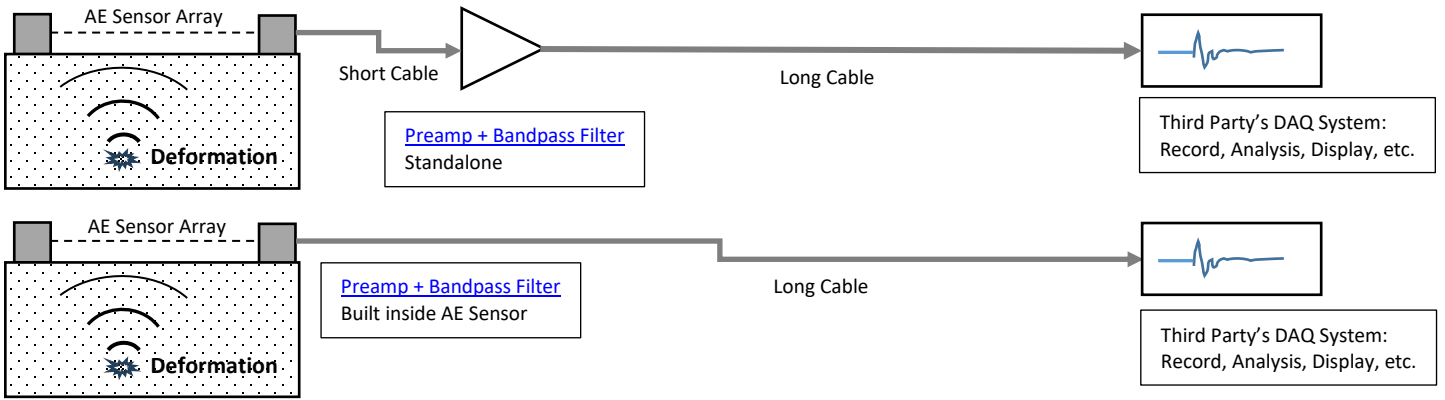
BII7230 Series AE Sensors for Acoustic Emission Testing

AE (acoustic emission) sensors with aperture $\Phi 2$ to $\Phi 12.7$ mm detects wideband stress wave released by the structural (Macro or Micro) deformation: cracking, leaking, ageing under load, chemical reaction, temperature gradients, etc. AE sensors are used as contact sensors in air and liquids/water (immersion sensors) to detect AE sources up to 198°C (388°F), or as embedded AE sensors which are encapsulated in structures/materials for Structural Health Monitoring (SHM). Linear and planar phase arrays can be configured with these small-aperture AE sensors to position 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).

AE sensors with preamps can transmit signals over long cable without degrading signals up to 1000m. This feature presents a solution for long-distance health monitoring of a structure.

Typical Applications:	Examination of Structure	Structural Health Monitoring SHM	Material Study	Control and Monitoring of Manufacturing Process
Related Products:	Miniature AE Sensor: BII7180 Series	NDT Transducers: BII7690 Series	Directional Hydrophone (Acoustic Sensor): BII7070 Series	

AE (Acoustic Emission) Detection System



Question:

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

- Buyer may order BII products with wire leads, and buyer assembles the mating connector to the cable end.
- 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.
- 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.

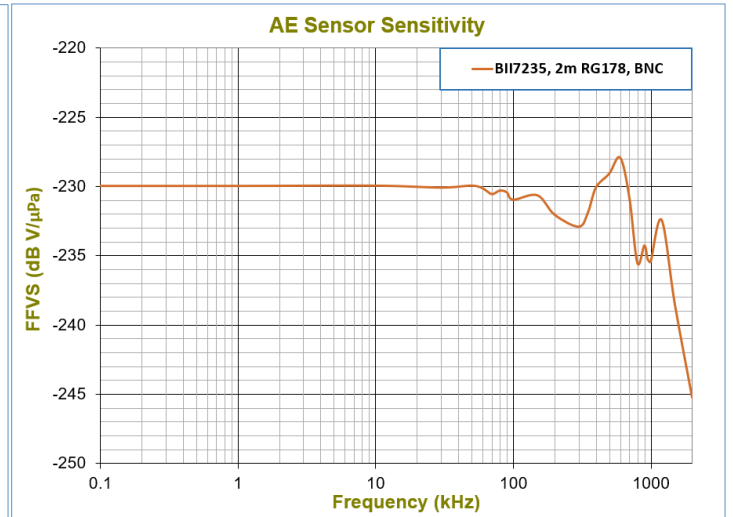
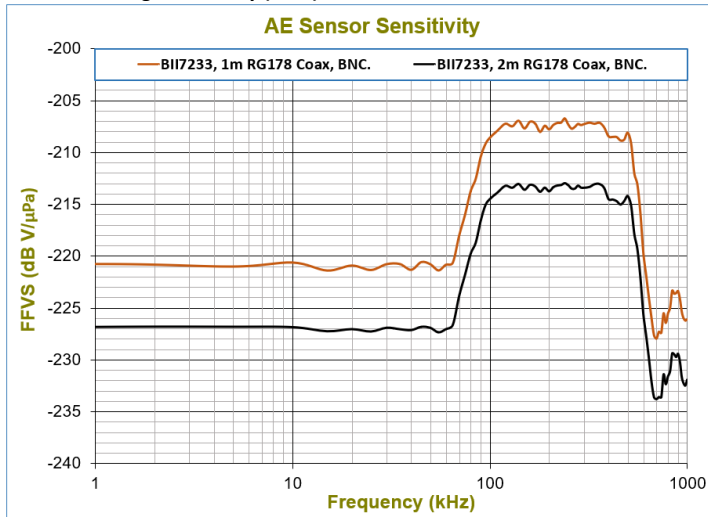
When a **Gain Selection wire** is floating or open, its digital logic is High or "1". When a **Gain Selection wire** is short to **Digital Common**, its digital logic is Low or "0". Sensitivity of a Hydrophone is fixed when its Gain Selection wires are fixed to **Digital Common** or open (floating) during operation.

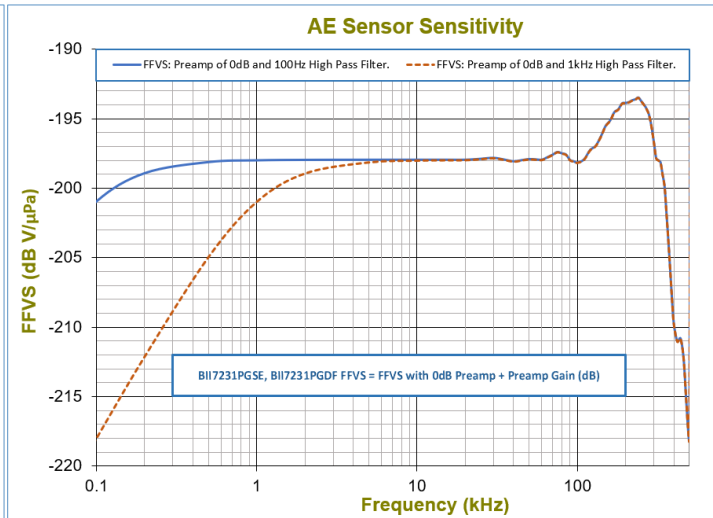
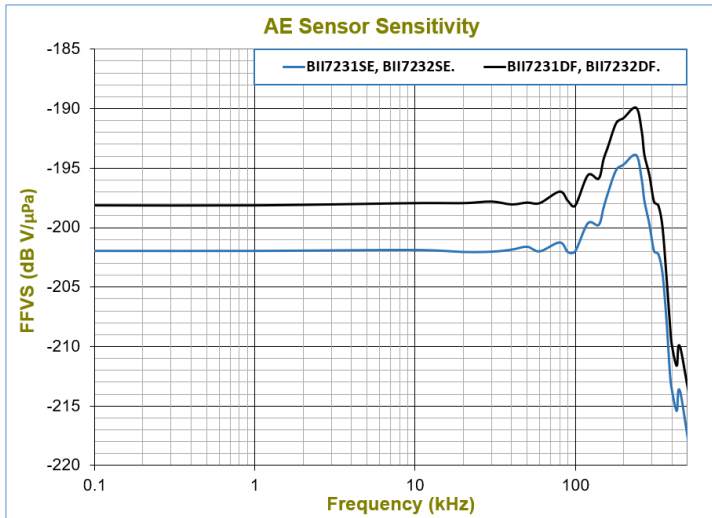
- Gain Selection with Digital Outputs.** Digital Outputs of a DAQ (data acquisition device) select gains with TTL/CMOS logic levels.

This document contains:

Specification of AE Sensor (No Preamp)	Specification of AE Sensor with Built-in Preamp	Outline Drawings of AE Sensors and Installation on DUT.
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Free-field Voltage Sensitivity (FFVS) in Water.





Specification of AE Sensor (No Preamp)

FFVS: Free-field Voltage Sensitivity, in dB V/μPa; SE: Single-ended Output; DF: Differential Output.						
The sensitivity FFVS of BII's AE sensors is calibrated in water at 23 °C.						
AE Sensor	BII7231SE	BII7231DF	BII7232SE	BII7232DF	BII7233	BII7235
Applications:	Contact sensors in air and immersion sensors in liquids or water, AE Sensor Array Elements, and Embedded AE Sensors.					
FFVS (V/μPa):	-202dB	-198dB	-202dB	-198 dB	-211 dB	-214 dB
FFVS:	Sensitivity Loss over Extension Cable (dB) = 20*log[C _h /(C _h +C _c)]. Valid for hydrophone without preamplifier. C _h : Hydrophone Capacitance; C _c : Capacitance of Extension Cable. Cable is of 100 pF/meter roughly.					
Usable Frequency:	Refer to Graph of FFVS vs. Frequency . Free-field Voltage Sensitivity.					
Quality Factor Q _m :	1 to 3	1 to 3	1 to 3	1 to 3	2 to 4	2 to 4
Capacitance C _h :	0.32nF	0.1nF	0.1nF	0.1 nF	0.09 nF	0.27 nF
Dissipation D:	0.015	0.015	0.015	0.015	0.005	0.02
Noise Density at f << f _s : dB μPa/√Hz	43.1 – 10*log f 44.9 – 10*log f 49.4 – 10*log f 44.9 – 10*log f 54.4 – 10*log f 56.6 – 10*log f					
Total Noise Density:	1. f in kHz; f _s : Resonance Frequency which is close to the frequency of maximum FFVS. 2. Noise densities in this datasheet are calculated values with transducer parameters being measured in water. 3. As hydrophones works with preamps or data acquisition modules, total noise density is determined by all noise sources. Generally, the total noise density is much higher than the ones stated in this datasheet.					
Sensing Aperture ΦD:	Φ12.7 mm	Φ12.7 mm	Φ6 mm	Φ12.7 mm	Φ2 mm	Φ3 mm
Directivity Pattern:	Conical Beam.					
-3dB Beam Width:	58.9°C/(f*ΦD), in °. C: sound velocity or stress wave speed in load medium. f: Operating Frequency.					
Side Lobe Level:	No side lobes when -3dB Beam Width ≥ 50°. ≤ -17.7 (dB) when -3dB Beam Width <50°.					
Signal Output Type:	SE	DF	SE	DF	SE	SE
Preamplifier:	No					
Housing Material:	Plastics	Plastics	SS316/316L	SS316/316L	Plastics	Plastics
Max. Water Depth:	300 m	300 m	Use in Air Only	Use in Air Only	10 m	10 m
Mounting:	1. AE sensors are installed on the DUT (device under test) with mechanical clamping or epoxy adhesives. 2. AE sensors can be embedded onto the DUT with potting and encapsulation compounds. BII does NOT provide clamp parts and encapsulation compounds.					
Cable Type:	RG174	SC60	RG178	SC32	RG178	RG178
Cable Information:	1. Coax RG174/U (RG174) (for Single Ended Output ONLY) 2. Coax RG178/U (RG178) (for Single Ended Output ONLY), up to 200°C. 3. Coax RG58/U (RG58) (for Single Ended Output ONLY) 4. Shielded Cable with Polyurethane Jacket, ΦD=2.6 mm (SC26) 5. Shielded Cable with Twisted Pair and Teflon (PTFE) Jacket, ΦD=3.2 mm (SC32), up to 200°C. Not water-proof. 6. Shielded Cable with Twisted Pair and Polyurethane Jacket, ΦD=4.7 mm (SC47) 7. Default: Shielded Cable with Twisted Pair and PVC Jacket, ΦD=6.0 mm (SC60) (for Differential Output ONLY) 8. Shielded Cable with Rubber Jacket, ΦD=6.5 mm (SC65)					

	Differential (balanced) output with shielded Twisted Pair Cable is recommended to reject Electromagnetic Interference (EMI) over long cable.					
Cable Orientation:	Cable goes out from side wall or top end face of the housing. Refer to Outline Drawings .					
Cable Length:	1. Default: 1 m. 2. Customization: Custom-fit Cable Length					
Connector Type:	BNC Male	Wire Leads	Wire Leads	Wire Leads	BNC	BNC
	Customization: Bespoke Connector.					
Connector Info:	SE: Single ended Output, DF: Differential Output. 1. Default: Wire Leads (WL) 2. Male BNC (BNC), Max. Diameter $\Phi 14.3$ mm, for SE ONLY. BNC with RG178 Coax: Service Temperature up to 165°C or 329°F. 3. SMA (Plug, Male Pin) (SMA), Voltage Rating: 335 V _{RMS} Continuous. Max. Diameter $\Phi 9.24$ mm, for SE ONLY. 4. SMC (Plug, Female Socket) (SMC), Voltage Rating: 250 V _{RMS} Continuous. Max. Diameter $\Phi 6.2$ mm, for SE ONLY. 5. 1/8" (3.5mm) TRS Plug (TRS), Max. Diameter $\Phi 10.5$ mm, for SE or DF. 6. XLR (pin) (XLR), Max. Diameter $\Phi 20.2$ mm, for SE or DF. 7. MIL-5015 Style (pin) (MIL), Max. Diameter $\Phi 30$ mm with 3 contacts, for SE or DF. 8. Underwater Mateable Connector (pin) (UMC), Max. Diameter $\Phi 21.5$ to $\Phi 35$ mm, for SE or DF. Underwater Mateable Connector is for uses underwater. Other connectors and wire leads are for dry uses and are not waterproofed.					
Weight:	56 grams	56 grams	65 grams	86 grams	36 grams	36 grams
	Weight depends on Cable Types and Length.					
Overall Size (Φ DxH):	$\Phi 21 \times 20$ mm	$\Phi 21 \times 20$ mm	$\Phi 9.8 \times 15$ mm	$\Phi 15.8 \times 15$ mm	$\Phi 6.2 \times 15$ mm	$\Phi 8 \times 6.2$ mm
Service Temperature:	-20 to 60 °C, or -4 to 140 °F		-20 to 198 °C, or -4 to 388°F		-20 to 120 °C, or -4 to 248 °F	
Storage Temperature:	-20°C to +60 °C or -4°F to 140 °F.					

How to Order

Part Number	-Cable Length in Meter	-Cable Type	-Connector Type
Example:	Description		
BII7233-2m-RG178-BNC	BII7233 AE Sensor, 2m RG178 Coax, Male BNC.		

Wiring of AE Sensor without Preamp.

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

Specification of AE Sensor with Built-in Preamp

The sensitivity FFVS of BII's AE sensors is calibrated in water at 23 °C.	
AE Sensor	BII7231PGSE BII7231PGDF
Applications:	Contact sensors in air and immersion sensors in liquids or water, AE Sensor Array Elements, and Embedded AE Sensors.
Sensing Aperture Φ D:	$\Phi 12.7$ mm
Sensitivity FFVS at 1 kHz:	-198 + Preamp Gain, ± 2 dB V/ μ Pa.
FFVS:	Refer to Graph of FFVS vs. Frequency . Free-field Voltage Sensitivity.
Pressure Noise Density:	≤ 32 μ Pa/ \sqrt Hz. Referred to Input (RTI) at $f \geq 1$ kHz. ≤ 36 μPa/\sqrtHz. Referred to Input (RTI) at $f \geq 1$ kHz.
Usable Frequency:	In Water: 1 ~ 350 kHz at ± 3 dB V/ μ Pa. In Air: 1 ~ 350 kHz at -3dB V/ μ Pa.
Built-in Filters:	1. Default: Hig Pass Filter 0.1 kHz. 2. Bespoke High Pass Filter. Specify -3dB cut-off frequencies when ordering. 2. Bespoke High Pass Filter or Band Pass filter. Specify -3dB cut-off frequencies when ordering. Both ocean ambient noises and the self-noises of electronic devices decrease when frequency increases. It is recommended to choose a built-in high pass filter to reject noises in low frequency range. For example, if you are interested in the signals greater than 10kHz, you may specify a high pass filter with -3dB cut-off frequency at 3kHz to improve signal to noise ratio of the signals of the interest.
Quality Factor Q_m :	≤ 3 ≤ 3 Broadband. Q_m determines the transient response or the rise and fall rings of steady-state response.
Preamp Gain (dB):	Programmable Gain Preamp: 20, 60 dB. Programmable Gain Preamp: 0, 20, 40, 60 dB.
Gain Selection Voltage:	CMOS/TTL Compatible. Logic Low 0: Gain Selection Wire to COM, or 0 to +0.8VDC. Logic High 1: Gain Selection Wire Open, or +2.4 to V_s . Note: If Digital Outputs or switches are used to select gains, Voltage Protection Rating or Absolute Maximum Voltage Ratings of these devices must be greater than V_s Supply Voltage.
Directivity Pattern:	Conical Beam.
-3dB Beam Width:	$58.9^\circ C / (f * \Phi D)$, in °. C: sound velocity or stress wave speed in load medium. f: Operating Frequency.
Side Lobe Level:	No side lobes when -3dB Beam Width $\geq 50^\circ$. ≤ -17.7 (dB) when -3dB Beam Width $< 50^\circ$.
Signal Output Type:	SE: Single-ended Output; DF: Differential Output.
Maximum Output V_{omax} :	Supply Voltage $V_s - 1$, in Vpp. Supply Voltage $V_s - 4$, in Vpp.
Housing Material:	Plastics Plastics

	Plastic housing resists attack by acids, alkalis, salt solutions and most other chemicals. There is no risk of corrosion when exposed to naturally corrosive conditions. It does not rust or corrode from electrochemical and galvanic environment. Solvents shall not be used with the AE sensors, such as hydrochloric acid, isopropyl alcohol, ethyl lactate, acetone, xylene, Iso hexanes, mineral spirits, etc...	
Overload Pressure Level:	198 or $[20 \cdot \log(V_{omax}/2.828) - \text{Sensitivity}]$, whichever is less, in dB μ Pa.	
Operating Depth:	Maximum 300 m or 3 MPa pressure and limited by the cable length if the cable has wire leads or a non-waterproof connector.	
Mounting:	1. AE sensors are installed on the DUT (device under test) with mechanical clamping or epoxy adhesives at buyer's cost. 2. AE sensors can be embedded onto the DUT with potting and encapsulation compounds.	
Cable	Six Conductor Shielded Cable (SC).	
Cable Orientation:	1. By default, cable goes out from side wall of housing. 2. Customization: cable goes out from top end face of the housing.	
Cable Length:	Default: 10 m.	
	Custom-fit Cable Length up to 100m.	Custom-fit Cable Length up to 1000m.
Connector:	SE: Single ended Output, DF: Differential Output. 1. Default: Wire Leads (WL) 2. Male BNC (BNC) (Max. Diameter Φ 14.3 mm), for SE ONLY. 3. 1/8" (3.5mm) TRS Plug (TRS) (Max. Diameter Φ 10.5 mm), for SE or DF. 4. XLR Plug (pin) (XLR) (Max. Diameter Φ 20.2 mm), for SE or DF. 5. Underwater Mateable Connector (pin) (UMC) (Max. Diameter Φ 21.5 to Φ 35 mm), for SE or DF. 6. +9VDC Battery Snap (BS), for +9VDC or +18VDC power supply. 7. 4mm Banana Plug Pair (Red and Black Color) (BP), for DC power supply ONLY. Underwater Mateable Connector is for uses underwater. Other connectors and wire leads are for dry uses and are not waterproofed.	
	Supply Voltage V_s :	
	+4.5 to +32 VDC. +8.2 to +32 V	
Suggested DC Supply:	+9 VDC Battery, Marine Battery, Automobile Battery, Fixed DC Linear Power Supply, Not Included. DO NOT use variable power supply whose maximum supply voltage is higher than the rated voltage. DO NOT use switching mode DC power supply.	
Current (Quiescent):	2.1 mA	13 mA
Weight:	\geq 0.55 kg with 10 m cable. Actual weight depends on Mounting Parts, Cable Types and Length.	
Overall Size (Φ DxH):	Φ 21x 65 mm	
Service Temperature:	-20 to 60 °C, or -4 to 140 °F	
Storage Temperature:	-20°C to +60 °C or -4°F to 140 °F.	
AE (Acoustic Emission) Applications: These hydrophones are tested and calibrated in water. It is buyer's responsibility and liability to calibrate and maintain the AE sensors according to the acoustic emission national standards of buyer's country.		

How to Order.

PG: Programmable Gain; DF: Differential Output; SE: Single Ended Output; HPF: High Pass Filter; LPF: Low Pass Filter.			
Part Number	-HPF/LPF	-Cable Length	-Connectors for Signal/Gain/DC Supply
BII7231PGSE	-3dB High Pass Filter Frequencies, in Hz or kHz. Default: 0.1 kHz.	in meter. Default: 10m.	Refer to Options. Default: Wire Leads.
BII7231PGDF	-3dB High Pass or Band Pass Filter Frequencies, in Hz or kHz. Default: 0.1 to 700 kHz.		
Example of Part Number:		Description	
BII7231PGSE-1kHz-50m-BNC/WL/BS		BII7231PGSE AE Sensor, 1kHz high Pass Filter, 50m Shielded Cable, Connector: Male BNC for Signals, Wire leads for Gain Selection, Battery Snap for +9VDC Batteries.	
BII7231PGDF-1kHz/300kHz-100m-XLR/WL/WL		BII7231PGDF AE Sensor, 1 to 300kHz Band Pass Filter, 100m Shielded Cable, Connector: 3-pin XLR Plug for Signals, Wire Leads for Gain Selection, Wire Leads for DC Supply.	

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

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

Selecting Sensitivity FFVS of Two-bit Digitally Programmable

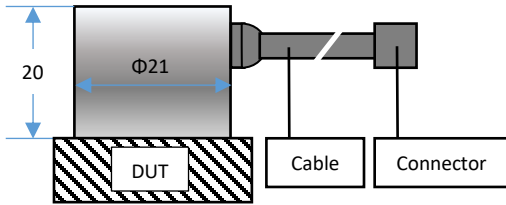
FFVS Selection Wire A1	FFVS Selection Wire A0	AE Sensor Sensitivity at 1kHz
0 (Logic Low)	0 (Logic Low)	-198 + 20dB V/ μ Pa
0 (Logic Low)	1 (Logic High)	-198 + 40dB V/ μ Pa
1 (Logic High)	0 (Logic Low)	-198 + 60dB V/ μ Pa
1 (Logic High)	1 (Logic High)	-198 + 80dB V/ μ Pa

Wiring Information of Hydrophones with One-Bit-Word Programmable Gain Preamps:

Single-Ended Output:	Wire Leads	Underwater/XLR Connector	9V Battery Snap and BNC/SMA/SMC Male	XLR + 9V Battery Snap	TRS + 9V Battery Snap
+VDC	Red	Pin 3	Battery Female Snap	Battery Female Snap	Battery Female Snap
Common	Black	Pin 1	Battery Male Snap	Battery Male Snap, XLR Pin 1.	Battery Male Snap, TRS Sleeve.

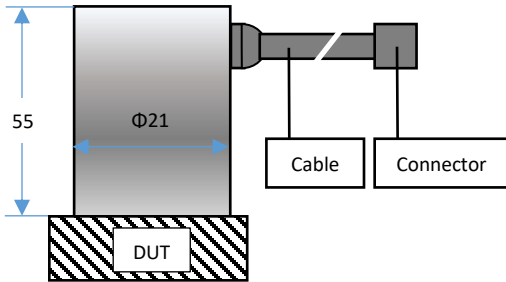
Digital Common	Yellow or Brown	Pin 5	Yellow or Brown	Yellow or Brown	Yellow or Brown
Digital A0 (FFVS Selection)	Blue	Pin 6	Blue	Blue	Blue
Output Signal	White	Pin 2	BNC/SMA/SMC Center	XLR Pin 2	TRS Tip
Output Signal Common	Green	Pin 4	BNC/SMA/SMC Shield	XLR Pin 3	TRS Ring
Shielding	Shield	N/A	Shield	XLR Metal Shell	N/A
4mm Banana Plug Pair: Red Plug for +VDC, Black Plug for Common of the DC power supply.					
Selecting Sensitivity of One-Bit-Word Digitally Programmable					
FFVS Selection Wire A0	Sensitivity FFVS at 1kHz.				
0 (Logic Low)	-198 + 20 dB V/ μ Pa				
1 (Logic High)	-198 + 60 dB V/ μ Pa				

Outline Drawings of AE Sensors and Installation on DUT.
BII7231SE and BII7231DF AE Sensor Plastic Housing (Unit: mm):



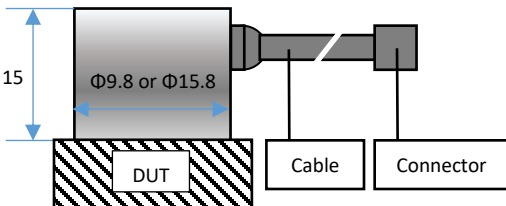
1. Housing: Plastics. No Preamplifier or with Built-in Preamp.
2. Air or Underwater Uses. Maximum Underwater Depth: 300 m.
3. Service Temperature: -20 to 60 °C or -4 to 140 °F.
4. No Preamp.

BII7231PGSE and BII7231PGDF AE Sensor Plastic Housing (Unit: mm):



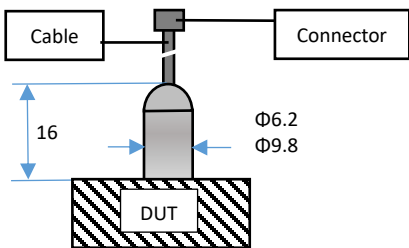
1. Housing: Plastics. No Preamplifier or with Built-in Preamp.
2. Air or Underwater Uses. Maximum Underwater Depth: 300 m.
3. Service Temperature: -20 to 60 °C or -4 to 140 °F.
4. Built-in Programmable Gain Preamp.

BII7232SE and BII7232DF AE Sensor Stainless 316 Housing (Unit: mm):



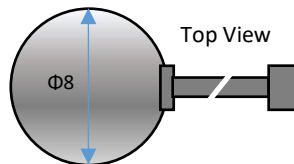
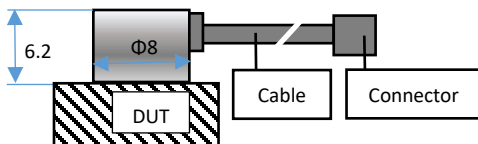
1. Housing: Plastics. No Preamplifier.
2. Use in Air, Not for Underwater Use.
3. Service Temperature of the Sensing Head: -20 to 198 °C or -4 to 390 °F.
4. Service Temperature of BNC Connectors: -40 to 165 °C or -40 to 329 °F.
5. No Preamp.

BII7233SE and BII7233DF AE Sensor Plastic Housing (Unit: mm):



1. Housing: Plastics. No Preamplifier.
2. Small Size suitable for AE Sensor Array.
3. Maximum Underwater Depth: 10 m.
4. Service Temperature: -20 to 120 °C, or -4 to 248 °F.
5. Cable Options: RG178B/U.
6. Connector: Wire Leads, BNC, SMA, SMC, etc.
7. No Preamp.

BII7235 AE Sensor Plastic Miniature Housing (Unit: mm):



1. Housing: Plastics. No Preamplifier.
2. Suitable for AE Sensor Array and Embedded Applications.
3. Maximum Underwater Depth: 10 m.
4. Service Temperature: -20 to 120 °C, or -4 to 248 °F.
5. Cable Options: RG178B/U.
6. Connector: Wire Leads, BNC, SMA, SMC, etc.
7. No Preamp.