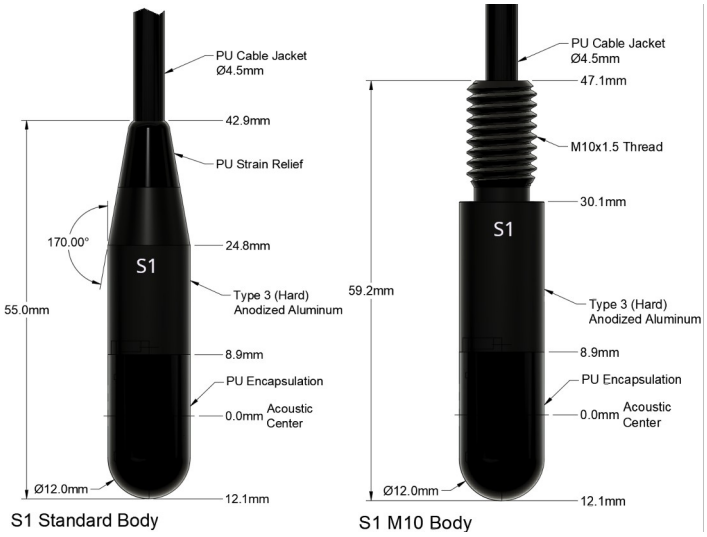
Aquarian Scientific

Product Datasheet

S1 Hydrophone

The S1 hydrophone is a modified version of the AS-1 hydrophone, manufactured by Aquarian since 2013. This device is designed to provide stable and linear broadband response within the range of frequencies supported by the best mass-produced audio recording devices. The S1 builds on the AS-1's capability and convenience by supporting multiple in-built signal-conditioning options and two body styles. Integrated signal conditioning will generally improve sensitivity and lower noise, while making the hydrophone more convenient to use with standard devices.



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Part Variants

Product Identification

Product codes for the S1 will include the following <variants> for signal conditioning amplifiers, output connectors and cable length in meters. Part numbers may include options as described below.

S1<signal conditioning><OUTPUT CONNECTOR><cable length in meters> - <OPTIONS>

The signal conditioning type dictates the type of connector used so that it mates with standard audio devices or measurement tools. It also determines the cable type. Aquarian Scientific can accommodate many requests for customized products. The following table lists standard configurations.

Standard Configurations

Signal Cond. Code	For use with (additional details below)	Cable	Output	Product Code
n	Passive device. No signal conditioning. Select when the hydrophone will be used as a projector, when application-specific amplifiers are required, or when the hydrophone will be used with various types of equipment and external signal conditioning modules	CA-53	BNC	S1nB
e	Microphone preamps typically incorporated into higher-quality digital recorders, audio interfaces and mixing boards. 24 or 48-volt phantom power is required	CA-70	XLR	S1eX
f	Test and measurement equipment that offers IEPE power (proprietary terms include ICP, CCLD, and others) 24V at 4mA constant current is typical. Minimum 18V at 2mA required. Maximum of 20mA can be used for driving very long cables	CA-53	BNC	S1fB
i	Microphone preamps typically found in more compact, lower-cost recorders. Also used with adapters for smart phones, single-board computers and their daughter boards (“hats” or “shields” for Raspberry Pi or Arduino and similar), compact USB sound dongles and more.	CA53	3.5mm TRS	S1iM

Output Connector Options

The following codes are bolded if they are a **standard option**. We commonly ship hydrophones with no connector attached. Others specifically listed here are less common, but typically stocked with some precedent for use in the given application. Aquarian can likely accommodate using the connector of your choice for OEM applications or when needed for specialized equipment. Contact us with your details for pricing and lead times.

Connector Code	Compatibility Sig.Cond./Cable	Description / Typical Application
W	Any	Bare wire output. All conductors stripped and tinned.
	Any	Used with devices that have terminal block inputs, OEM applications, and when the cable must be routed through a penetrator for high pressure seals to equipment enclosures.
B	n, f	BNC (Male, standard size)
	CA-53, CA-80	Common connector used in test and measurement equipment
X	e	XLR (Male, 3-pin, full size, standard wiring for mic preamps: pin1 ground; 2&3 straight and inverted differential signals)
	CA-60, CA-70	Commonly used with pro-quality microphone preamps—either stand-alone or incorporated into recording devices, computer audio interfaces, or mixing consoles

M	i	3.5mm TRS (Male, “Mini” plug)
	CA-53	Commonly used with compact digital recorders and single-board computers or USB audio dongles.
P	Any	¼” TS or TRS (Male)(6.35mm—traditionally called a “Phone” plug)
	Any	This connector is primarily used today with musical instrument amplifiers, such as guitar amps or line-level balanced audio. The S1n would function at some level with these devices, but they are not recommended. TRS connectors would be used with balanced cables; TS would be used with coaxial cables.
S	n,f	SMA (Male)
	CA-53, CA-80	Used primarily for RF applications, but also used in some hydrophone preamps.
U	n, f, i	Microdot (Male, 10-32 UNF)
	CA-80	Used with many lapel-type microphones and also some small hydrophones. This is a very small, secure connection that can easily be passed through the mounting hole for the M10 body. Microdot-to-BNC adapters are inexpensive and readily available.
Custom	Contact us with your special needs. We often build these hydrophones with dry-mate connectors from Blue Trail Engineering. We’ve also used wet-mate connectors from Subconn. We build leak-finding hydrophones for application-specific amplifiers using Switchcraft circular connectors. Send us your requirements.	

Cable Options

Cable is determined by signal conditioning and output connector needs. We do not assign a cable code to the part number. Please refer to the website for specifications using links provided. Our two primary cables are presently the CA-53 (22g coaxial cable with braided shield), and the CA-70 (26g Kevlar-reinforced twisted pair with spiral shield). Optionally, the S1 can be built using our smaller RG-174-sized CA-80 cable for applications that require minimum connector sizes and smallest bend radius when installed in buoys, camera enclosures and similar. The larger CA-60 24g twisted pair with braided shield is often used for long cable lengths.

Length of cable in meters is specified in the part number after the connector code.

Additional Options

- **-M10** designates the threaded body style option. See the drawings at the top of this document for detail. Be advised with the M10 option that most connectors will be larger in diameter than the mounting hole for this hydrophone. Please review M10 notes for each variant under the “Use and Care” heading below. Nylon retaining nut and Nitrile o-ring are included.
- **-WT** designates the addition of our WT150g movable cable weight. The WT150g clamps onto the cable with a rubber chuck and thumbscrew assembly. It must be installed before any connectors are added. NOT AVAILABLE FOR USE WITH CA-80 CABLE.

  By making the weight an optional item, the hydrophone can be used where more neutral buoyancy is needed, where mounted to a buoy or ROV, or where visual disturbance must be minimized. When the weight is needed, placing the weight on the cable near the hydrophone dampens cable vibrations that will induce acceleration noise in the hydrophone. It is also safer for the hydrophone in the case of an accidental drop or impact, as the primary mass is not rigidly attached to the sensor. Distancing the weight from the sensor minimizes sound field disturbance and can even be used as an anchor point for attaching a shroud tube when monitoring moving water (or moving the hydrophone through still water). Please visit the S1 web page for pricing and photos.
- **Non-standard cables, or any other need to designate an auxiliary feature, may be appended to the part number.**

Summary Examples

- *S1nW15* would designate the S1 hydrophone with no signal conditioning and no output connector and 15 meters of attached CA-53 standard hydrophone cable. No options are designated, so we assume a standard body and no weight.
- S1eX10-WT would designate the S1 hydrophone that is compatible with microphone preamps that offer XLR input and phantom power. Ten meters of CA-70 cable is attached. The standard body style with WT150g optional weight are included.
- S1fU0.4-M10 would designate the S1 hydrophone that is compatible with IEPE powered measurement devices. The hydrophone is built into the threaded body style, requiring the microdot connector for easy cable routing, The microdot connector in turn requires the use of the smaller CA-80 cable—40cm attached.

Use and Care

Common

The S1 uses a small thin-wall PZT sensing element that can easily be cracked or broken with asymmetric pressure. As with any product, there is a balance of cost, size, performance and durability that limits focus on any one of these attributes. Be careful to avoid rough service, such as accidental drops, and impacts from swinging into the boat or other objects while suspended from the cable. Hydrophones do get crushed more commonly than one might expect.

Cable damage that leads to water ingress is the second-most leading cause of failure. We use a top-quality polyurethane jacket material on all of our cables that is exceptionally resistant to cuts and abrasion and stays flexible under very cold temperatures. We also want that cable to be compact and flexible, which limits the wall thickness. Be careful of entanglement when using around barnacle-encrusted pilings or float structures or any sharp edges. Be aware of the fact that animals will attack the cable if left exposed for long periods or used in aquarium-type environments. We have seen everything from severed cables from crabs and rodents—and even manatee—to tooth punctures in the hydrophone encapsulation from fish. Mind your cable around propellers and other machinery. Consider using a protective cage around the hydrophone and route cable through a conduit for protection during long-term deployments.

The S1 is designed for use in natural aquatic environments. If using in liquids other than fresh or sea water, check for chemical compatibility between your liquid and polyether urethane rubbers. Try short-immersion samples or add drops of liquid to the end of the hydrophone or cable jacket and check for softening and swelling or cracking of those surfaces.

Though the hydrophone is designed for seawater, the connectors will become corroded if exposed to salts from water or vapors. Do not store your hydrophone in a waterproof enclosure and do not store it in the same enclosure as your electronic devices! Moisture that clings to the hydrophone and cable will evaporate into a corrosive gas. If not allowed sufficient ventilation, corrosion to electrical contacts is likely. This is why we ship the hydrophone in a zippered EVA case with loose open-cell foam, rather than a sealed hard case. If possible, place the protective foam over the hydrophone and allow time for drying in a place with free air movement before storage. Rinse with fresh water and dry before long-term storage. If the output connector is accidentally submerged in seawater or handled with very wet hands, gently rinse in fresh water and dry as soon as possible.

Aquarian offers substantial replacement discounts for hydrophones that we can not repair. Corrosion of the output plug and physical damage including, but not limited to, what is noted above is not covered under warranty. Though not typically a service issue, we do highly recommend that the user take care to lay clean coils when retrieving the hydrophone. This is easy to do when coiling the hydrophone while pulling from deep water, but can be challenging when dropped on the deck of a boat or when pulling a long cable from a field-recording application. Avoiding kinks and twists in the cable will prolong service life and make future deployment and retrieval much easier.

M10 body: S1 ordered with the M10 body style will include one M10-PMK panel-mount kit, including Nylon retaining nut and nitrile o-ring. For additional details about reliably mounting the hydrophone, please see M10 Panel Mounting Guide.

S1n

The S1n is a passive piezo device and thus will require an amplifier with high input impedance to achieve the best low-frequency response and noise performance. The low-frequency cutoff (Fc-HP) (-3dB) is determined by the total capacitance of the hydrophone and cable and the input impedance of your amplifier. A typical audio interface with Hi-Z input of 1MΩ, connected to a typical S1n with 10m cable, will result in a Fc-HP of approximately 23Hz. A 10MΩ input from a piezo preamp, oscilloscope or data acquisition device with the same hydrophone will result in a Fc-HP of 2.3Hz.

Using very high input impedance amplifiers will allow the S1n to monitor sounds of well under 1Hz. Keep in mind though that most audio equipment is designed to filter infrasound and you can not hear it. Using an amplifier with excessively-high input impedance is usually not desirable, as substantial noise from movement or wave pressure may saturate your amp and cause severe distortion or cause the recording to drop out until such noise stabilizes and the system recovers.

Long cables will attenuate the broadband signal from the S1n while using a standard voltage-mode amplifier, or cause additional noise with charge-mode amplifiers.

The S1n can also be used as a projector for transmitting sound into the water. Note that it will only be useful for higher-frequency sound. See specifications below for input limits and transmit voltage response.

M10 body: The S1n standard output is BNC male, which will not pass through an M10 mounting hole. If buying the M10 body option, consider ordering this hydrophone with “W” (bare wire) output option, or when the smaller CA-70 cable is desired, order with “U” (microdot 10-32) connector and use BNC adapter if needed.

S1e

The S1e is designed for use with microphone preamplifiers offering phantom power. These are incorporated into higher-quality audio recorders and computer sound interfaces, as well as some video cameras. Phantom power typically must be activated with a switch or within the menu options of modern recording devices. If you do not get sound from your hydrophone, this is the first thing to check. Many devices will offer options for phantom voltage. 48V is the original standard for phantom power and will work well with the S1e. The S1e requires a minimum of 24V. You may benefit from longer battery life in the recording device by selecting a lower phantom voltage.

Operation is as simple as using any common condenser microphone. Connect the S1e directly to the recording or PA device. No additional accessories are needed.

Though some measurement tools use this type of microphone connection, please note that nearly all recording devices and audio interfaces will not offer a calibrated input. These types of mass-produced audio devices can offer exceptional performance at a very low cost when making relative measurements, but absolute measurements (such as trying to measure sound intensity levels) will require the user to calibrate the system for any given gain adjustment in the recorder. See *Additional Resources* below.

M10 body: The S1e standard output is XLR male, which will not pass through an M10 mounting hole. We solve this problem by modifying the XLR connector so that the contact pins can be removed during wire routing. For additional detail, see NC3_MXX_MOD assembly notes.

S1f

The S1f is designed for use with test equipment that offers IEPE (Integrated Electronics Piezo Electric) power. This is a constant-current bias on the hydrophone’s output to power the internal signal conditioning board. 4MA @ 24V is typical, but the S1f can operate with as little as 2mA @ 18V, or as much as 20mA @ 50V. IEPE is commonly used in accelerometers and measurement microphones, and is commonly supported by DAQ equipment used for sound and vibration. Other proprietary names include “CCLD”, “ICP”, “Piezotron” and more. IEPE power will likely need to be switched on in your measurement device’s controls system. More information can be easily found on Wikipedia and other Internet sources.

The minimum (2mA) current will drive 100m cables without significant losses in the linear bandwidth of the S1f. Higher current will allow longer cable lengths. See *Additional Resources* below.

M10 body: See notes for S1n above.

S1i

The S1i is designed for use with microphone preamplifiers offering plug-in power (PIP). These are typically

designed for low-cost electret microphone capsules. These are ubiquitous in consumer electronic devices made to pick up sound, including compact digital recorders, single-board computers and their various daughter boards, radio transmitters, low-cost USB sound dongles made for computers and smart phones, video cameras, some autonomous recorders and more.

Designing signal-conditioning for PIP is more challenging than for the other options above because there is no standard for compliance voltage or bias current, which severely complicates making any kind of optimized circuit. These variations in PIP also affect gain stability in the simplest, lowest-noise amplifier designs. Limited power availability from PIP leads to higher noise and lower dynamic range. The “i” signal conditioning board comes from years of development in finding the best balance of compatibility, stability and performance.

The S1i will operate effectively with a wide range of bias currents, from from 400µA up to 10mA, while maintaining the same sensitivity with minimal differences in noise (dynamic range will suffer some with very low bias currents). It also drives long cables well if needed, especially when used with higher bias current, as would be typical when driving both channels of a compact digital recorder. Though not matching the gain and dynamic range of the “e” and “f” designs, the “i” model can be extremely helpful in utilizing the very wide range of small, mass-produced, low-cost products available for recording, monitoring and transmission of sound.

The S1i is terminated with a 3.5mm TRS plug and wired for dual-mono output (output is wired to both tip and ring contacts; sleeve contact is ground). The most common application is driving both left and right channels of a compact stereo digital recorder. The dual-mono configuration also solves compatibility issues older-style computer sound interfaces.

Please note that the 3.5mm jack is used for many kinds of audio connections. **The S1i will only work with microphone inputs.** The S1i plug will fit into auxiliary inputs on powered speakers or marine stereo systems, but these will not provide PIP to the signal conditioning board, nor will they provide adequate gain. This connector is also used with headphone and audio line outputs. An adapter will be needed for most headset jacks (TRRS jacks that are designed to support both microphone input headphone output). These are common on smart phones, tablets and laptop computers. Do not make the assumption that, if the plug fits, the system will work. Again, ensure that your audio device offers plug-in power.

M10 body: The low-profile 3.5mm connector that is used on the S1i will easily pass through an M10 mounting hole. No special considerations are required.

Specifications

Numerical

Specification	S1n	S1e	S1f	S1i	Notes
Linear Range	1Hz-110KHZ	4.3Hz-110KHz	4.4Hz-108KHz	19Hz-108KHz	Nominal RVS +1.2 / -3dB
Receive Voltage Sensitivity[1]	-206	-180	-180	-187	dBV re: 1µPa
Transmit Voltage Response	128	N/A	N/A	N/A	dB//µPa/V@1m
Maximum Input Voltage	50 / 200	N/A	N/A	N/A	V p-p (continuous / <10% duty cycle)
Horizontal Directivity (receive)	+0.2 / -1				Relative dB @ 50KHz
Vertical Directivity (receive)[2]	+0 / -5.9				Relative dB @ 50KHz
Operating Depth (maximum)	200 meters				
Survival Depth	350 meters				
Operating Temperature Range	-10°C to +80°C				
Nominal Capacitance	6.5nF	N/A	N/A	N/A	10m cable attached
Acoustic Overload Pressure[3]	-	188	185	180	DB SIL re: 1µPa
Output Connection	BNC	XLR	BNC	3.5TRS	Standard; options available
Size	Ø12mm x 43mm				Standard body style; see drawings
Weight (in air)	8 grams				Hydrophone only – see cable specs
Specific Gravity	1.4				Hydrophone only – see cable specs
Wetted Materials	polyurethane, anodized aluminum				

1 S1n sensitivity affected by cable length. +/-3dB passed in QC testing. Typical varaition between units of same build is less than 2dB.
2 Data derived from AS-1. See Charts notes next page.
3 S1n unknown—theoretically well over 200dB; S1i assumes 1.2mA bias current @ 3V

Charts

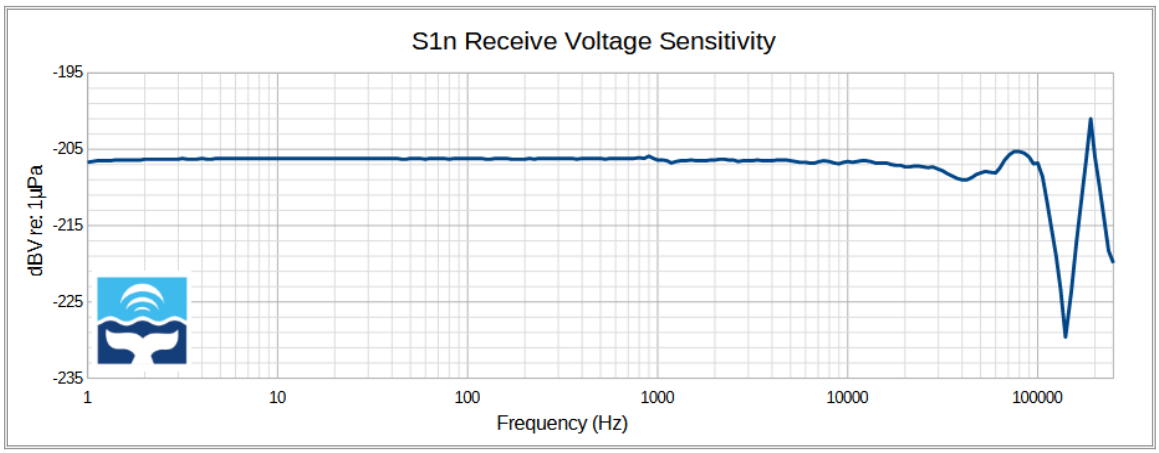
The following receive voltage sensitivity (RVS) and directional response (DR) charts are derived from data provided by the US Navy's Underwater Sound Reference Division calibration labs at Newport. Three S1ns were calibrated—two at the open-tank facility and one in the low-frequency facility. Response reported here are the average of these hydrophones. S1 *e*, *f*, and *i* plots were derived by summing amplifier response and S1n response.

At the time of this writing, S1 hydrophones have not been calibrated for transmit voltage response (TVR) and impedance nor DR in the vertical plane, nor transmit DR. For more information on these, see the AS-1 data sheet. The AS-1 uses the same sensor as the S1. As the AS-1 has been made since 2013, we have collected substantially more data for that device. TVR and DRs in the horizontal plane should be very similar; DRs in the vertical plane may be affected by S1's different body shape.

In most cases, Aquarian can likely accommodate requests for gain and input impedance modifications with *e*, *f*, and *i* signal conditioning. These modifications will affect sensitivity and frequency response. For example: S1 hydrophones could be made with reduced gain, which would allow for higher acoustic overload pressures. A lower input impedance at the signal conditioning board could filter unwanted low-frequency noise.

Noise and frequency response will be further limited by the devices to which they are connected. Check the specifications or test those to determine overall response. Microphone preamps used with the *e* and *i* variants will likely limit low-frequency response. Your ability to capture high frequencies will be limited by the sampling rate of your recording device. Sampling rate must be more than double the highest frequency you wish to capture. High sampling rates will not guarantee high-frequency response as anti-aliasing filters may also limit bandwidth.

S1n

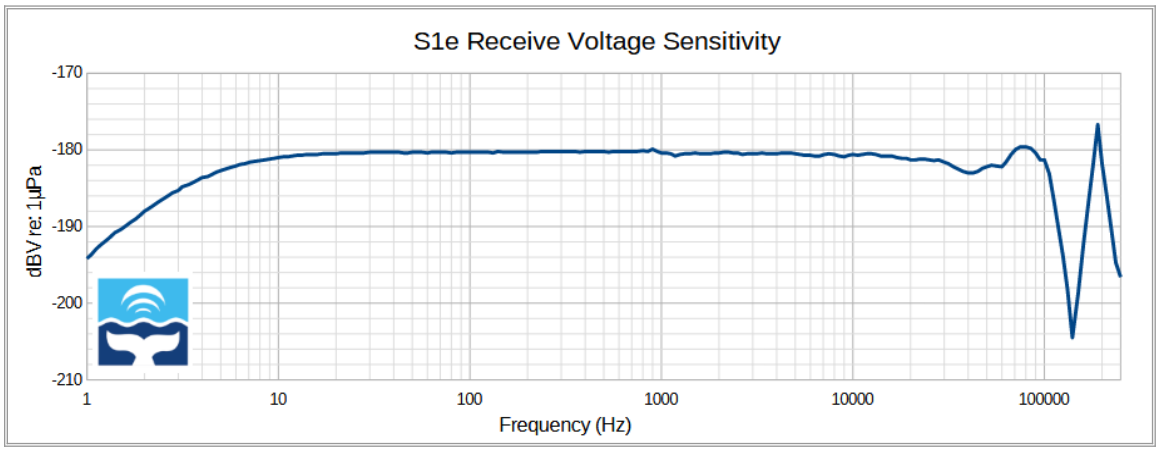


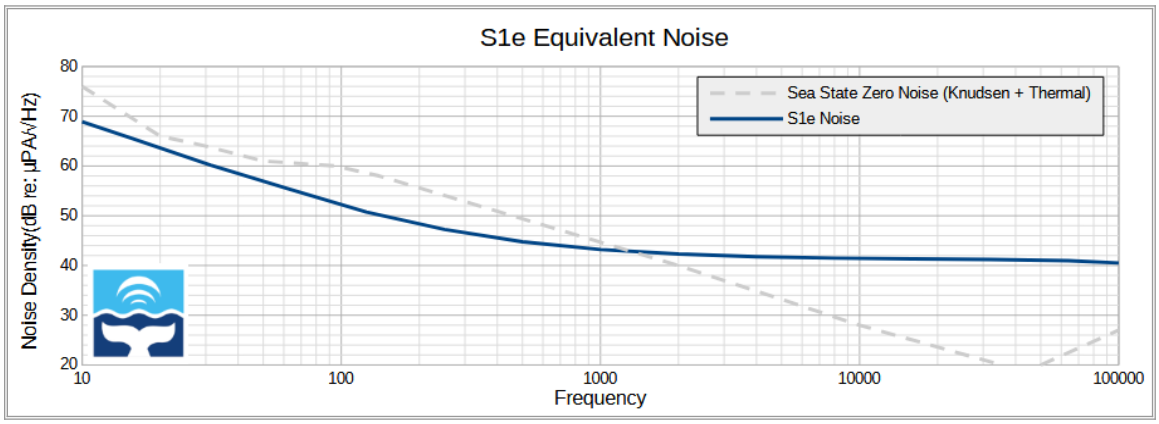
Transmit Voltage Response (TVR) and impedance plots: See AS-1

Low-frequency response will be affected by input impedance of the device to which the S1n is connected.

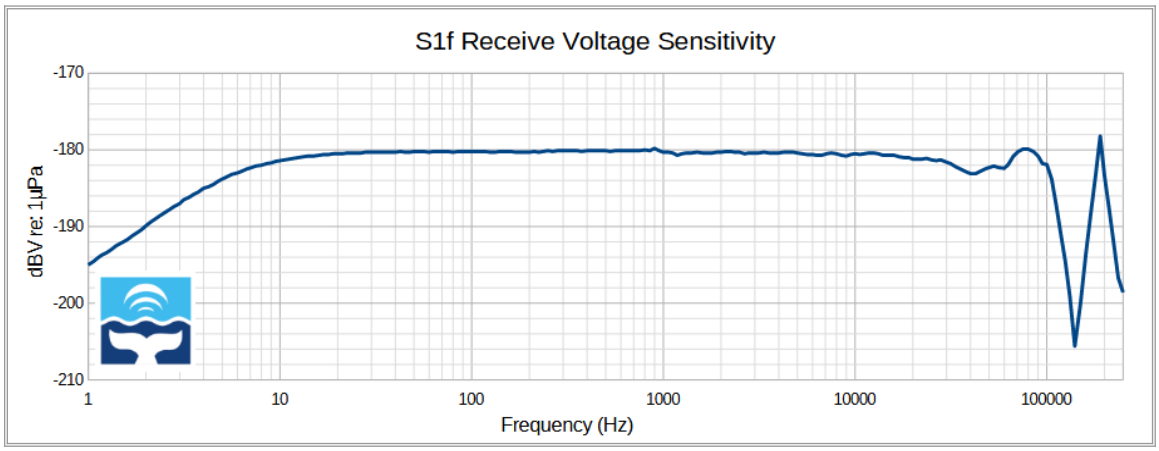
As a passive device, noise is below our measurement capabilities.

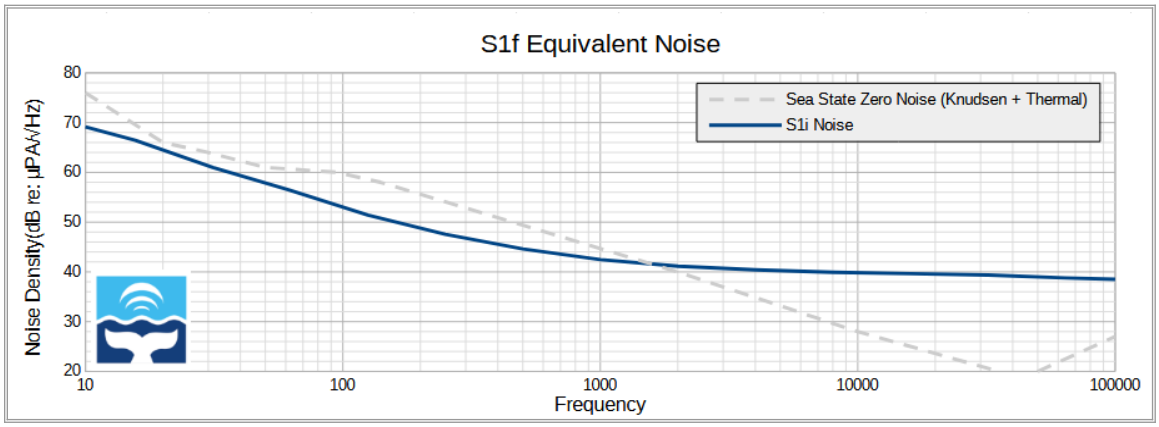
S1e


S1e Receive Voltage Sensitivity
-170
-180
-190
-200
-210
dBV re: 1µPa
1
10
100
1000
10000
100000
Frequency (Hz)

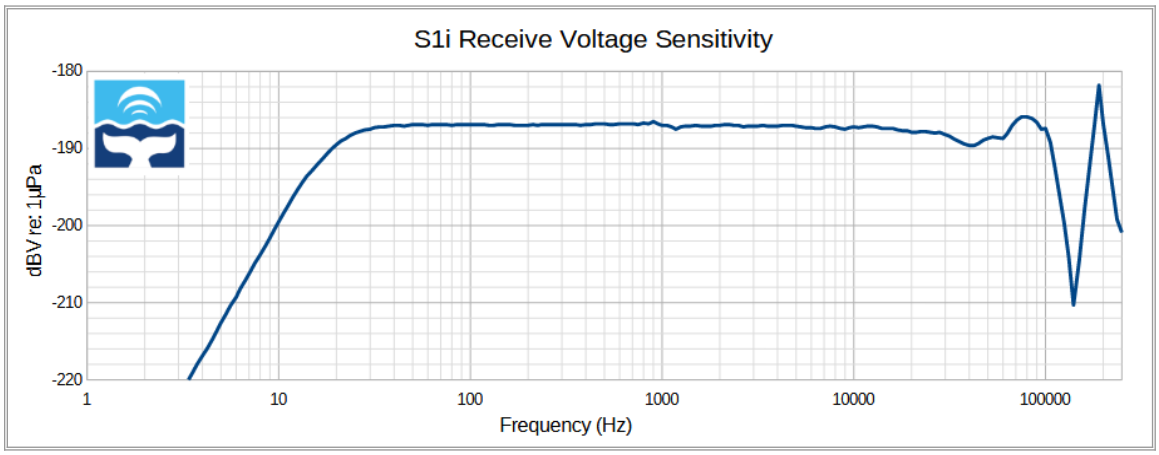

S1e Equivalent Noise
80
70
60
50
40
30
20
Noise Density(dB re: µPA√/Hz)
Sea State Zero Noise (Knudsen + Thermal)
S1e Noise
10
100
1000
10000
100000
Frequency

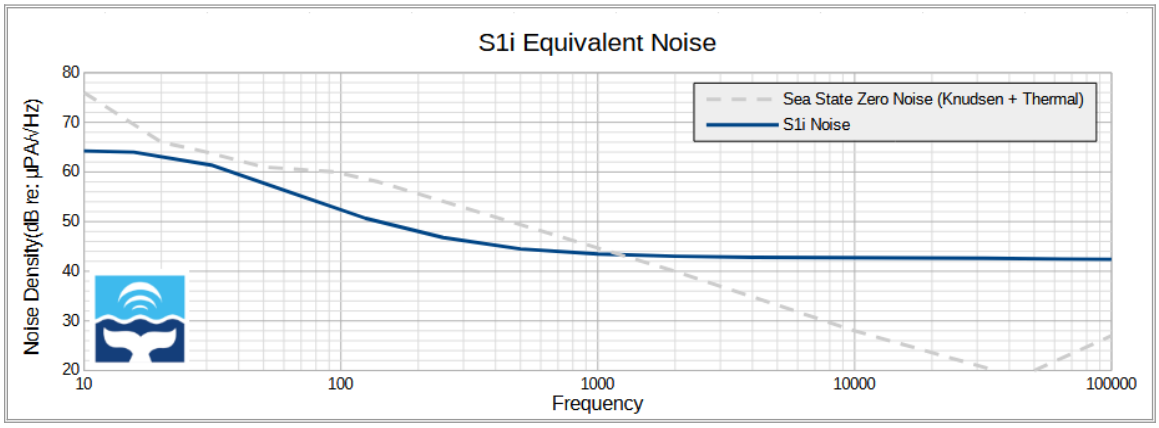
S1f


S1f Receive Voltage Sensitivity
dBV re: 1µPa
-170
-180
-190
-200
-210
1
10
100
1000
10000
100000
Frequency (Hz)


S1f Equivalent Noise
Noise Density(dB re: µPA√Hz)
80
70
60
50
40
30
20
10
100
1000
10000
100000
Frequency
Sea State Zero Noise (Knudsen + Thermal)
S1i Noise

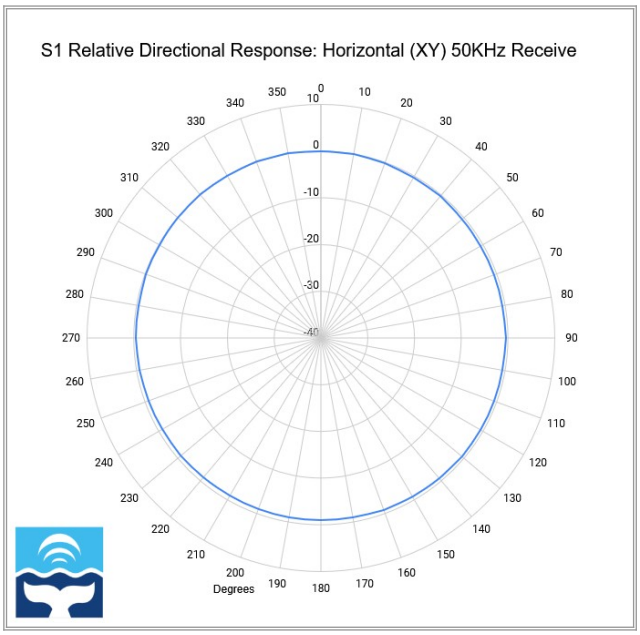
S1i





When comparing equivalent noise plots between the S1i and others, note that sensitivity of the S1i is 7dB lower. This should be added to the S1i plot line if making relative comparisons of signal-to-noise. Though noise levels appear similar while plotted as SIL equivalent, the S1i is noisier as a result of limitations with available power in plug-in power.

S1 Directional Response



“Horizontal” refers to sound originating from directions perpendicular to the lay of the hydrophone cable. For a more technical description, see USRD notes.

Additional Resources

Warranty and Policies: Aquarian Hydrophones are sold with a 1-year limited warranty. Please read details at our warranty page. All sales are final except wherein returns are explicitly offered prior to sale. For additional details about returns, payment, discounts, privacy and more, please visit our policy page.

Calibration: For information about calibration and accessories, please see our calibration resources.

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