How Does A Transducer Work?

What is a Transducer?

A good fishfinder depends on an efficient transducer to send and receive signals. The transducer is the heart of an echosounder system. It is the device that changes electrical pulses into sound waves or acoustic energy and back again. In other words, it is the device that sends out the sound waves and then receives the echoes, so the echosounder can interpret or "read" what is below the surface of the water.

Echosounder

B744V transducer

How Does a Transducer Work?

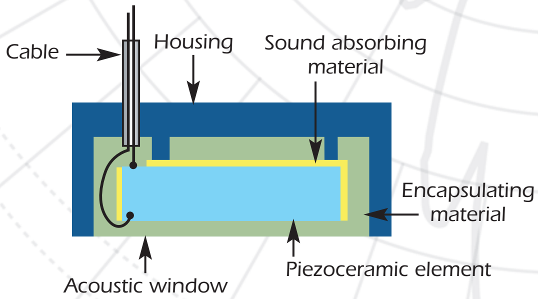
The easiest way to understand how a transducer functions is to think of it as a speaker and a microphone built into one unit. A transducer receives sequences of high voltage electrical pulses called transmit pulses from the echosounder. Just like the stereo speakers at home, the transducer then converts the transmit pulses into sound. The sound travels through the water as pressure waves. When a wave strikes an object like a weed, a rock, a fish, or the bottom, the wave bounces back. The wave is said to echo—just as your voice will echo off a canyon wall. When the wave of sound bounces back, the transducer acts as a microphone. It receives the sound wave during the time between each transmit pulse and converts it back into electrical energy. A transducer will spend about 1% of its time transmitting and 99% of its time quietly listening for echoes. Remember, however, that these periods of time are measured in microseconds, so the time between pulses is very short. The echosounder can calculate the time difference between a transmit pulse and the return echo and then display this information on the screen in a way that can be easily understood by the user.

What Goes into the Making of a Transducer?

The main component of a depth transducer is the piezoceramic element. It is the part that converts electrical pulses into sound waves, and when the echoes return, the piezoceramic element converts the sound waves back into electrical energy. Piezoceramic elements are most often in a disk form, but they may also be in the shape of a bar or a ring. A transducer may contain one element or a series of elements linked together called an array. A transducer is made up of six separate components:

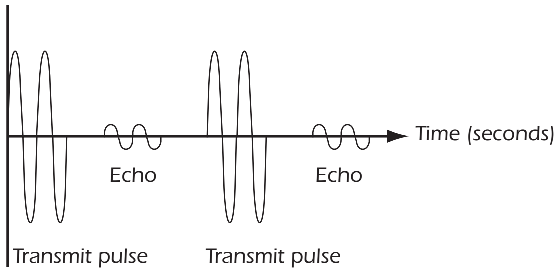
- Piezoceramic element or an array of elements
- Housing
- Acoustic window
- Encapsulating material
- Sound absorbing material
- Cable

How Does A Transducer Work?



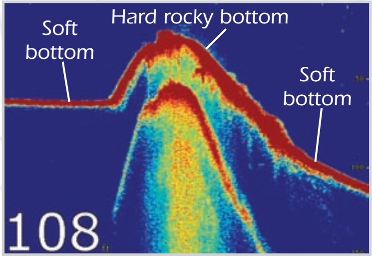
How Does a Transducer Know How Deep the Water is?

The echosounder measures the time between transmitting the sound and receiving its echo. Sound travels through the water at about 1,463 m/s (4,800 ft/s), just less than a mile per second. To calculate the distance to the object, the echosounder multiplies the time elapsed between the sound transmission and the received echo by the speed of sound through water. The echosounder system interprets the result and displays the depth of the water in feet for the user.



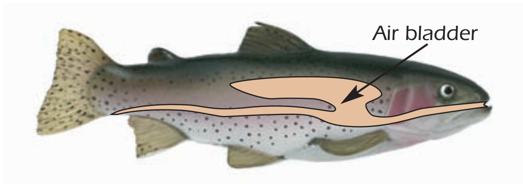
How Does a Transducer Know What the Bottom Looks Like?

As the boat moves through the water, the echoes of some sound waves return more quickly than others. We know that all sound waves travel at the same speed. When a sound wave in one section of the sound field returns more quickly than another, it is because the wave has bounced off something closer to the transducer. These early returning sound waves reveal all the humps and bumps in the underwater surface. Transducers are able to detect whether a bottom is soft or hard and even distinguish between a clump of weeds and a rock, because the sound waves will echo off of these surfaces in a slightly different manner.



How Does a Transducer See a Fish?

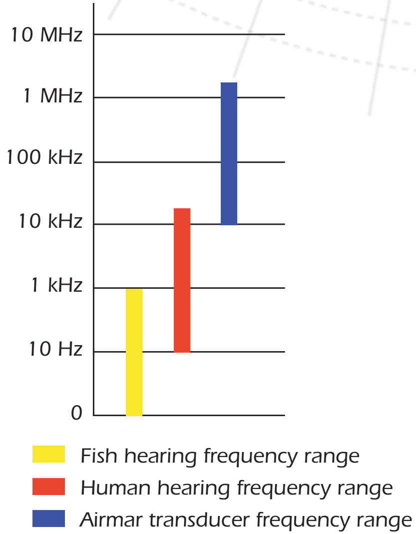
The transducer can see a fish, because it senses the air bladder. Almost every fish has an organ called an air bladder filled with gas that allows the fish to easily adjust to the water pressure at different depths. The amount of gas in the air bladder can be increased or decreased to regulate the buoyancy of the fish. Because the air bladder contains gas, it is a drastically different density than the flesh and bone of the fish as well as the water that surrounds it. This difference in density causes the sound waves from the echosounder to bounce off the fish distinctively. The transducer receives the echoes and the echosounder is able to recognize these differences. The echosounder then displays it as a fish.



Selecting Frequencies

Can Fish Hear the Sound Waves Produced by a Transducer?

No, the sound waves are ultrasonic. They are above (ultra) the sound (sonic) that human ears are able to hear. Humans can hear sound waves from 10 Hz to 20 kHz. Most fish are unable to hear frequencies higher than about 500 Hz to 1 kHz. The ultrasonic sound waves sent out by Airmar transducers have frequencies ranging from 10,000 kHz to 2 MHz (200,000,000 Hz), clearly beyond the hearing of fish. However, most people can hear the transmit pulses of our 10 kHz transducers; they sound like a series of clicks.



What is Frequency?

Frequency is the number of complete cycles or vibrations that occur within a certain period of time, typically one second. Sound waves can vibrate at any one of a wide number of frequencies. The easiest way to understand frequency is to think of it in terms of sounds that are familiar. For example, a kettle drum produces a low-pitched sound (low-frequency). That is, it vibrates relatively few times per second. Whereas, a flute produces a high-pitched sound (high-frequency). It vibrates many more times per second than a kettle drum. The frequency of sound waves is measured in a unit called a Hertz. A Hertz is one cycle per second. For example: a 150 kHz transducer operates at 150,000 cycles per second.

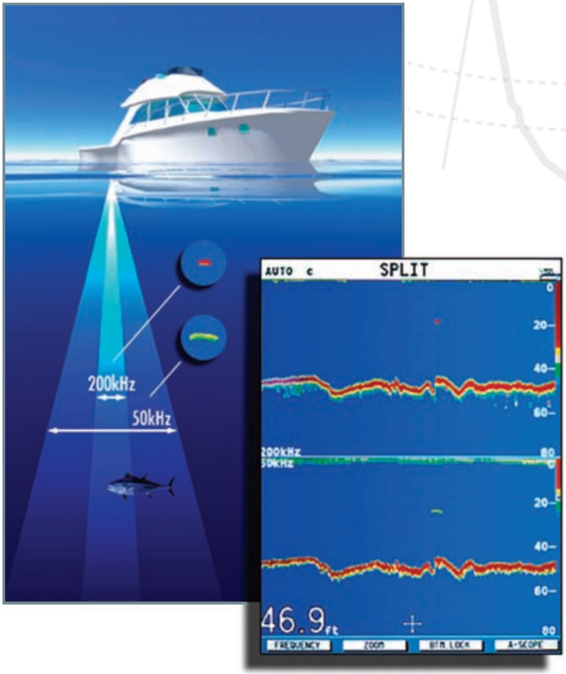
How Does a Customer Decide What Frequency is Needed?

Airmar transducers are often designed for 50 kHz (50,000 cycles per second) or 200 kHz (200,000 cycles per second). Transducers can be designed to operate efficiently at any number of specific frequencies depending upon the application and performance requirements of the customer. A higher-frequency sound wave will give the user a higher-resolution picture of what is present under the water, but the range will be short. Fishermen in more shallow lakes, who want a crisp clear picture of the bottom need a higher-frequency transducer. Low-frequency sound waves will not give the user as clear a picture of the bottom, but they have greater range for very deep areas where high-frequency sound waves cannot reach. A low-frequency unit will work well in the depths of Lake Michigan or the ocean.

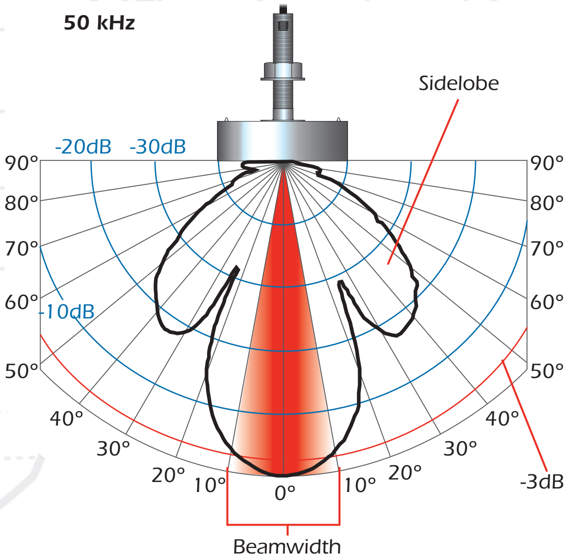
A higher-frequency transducer will put out quicker, shorter, and more frequent sound waves. Like the ripples made when a small pebble is thrown into still water, small waves of sound move evenly out and away from the source. Because they are just small waves, they will not travel far, and small obstacles will cause them to bounce back. Higher frequencies are more sensitive to small objects and will send back detailed information which will show as crisp high-resolution pictures on the echosounder screen. The range of high-frequency sound waves, however, is short. In fact, sound waves emitted by a 200 kHz transducer have a limited range of about 200 m

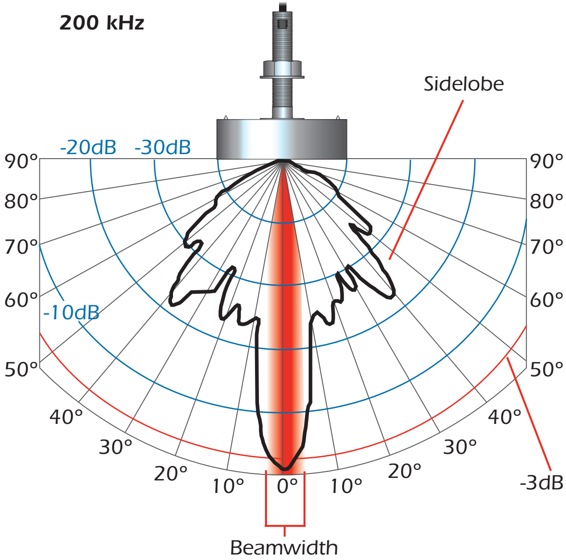
Selecting Frequencies

(600'). Now, think of the large waves created by a large boulder thrown into still water. Low-frequency sound waves are like these large waves; they travel much farther than high-frequency waves. But because low-frequency waves are so large, they wash right over small obstacles. Low-frequency sound waves are not as sensitive in detecting small fish or other small obstacles as are high-frequency waves, and although they can see to greater depths, they will not send back detailed information or clear crisp pictures.



This illustration shows the differences in beamwidth of a transducer operating at both 50 kHz and 200 kHz. Notice the different way the fish appear as "marks" at each frequency.





Transducer Style and Screen Images

In-Hull Transducers

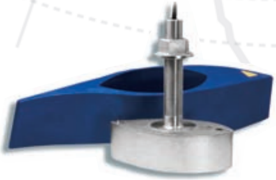
P79

M260

R199 / R299 / R399

Thru-Hull/External Transducers

B744V



SS260

R99 / R209 / R309

Transom-Mount Transducers

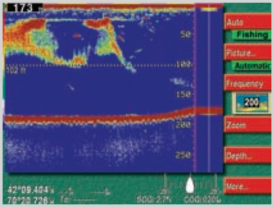
P58

P66

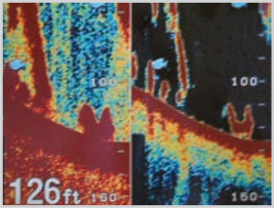
TM258

Transducer Style and Screen Images

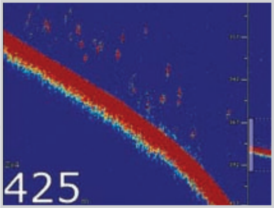
In-Hull Screen Images



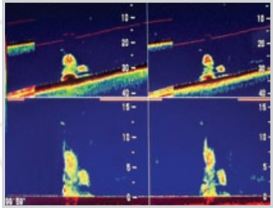
600 W



1 kW

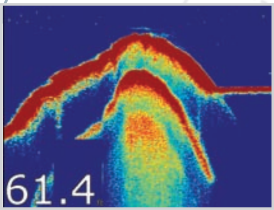


2 kW

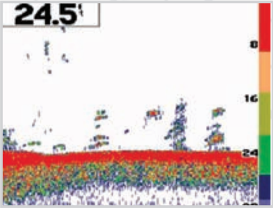


3 kW

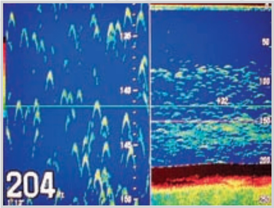
Thru-Hull/External Screen Images



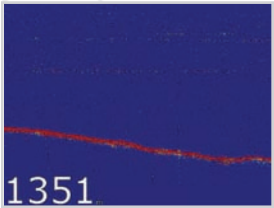
600 W



1 kW

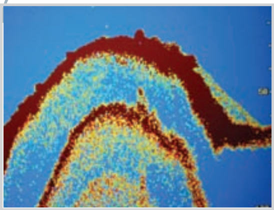


2 kW

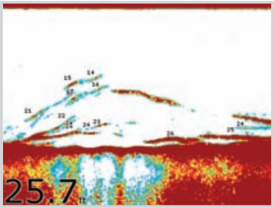


3 kW

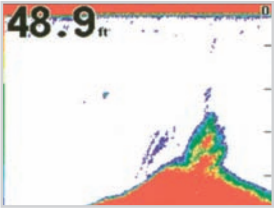
Transom-Mount Screen Images



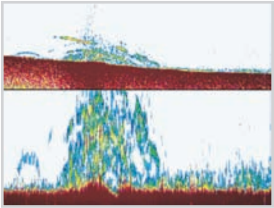
600 W



600 W



1 kW



1 kW

Transducer Styles and Mounting Methods

Choosing the Right Transducer

There are three main considerations when selecting a transducer.

- Transducer mounting style
- Type of boat and its hull material
- Application or expectation for the transducer

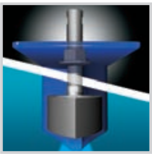
Transducer Mounting Style

Transducers are typically mounted in one of three ways: through the hull, inside the hull, or on the transom.

Through the Hull

The transducers in this mounting style fall into two categories. There are "flush" thru-hull sensors that sit flush or nearly flush with the boat hull. They are recommended for smaller boats with a minimum deadrise angle. And they are often installed on sailing vessels because they produce minimal drag.

External thru-hull transducers extend beyond the hull's surface and usually require a fairing to aim the sound beam vertically. They are right for larger un-trailered vessels. When external mounts are installed with a High-Performance Fairing, the transducer face is flush with the surface of the fairing and parallel to the waterline, resulting in a truly vertical beam, putting maximum energy on the target. This installation, when mounted in "clean water," forward of propellers and running gear, produces the most effective signal return, since nothing on the vessel interferes with the transducer's active face.



Inside the Hull

An in-hull transducer is installed inside a boat hull against the bottom and sends its signal through the hull. Some people prefer this mounting style, because it is not necessary to drill through the vessel. A unit cannot be damaged when a boat is trailered, the transducer is not exposed to marine growth, and there is no drag. Additionally, a transducer can be installed and serviced while the vessel is in the water. Most in-hull transducers are mounted inside a liquid filled tank that is first epoxied in place. As long as the water flow below the transducer is "clean", it will give great high-speed performance.

On the Transom

Transom-mounts are attached to the back (transom) of a boat hull. Trailered boats typically use this mounting style, since it is out of the way of the rollers. Some people prefer a transom-mount, because it is easy to install and remove a unit—especially if a kick-up bracket is used. Kick-up brackets move a transducer out of the way to prevent damage from floating debris when a boat is underway. Also, they protect the transducer when a boat is trailered, or when it is kept in the water for a long period of time. A transom-mount installation gives better performance than an in-hull at boat speeds below 30 knots (34 MPH).

Transducer Styles and Mounting Methods

Type of Boat and its Hull Material

The type of boat and the material used to make the hull must be taken into consideration when selecting the transducer mounting style. Each has its limitations.

Thru-Hull/External Mount

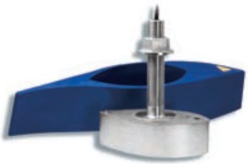
Thru-hull transducers will work with any engine type: inboard, outboard, or I/O. And these transducers are right for power and sailboats alike. There are thru-hull units for every hull material.

Thru-hull units are not recommended in two situations.

- Plastic thru-hull housings cannot be used in a wooden boat. Wood swells as it absorbs water, so it may crack the housing.
- Bronze thru-hull housings cannot be used in aluminum boats. The interaction between the aluminum and the bronze, especially in the presence of salt water, will eat away the aluminum hull and/or the bronze housing.

Plastic

Bronze



Stainless steel

In-Hull Mount

In-hull transducers will work with any engine type: inboard, outboard, and I/O. These transducers perform well on both power and sailboats.

Thick aluminum hulls are not recommended for in-hull installations, because there is too much signal loss transmitting through the metal. In addition, this installation will not work on wooden boats or cored fiberglass hulls (foam, balsa wood, or plywood layers sandwiched between an inner and an outer skin). These materials contain air bubbles that reflect and scatter sound pulses before they reach the water.

Some in-hull transducers, such as the P79, can be used on small aluminum-hull boats up to 6.7 m (22') with a hull thickness of 0.38 mm (0.150") or less. In these installations, the transducer face is epoxied directly to the hull.

P79

Transom-Mount

Transom-mount transducers can be used with any hull material. However, they will not work on a vessel with an inboard engine due to the turbulence forward of the sensor. And because of excessive heeling, transom-mounts are not recommended for sailboats.

P58

Transducer Styles and Mounting Methods

Application or Expectation for the Transducer

Cruising and Sailing

If time on the water is spent sailing or cruising, a high-power transducer is not needed. Single-frequency 200 kHz transducers with 200 W to 600 W RMS power will be more than enough in this application. Accurate depth readings will range from 61 m to 152 m (200′ to 500′) depending on the depth instrument.

DST800

Recreational Fishing

If the application is recreational fishing, a 600 W transducer will do the job. These transducers have enough power to read bottom in over 305 m (1,000′) of water and have 50 kHz and 200 kHz dual-frequency capability. Typically matched with small to mid-size fishfinders, a 600 W transducer is perfect for bottom fishing, marking bait, and marking game fish.

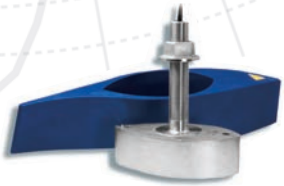
B744V

P66

Tournament Sport Fishing

A 1 kW to 2 kW transducer is a must for tournament sport fishing. These powerhouses will give the user a crystal clear screen on medium to large fishfinders. The multiple elements that make up the transducer can distinguish schools of fish as closely-spaced individual targets and can distinguish fish close to the bottom. These transducers are so precise; fish are no longer concealed by their surroundings.

Many of the 1 kW and 2 kW transducers have Airmar's exclusive Broadband Ceramic Technology. The 200 kHz element produces the highest resolution available today without sacrificing sensitivity.



SS260

R199

Commercial Fishing

These transducers are available in frequencies from 24 kHz to 200 kHz and power from 1 kW to 4 kW. Units feature high-efficiency designs producing superior fishfinding and clear and distinct images of both the bottom and closely-spaced fish.

R99

Transducer Styles and Mounting Methods

Navigation/Ocean Survey/Custom

Airmar offers custom engineered transducers for consumer, commercial, and scientific applications. Airmar designs and manufactures transducers ranging in frequency from 10 kHz to 2 MHz and power outputs ranging from 100 Watts to 10,000 Watts depending on the specific application. Typical applications vary from portable units for harbor survey to custom fishfinder transducers to multi-frequency arrays used in deep-sea sounding. Transducer arrays of more than 100 piezoceramic elements have been designed and manufactured. Airmar can produce dual-beam and split-beam transducers, phased-array transducers, SWATH and Forward Looking Sonar Transducers—all built to the customer's specifications. Airmar also can supply a wide range of flow sensing transducers.

CS229

M42

Cruising and Sailing

Recreational Fishing

Tournament Sport Fishing

Commercial Fishing

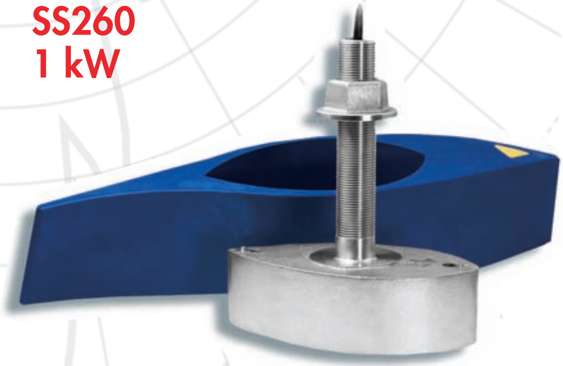
Navigation/ Ocean Survey/ Custom

600 W vs 1,000 W High-Performance Units

B744V 600 W

Frequencies	Number of Elements and Configuration	Beam Width (@-3dB)	Rated RMS Power (W)
50/200 kHz-A	○	45°	600 W
		12°	600 W

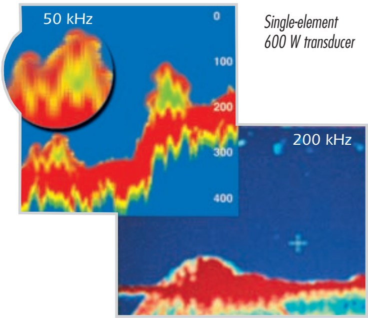
SS260 1 kW



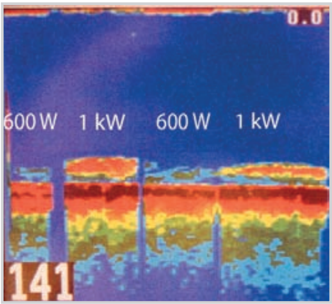
Frequencies	Number of Elements and Configuration	Beam Width (@-3dB)	Rated RMS Power (W)
50 kHz-AE	✿	19°	1 kW
200 kHz-BH	○	6°	1 kW

Transducer Comparison: 600 W versus 1 kW

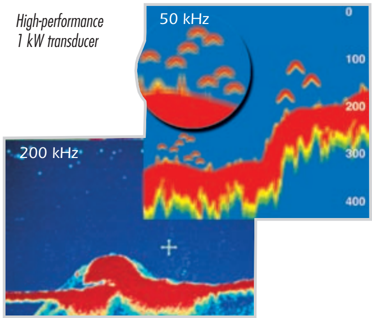
The photos below clearly show the screen resolution differences between a single-element 600 W transducer and a multiple-element 1 kW transducer.

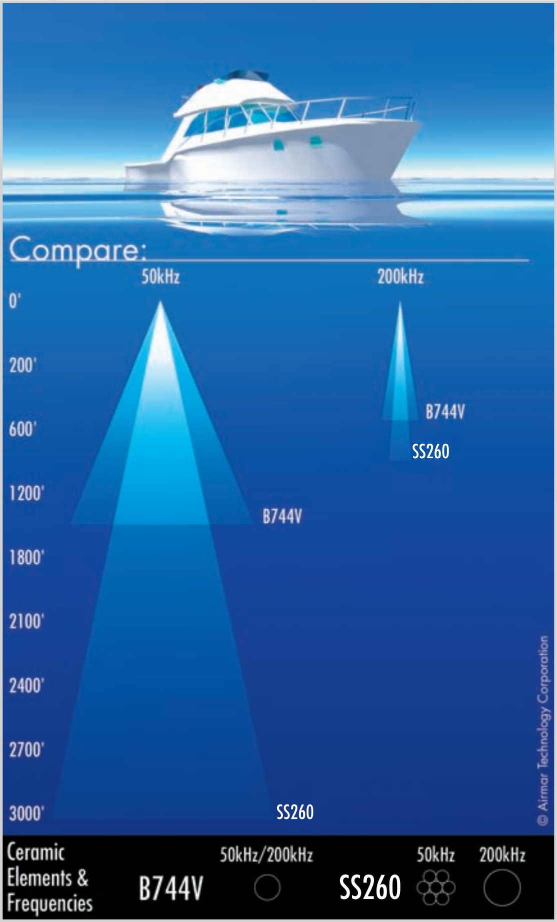


Single-element 600 W transducer



High-performance 1 kW transducer





The image above shows the depth and beamwidth differences between the single-element, 600 W, B744V and the multiple-element, 1 kW, SS260.

Xducer ID™ Feature

Airmar's exclusive Transducer ID feature allows echosounders to query the connected transducer gathering important operating characteristics. With this data, the echosounder and transducer function as a precisely-tuned system. A Transducer ID enabled sensor contains an embedded microcontroller that communicates with the connected echosounder via a single conductor in the transducer cable. The principal data transmitted is intended to identify the type and configuration of the transducer. Then the echosounder can alter its parameters of operation to optimize performance and to protect the transducer from overdrive. The Transducer ID feature also provides important information to installers and technicians such as serial number and housing style. Listed below is a summary of the information that the Transducer ID feature can provide to future fishfinders.

- Airmar part number
- Housing style
- Serial number
- Ceramic element configuration
- Date of manufacture
- Acoustic window
- Impedance matching configuration
- Nominal frequency(s)
- Best transmit frequency(s)
- Power rating
- Beam pattern

Advantages of a High-Performance Fairings

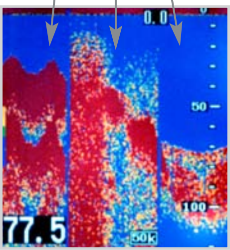
Without High-Performance Fairing

With High-Performance Fairing

High-Performance Fairing

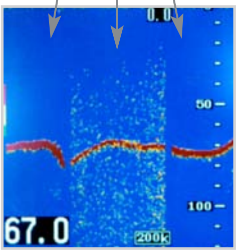
Achieve maximum fishfinder performance by installing an Airmar transducer with a High-Performance Fairing. Each High-Performance Fairing is custom designed to match its transducer model. The fairing assures a vertical beam which results in strong return echoes. Additionally, the streamlined shape reduces drag and minimizes turbulence over the face of the transducer. At speeds above 30 knots (34 MPH), screens continue to display clear images and solid bottom tracking.

High-Performance Fairing
Standard Fairing



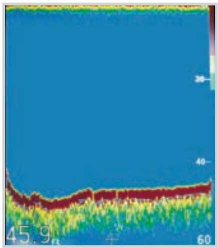
50 kHz, 23 knots (26 MPH)

High-Performance Fairing
Standard Fairing



200 kHz, 25 knots (29 MPH)

High-Performance Fairing Only



50 kHz, 36 knots (41 MPH)

The photos above show a boat-test comparison of a transducer installed with a High-Performance Fairing versus a standard fairing. The same transducer model was used. One transducer was installed on the port side of the boat with a High-Performance Fairing, and the other was installed on the starboard side with a standard fairing. Using a switchbox, we were able to swap from one transducer to the other. At speed, the significant resolution and clarity on the fishfinder screen when using the transducer with a High-Performance Fairing is clearly depicted.

Without a fairing, the beam is angled improperly.

With a fairing, the beam is angled properly.

Benefits of Broadband Transducer Technology

Airmar is the first to introduce affordable Broadband Transducers. This is an enabling technology that provides better fish detection today and will lead to dramatic advances in echosounder performance in the future. While these transducers are more costly to manufacture, the present and future benefits are huge.

Broadband Transducers enhance fish detection on virtually all of today's fishfinders. They give better definition; it is far easier to distinguish among individual fish and between fish and the bottom.

Airmar achieves superior results by using a new ceramic material. It lets transducers operate over a range of frequencies while maintaining sensitivity. These Broadband Transducers are, by definition, low-Q devices. In other words, they exhibit very low ringing. There is little variation from transducer to transducer. Additionally, Broadband Transducers are relatively immune to the effects of aging, so their frequency range remains stable over time.

Benefits Today

Manufacturers now market echosounders that can adjust operating frequency and power output. While these are premium products, the designs are a precursor of things to come. With the ability to adjust frequency, an echosounder can operate Airmar's broadband ceramics anywhere in the 160 kHz to 260 kHz band. By selecting different operating frequencies, two or more high-frequency sounders can work simultaneously without interference. The frequency also can be adjusted to the mission. Lowering the operations frequency increases the beamwidth and depth capability; raising the frequency narrows the beamwidth, increases echo definition, and improves high-speed performance.

Future Benefits

Here is where it gets really exciting. In today's fishfinders, good fish detection is obtained by transmitting a long pulse. This puts more energy on the target. With a long pulse, closely-spaced fish cannot be separated—you get a big blob. Fish close to the bottom appear attached to the bottom and are difficult or impossible to detect.

Airmar's broadband transducers enable frequency modulated (FM) transmissions; a.k.a. CHIRP or coded transmissions. Using FM transmissions, you can achieve both the benefits of long pulse, more energy on target, and short pulse, segregation of closely-spaced fish and identification of fish on or close to the bottom. This is because the coding of the transmission is known and the return echoes are similarly coded. The technique is also known as pulse compression. In summary, fishfinders of the future with FM transmissions will have dramatically improved target resolution and signal-to-noise ratio. Airmar's broadband transducer technology will enable this to happen.