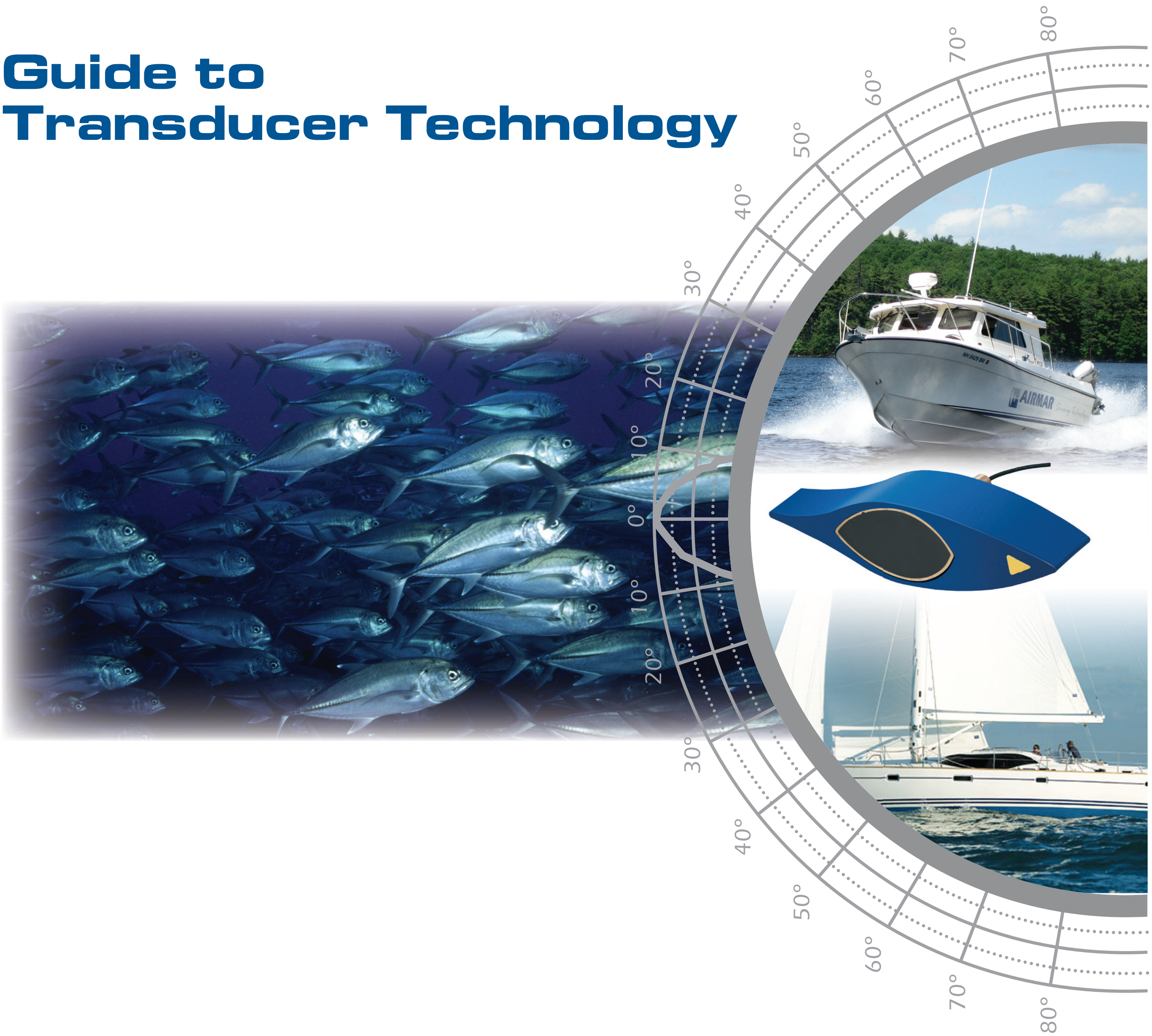
# Guide to Transducer Technology



AIRMAR®
TECHNOLOGY CORPORATION

*Sensing Technology*

# How a Transducer Works

## 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 "detect" what is below the surface of the water.

Echosounder

B744V transducer

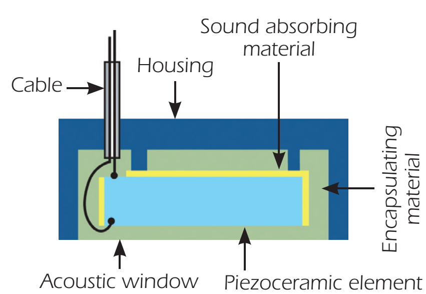
## How Does a Transducer Work?

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 is reflected. The wave is said to echo—just as your voice will echo off a canyon wall. When the reflected sound wave returns 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?

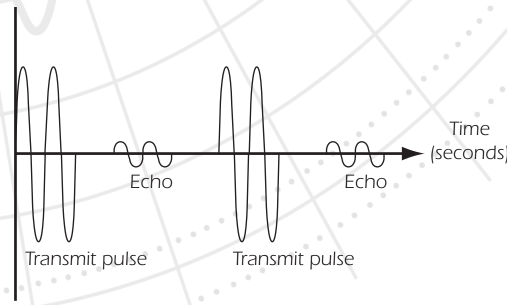
The main component of a depth transducer is the piezoceramic element. It is the part that converts electrical pulses into sound waves, and when the echoes return, the piezoceramic element converts the sound waves back into electrical energy. Piezoceramic elements are most often in a disk form, but they 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



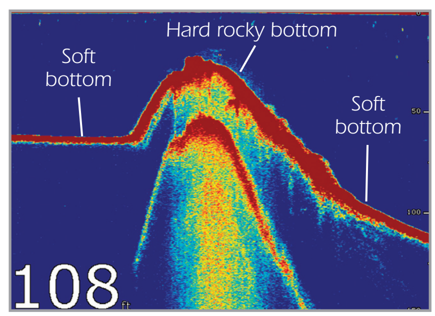

## How Does a Transducer Know How Deep the Water is?

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 for the user.



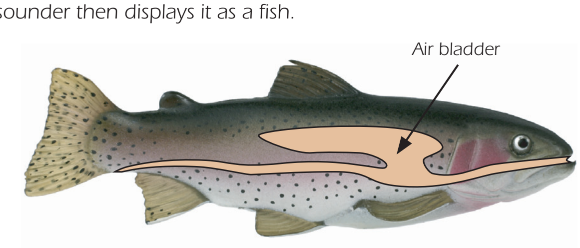

## How Does a Transducer Know What the Bottom Looks Like?

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. Echosounders 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 Detect Fish?

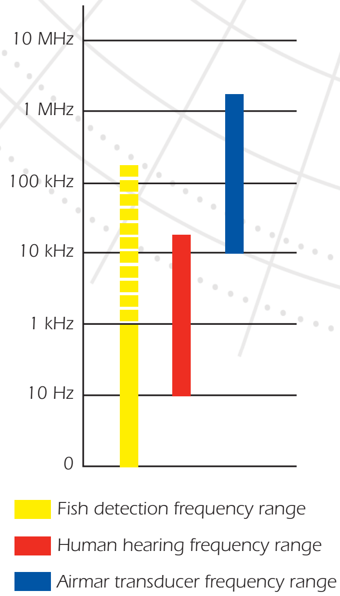
The transducer can detect fish, because it senses the air bladder. Almost every fish has an organ called an air bladder filled with gas that allows the fish to easily adjust to the water pressure at different depths. The amount of gas in the air bladder can be increased or decreased to regulate the buoyancy 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?

Sound waves are ultrasonic. 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 kHz to 2 MHz (10,000 Hz to 2,000,000 Hz), clearly beyond the hearing of fish. They are also above (ultra) the sound (sonic) that human ears are able to hear. Humans can hear sound waves from 10 Hz to 20 kHz. However, most people can hear the transmit pulses of our 10 kHz transducers; they sound like a series of clicks.



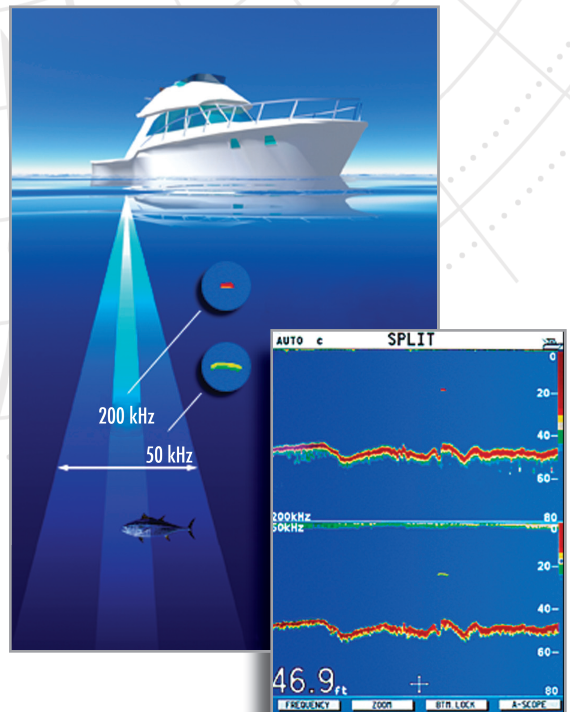

## What is Frequency?

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?

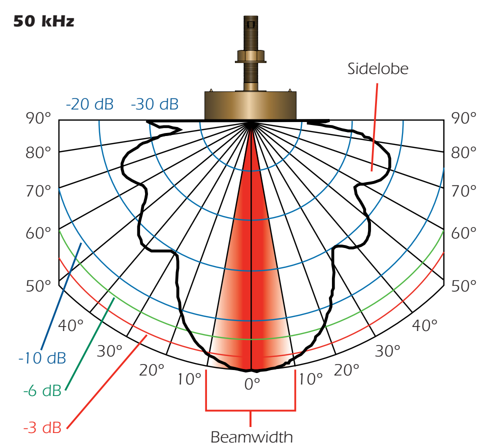
Airmar transducers are often designed for 50 kHz (50,000 cycles per second) or 200 kHz (200,000 cycles per second). Transducers can be designed to operate efficiently at any number of specific frequencies depending upon the application and performance requirements of the customer. A higher-frequency 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 (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.

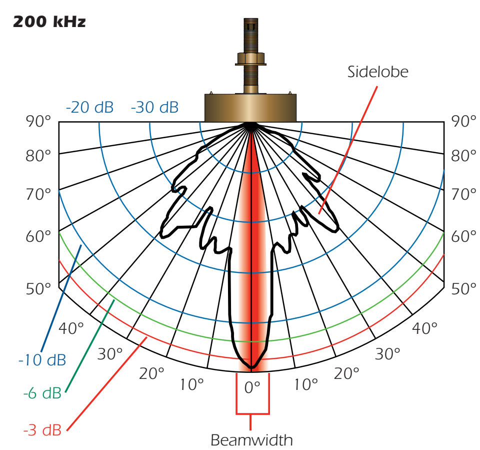



This illustration shows the differences in beamwidth of a transducer operating at both 50 kHz and 200 kHz. Notice the different way the fish appear as "marks" at each frequency.

**50 kHz**




**200 kHz**



# Transducer Style and Screen Images

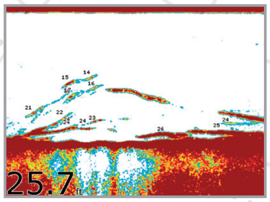
## In-Hull Transducers

P79

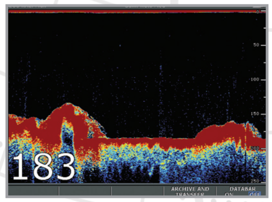
M260

R199 / R299 / R399

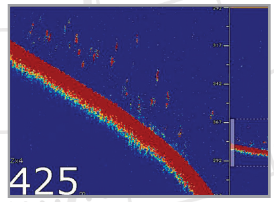
### In-Hull Screen Images



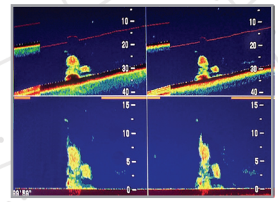

600 W




1 kW



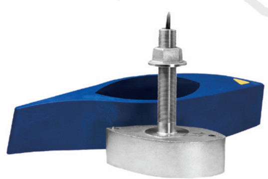

2 kW



3 kW

## Thru-Hull / External-Mount Transducers

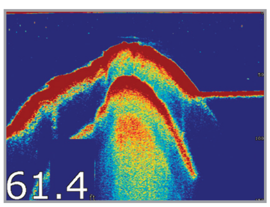
B744V



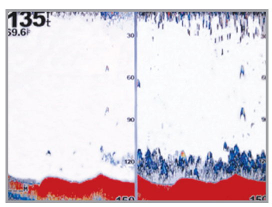
SS260

R99 / R209 / R309

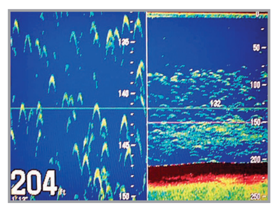
### Thru-Hull / External-Mount Screen Images



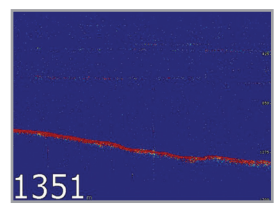

600 W




1 kW




2 kW




3 kW

## Transom-Mount Transducers

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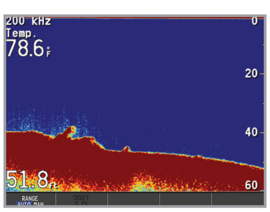
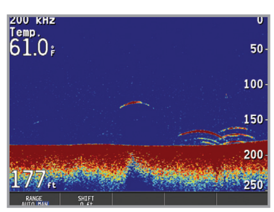
TM260 / TM270W

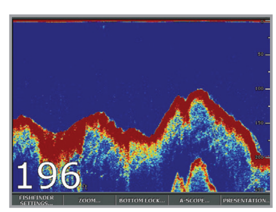
### Transom-Mount Screen Images



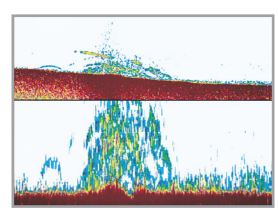

600 W




600 W




1 kW



1 kW

# Transducer Styles, Mounting & Installation Tips

## Transducer Mounting Styles

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

## Thru-Hull—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 designed for larger untrailered 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.

### *Thru-Hull Applications*

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.

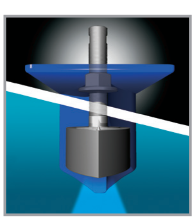
Thru-hull units are not recommended in two situations:

- 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 and stainless steel boats. The interaction between the metal hull and the bronze transducer, especially in the presence of salt water, will eat away the metal hull and/or the bronze housing.

### *Thru-Hull Mounting Tips*

Mount a thru-hull where the transducer will be under the water at all times.

- Mount where the water flowing across the transducer face is smoothest with a minimum of bubbles and turbulence (especially at high speeds).
- Be sure transducer beam will not be blocked by the keel or propeller shaft(s).
- Do not mount the transducer near water intake or discharge openings; or behind strakes, fittings, or hull irregularities.
- **Displacement Hull Powerboat**—Locate 1/3 aft LWL and 150 mm to 300 mm (6″ to 12″) off the center-line. The starboard side of the hull where the propeller blades are moving downward is preferred.
- **Planing Hull Powerboat**—Mount well aft near the center-line and well in-board of the first set of lifting strakes to insure that the transducer is in contact with the water at high-speeds. The starboard side of the hull where the propeller blades are moving downward is preferred.
- ***Outboard and I/O***—Mount just forward and to the side of the engine(s).
- ***In-board***—Mount well ahead of the propeller(s) and shaft(s).
- **Stepped Hull**—Mount just ahead of the first step.
- ***Boats Capable of Speeds Above 25 knots (29 MPH)***—Review transducer location and operating results of similar boats before proceeding.
- **Fin-Keel Sailboat**—Mount to the side of the center-line and forward of the fin keel 300 mm to 600 mm (1′ to 2′).
- **Full-Keel Sailboat**—Locate amidships and away from the keel



Plastic

Bronze

## In-Hull—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 adhered in place. As long as the water flow below the transducer is "clean", it will give great high-speed performance.

### *In-Hull Applications*

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

Metal, wood, and cored fiberglass hulls are not recommended for in-hull installations, because there is too much signal loss transmitting through the hull.

### *In-Hull Mounting Tips*

- Mount and In Hull where the hull below the transducer will be in contact with the water at all times.
- Mount where the water flowing across the hull is smoothest with a minimum of bubbles and turbulence (especially at high speeds).
- Be sure transducer beam will not be blocked by the keel or propeller shaft(s).
- Do not mount the transducer near water intake or discharge openings; or behind strakes, fittings, or hull irregularities.
- Use non-toxic anti-freeze (propylene glycol) to fill the tank.
- **Displacement Hull Powerboats**—Locate amidships near the center-line. The starboard side of the hull where the propeller blades are moving downward is preferred.
- ***Planing Hull Powerboats***—Mount well aft, on or near the center-line, and well inboard of the first set of lifting strakes to insure that the transducer will be in contact with the water at high speeds. The starboard side of the hull where the propeller blades are moving downward is preferred.
- ***Outboard and I/O***—Mount just forward of the engine(s).
- ***Inboard***—Mount well ahead of the propeller(s) and shaft(s).
- **Stepped hull**—Mount just ahead of the first step.

P79

## Transom-Mount—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. A transom-mount installation gives good performance at boat speeds below 30 knots (34 MPH).

### *Transom-Mount Applications*

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.

### *Transom-Mount Mounting Tips*

To ensure the best performance, the sensor must be in contact with aeration-free and turbulence-free water. Mount the sensor on the transom as close to the center-line (keel) of the boat as possible. On slower heavier displacement hulls, positioning it farther from the center-line is acceptable.

- Do not mount the transducer near water intake or discharge openings; or behind strakes, fittings, or hull irregularities.
- Avoid mounting the sensor where the boat may be supported during trailering, launching, hauling, or storage.
- ***Single Engine Boat***—Mount on the starboard side at least 75 mm (3″) beyond the swing radius of the propeller to avoid propeller turbulence.
- ***Twin Engine Boat***—Mount the sensor between the drives to avoid propeller turbulence.

P66

# Transducer Styles & 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 or a 235 kHz Smart™ Sensor is adequate. Accurate depth readings will be achieved up to 152 m (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.*

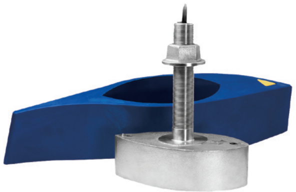
B744V

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.*

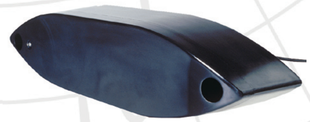


SS260

R199

***Commercial Fishing***

*These transducers are available in frequencies from 24 kHz to 210 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.*

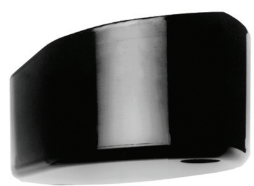


R99

***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



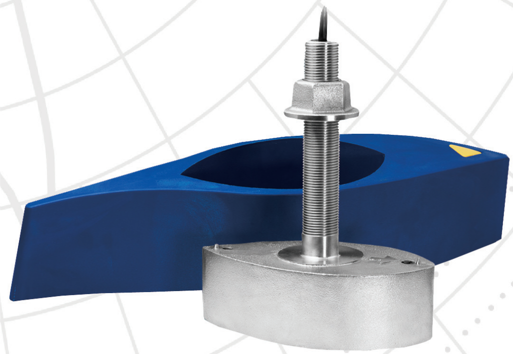
M42

# 600 W vs 1,000 W High-Performance Units

## B744V 600 W

| | 50/200 kHz-A | |
|---|---|---|
| **Number of Elements and Configuration** | ○ | |
| **Beamwidth (@-3 dB)** | 45° | 12° |
| **RMS Power (W)** | 600 W | 600 W |

## SS260 1 kW

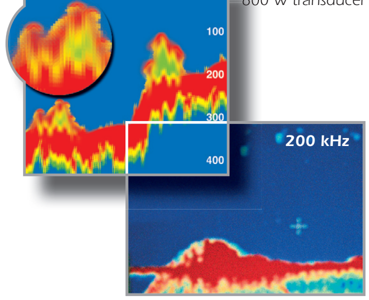


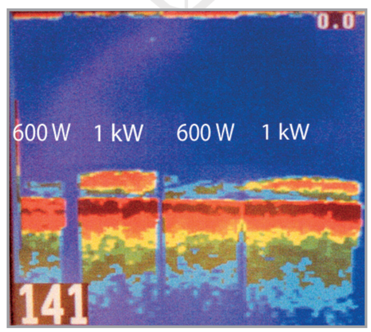
| | 50 kHz-AE / 200 kHz-BH | |
|---|---|---|
| **Number of Elements and Configuration** | ✿ | ○ |
| **Beamwidth (@-3 dB)** | 19° | 6° |
| **RMS Power (W)** | 1 kW | 1 kW |

## Transducer Comparison: 600 W versus 1 kW

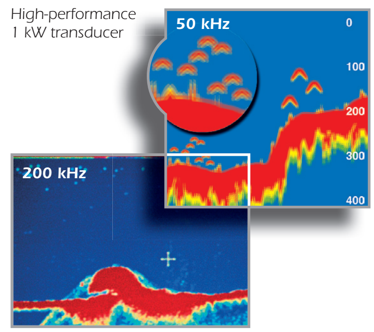
The photos below clearly show the screen resolution differences between a single-element 600 W transducer and a multiple-element 1 kW transducer.

Single-element 600 W transducer

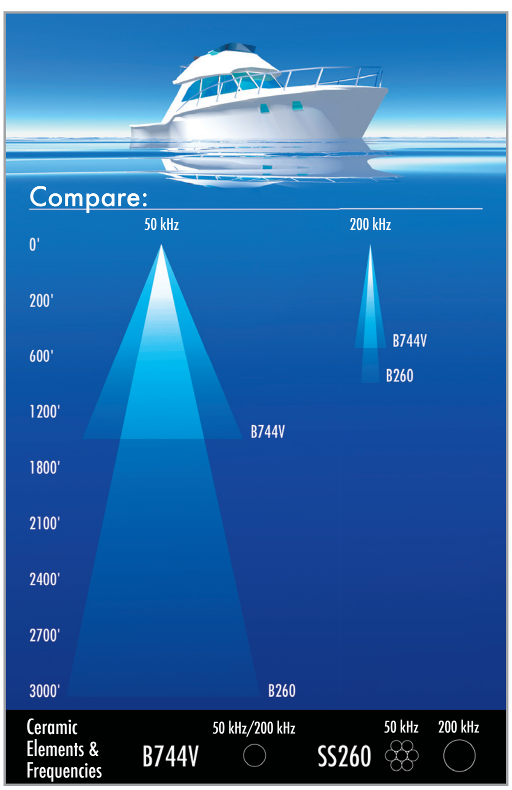



High-performance 1 kW transducer




# 600 W vs 1,000 W Performance



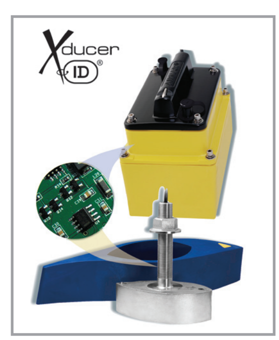

The image to the left shows the depth and beamwidth differences between the single-element, 600 W, B744V and the multiple-element, 1 kW, SS260.

# Transducer ID®

## Transducer 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 micro-controller 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 High-Performance Fairings

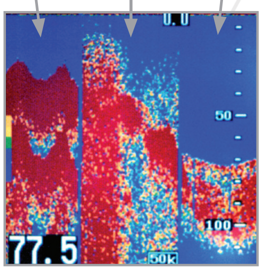
## Without High-Performance Fairing

## With High-Performance Fairing

### High-Performance Fairing

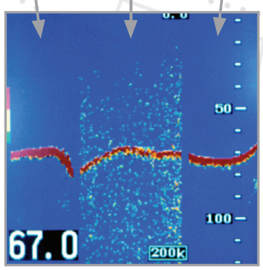
Achieve maximum fishfinder performance by installing an Airmar transducer with a High-Performance Fairing. Each High-Performance Fairing is custom designed to match its transducer model. The fairing assures a vertical beam which results in strong return echoes. Additionally, the streamlined shape reduces 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



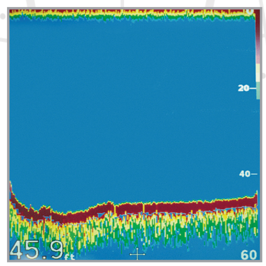

50 kHz, 23 knots (26 MPH)

High-Performance Fairing
Standard Fairing




200 kHz, 25 knots (29 MPH)

High-Performance Fairing
Only




50 kHz, 36 knots (41 MPH)

Without a fairing, the beam is angled improperly.

With a fairing, the beam is aimed straight down.

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 toggle 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.

# Benefits of Broadband Transducer Technology

Airmar achieves superior results by using a unique ceramic material. It lets transducers operate over a broad range of frequencies while maintaining sensitivity. These Broadband Transducers are, by definition, low-Q devices (refer to "Q" paragraph). 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.

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.

### Benefits of 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 frequency band. By selecting different operating frequencies, two or more sounders can work simultaneously without interference. The frequency can also 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.

### Q

A Transducer's quality factor, or "Q" describes the amount of ringing the ceramic element or elements undergo when power is applied to the transducer. Think of a church bell analogy—as the bell is struck it vibrates rapidly and then the vibration will eventually stop until the bell is struck again. Most competitor's recreational transducers have an average Q between 25 and 35. Airmar Q values range from 1 to 30, depending on models. The lower the "Q" number the less ringing in the transducer and the better the performance. Less ringing greatly improves individual fish separation along with bottom imaging in rapidly changing water depths such as ledges and offshore canyons.