Thusitha Dananjaya De Silva Mabotuwana

Table of Contents

Abstract

Sonar is a modern technology which helps us to track submarines, fish, ship wrecks, map the seabed and for other navigational purposes. The four main factors that affect the performance of a sonar system are a high power transmitter, an efficient transducer, a sensitive receiver and an acoustic communication system. Although the present day sonar systems have only a limited number of features such as a 2-dimensional screen and a view of less than 360 degrees of the surrounding, we are most likely to see better sonar systems with a 3-dimensional screen, attached to new computer systems along with a 360 degree view of the surrounding in the near future.

Introduction

Sonar is a technology that was designed and developed as a means of tracking enemy submarines during World War II. Although this was the main aim at that period of time this technology has taken a different shape in today's world. We use modern sonar systems for many purposes such as detection, identification and location of submarines, in acoustic homing torpedoes, in acoustic explosive mines and in mine detection, in finding schools of fish, in depth sounding applications, to map the seabed, for navigation purposes and in locating submerged wrecks and also for echo detection to maximise the range at which submarines can be detected and tracked and for many other applications.

This report highlights the basic concepts and principles of sonar, its modern-day uses and possible future applications. It also discusses the way we see fish and harmful effects of sonar systems while providing a brief description of the factors that affect the performance of a good sonar system.

How SONAR works

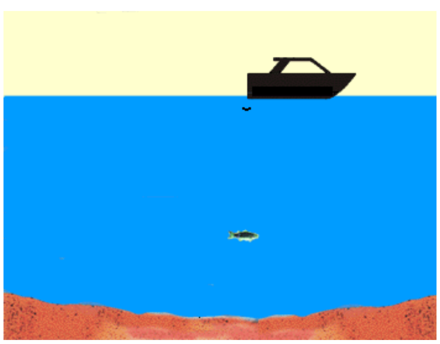

Illustration 1

The word "sonar" is an abbreviation for "SOund, NAvigation, and Ranging". This is a technology that was developed as a means of tracking enemy submarines during World War II. A sonar consists of a transmitter, transducer, receiver, and display.

In the simplest terms, an electrical impulse from a transmitter (such as a very short burst of electrical energy generated by an electronic "power pack") is converted into a sound wave (which is also a very short burst of high frequency sound energy) by the transducer and sent into the water. When this wave strikes an object, it rebounds.

This echo strikes the transducer, which converts it back into an electric signal, which is amplified by the receiver and sent to the display. The time variation is displayed on the read out of the sonar screen device by means of flashing lights, Liquid Crystal Display (LCD) or Cathode Ray Tube (CRT or TV screen). Since the speed of sound in water is constant (approximately 1440 metres per second), the time lapse between the transmitted signal and the received echo can be measured and the distance to the object determined.

Example: Let's assume that the time variation is 3 seconds and that the speed of sound in water is 1440 m/s the distance to the object would be:
(1440 m/s * 3 seconds)/2
= 2160m

As mentioned earlier, the sonar unit sends and receives signals, then “prints” the echo on the display. Since this happens many times per second, a continuous line is drawn across the display, showing the bottom signal. By knowing the speed of sound through water and the time it takes for the echo to be received, the unit can show the depth of the water and any fish in the water.

Factors that affect the performance of a sonar unit

There are four facets to a good sonar unit:

High power transmitter

This enables the user to get a return echo under deep or poor water conditions and also lets the user to see a fine detail, such as baitfish and structures.

Efficient transducer

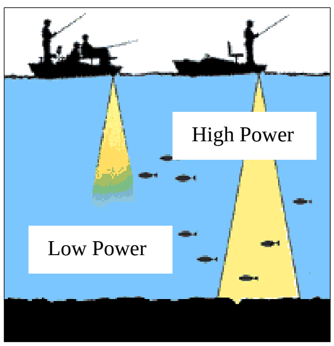

Illustration 2

This is a device that converts the electronic energy from the transmitter to high frequency sound, which is sent down through the water. When it strikes an object it bounces back as shown in illustration 1. (i.e. it echoes). When these echoes reach the transducer it converts them into electric signals once again, which are then amplified by the receiver and passed onto the display. Therefore this unit is quite often refereed to as the “antenna” of the sonar unit. The transducer should not only be able to withstand the high transmitter power impulses, converting as much of the impulses into sound energy as possible, but it also has to convert them with little loss in signal strength and has to be able to detect the smallest of echoes returning from deep water or tiny bait fish. (see Illustration 2)

There are two basic types of transducers.

Magnetostrictive transducers:
These are used with the higher powered, low frequency units. The advantage of this type is that they can take almost unlimited power and may be overloaded without damage

Ceramic transducers:
These have the advantage of having a higher efficiency factor than the magnetostrictive types. With ceramic transducers, the lower the frequency the higher the cost and also if too much power is applied it can be damaged.

Some of the more common frequencies used are 38, 40, 50, 75, 107, 120, 150, 192, 200, 400 and 455 kHz. (See
). However it should be noted that transducer must match the sonar unit's frequency. In other words, a 50 kHz transducer or even a 200 kHz transducer cannot be used on a sonar unit designed for 192 kHz.

Sensitive receiver

This has an extremely wide range of signals it has to deal with. It should dampen the extremely high transmit signal and amplify the small signals returning from the transducer. During amplification the strength of the signals is increase to the point that they can be used to light a neon bulb, Light Emitting Diode, or to activate a pixel on an LCD. The location of the flashes on a dial or the location of the pixels on the display can then be used to indicate the range, or distance, from the transducer to the object (bottom) or objects (fish) which have bounced back the echoes. It also has to separate targets that are close together into distinct and separate impulses for the display. This process repeats itself many times per second.

High resolution/contrast display

This must have high resolution (vertical pixels) and good contrast to be able to show all of the detail sharply and clearly. This allows fish arches and fine details to be shown.

All these facets together are called “Total System Performance”. All of the parts of this system must be designed to work together, under any weather condition and extreme temperatures.

How we see fish

Sound travels at different speeds in different mediums. (i.e. to say that sound has 2 different speeds when it travels through air and through water). The flesh of the fish is mostly water, and the difference between the speed of sound in water and in the gas of the swim bladder is so great, that much of the energy is reflected back. The importance of the swim bladder to a fish is that it enables the fish to remain at chosen depth without having to swim constantly to keep from rising or falling. Therefore with depth sounders what we see is not the fish but its swim bladder.

Thus are the basic concepts of any sonar system. Modern day sonar systems can be divided into three main categories depending on the places they are placed and the tasks they are used for. The three main categories are as follows:

Active sonar systems

Generally an acoustic projector is used in these systems to generate a sound wave that spreads outwards, which is reflected back by the target object. The projector may be placed on a floating sonobuoy, attached to a vessel’s hull, or suspended in the sea by a line lowered from a helicopter.

Passive sonar systems

These are usually mounted on a ship’s hull, deployed from a sonobuoy, towed behind a ship or laid on the ocean floor to monitor sound continuously. Passive sonar systems consists of a receiver that pick up the noise produced by an object such an s a ship or a submarine. The sound waves are analysed to identify the type of ship and to determine its direction, speed and distance.

Acoustic communication systems

Acoustic communication systems require a projector and a receiver at both ends of the acoustic path. These systems enable ships to communicate with submarines or divers.
The same principle allows dolphins to communicate among their own species.

Present day uses of sonar

- The military uses a large number of sonar systems to detect, identify and locate submarines.
- In acoustic homing torpedoes, in acoustic explosive mines and in mine detection
- In finding schools of fish
- For depth sounding applications
- Mapping of the seabed
- Navigation purposes
- Acoustic locating of submerged wrecks

- Special sonar systems are used for sound and echo detection to maximise the range at which submarines can be detected and tracked.
- Dam Inspection
- Marine Archaeology
- Bridge Footing and Abutments Inspection
- Location of sunken logs from lumber operations
- Oil pipe line location and inspection
- Reef monitoring

❖ Despite all these uses, there are several disadvantages in using sonar systems too.

The following is an abstract from a newspaper in Honolulu-Hawaii on the 17th of March 2000.

"A new sonar system being tested by the U.S. Navy could pose a threat to marine life, including whales, and to human swimmers and divers, critics say. Environmental groups, the Hawaii's County Green Party, and a member of the Hawaii's County Council have filed a lawsuit to halt the Navy's preparations to deploy the low frequency active sonar system. Humpback whales are among the marine species that could be harmed by the Navy's new sonar system. The suit alleges that the Navy is violating environmental laws by spending hundreds of millions of dollars on the sonar system before completing the analysis of the system's environmental effects. Increased concern about the safety of the low frequency sonar system emerged during testing off the Island of Hawaii's in March 1998. Whale watching vessel captains observed that humpback whales were leaving the testing area, and reported this to National Marine Fisheries Service (NMFS).

A snorkeler in the water during a 120-decibel broadcast emerged with symptoms a doctor described as comparable to acute trauma.

Two whale calves and one dolphin calf were found abandoned in the area of the Hawaiian testing. One abandoned calf would be extremely unusual, and three - all of different species - is unprecedented. The plaintiffs say NMFS claimed that they did not believe the reports of these abandoned calves, although two of the sittings were made by an experienced research team from the Ocean Mammal Institute (OMI), and the third abandoned calf was actually rescued and sent to Honolulu. Environmentalists also fear the new sonar system could threaten all marine species, including beluga whales

The NMFS permit under which the tests were being conducted stated that the tests would be suspended if whales left the test area or if other acute behavioral responses occurred, but NMFS did not suspend the tests."

This shows what drastic changes sonar could do to the natural environment and how important it is to do various tests and experiments under proper supervision and standards.

Conclusion

Sonar is of great importance to us in many different ways. It is being used almost in all parts of the world today. Although most of the present day sonar systems are not capable of giving a 360-degree view of the surroundings it should be noted that this technology is also being tested and experimented frequently. This would enable us to view a wider range of the surrounding which would make a considerable change in many fields such as the fishing industry, salvage and robotics in the near future. The fishermen would find it easier to track where the fish are and the people involved in salvage would find it easier to spot shipwrecks and to map the seabed with a lot of detail. Robots are presently used in many different ways including for fire fighting. When a 360 degree view of the surrounding is made possible, the robots will be able to get signals from all directions which would enable them to do a better service than doing the same with the signals from only one direction. Also sonar systems with higher resolution would enable the readers to identify the exact objects that are displayed on the sonar screen. Though the present day sonar screens can cater only 2 dimensions, the day we are going to see sonar screen which are attached to computers capable of producing a 3 dimensional view of the object is not far away.

Significance of frequency

Specific frequencies are used depending on the particular task concerned. For almost all the fresh water applications and most salt-water applications, 200 or 400 kHz is used because it gives the best detail on the sonar screen and works best in shallow water and at speed. It also shows less disturbances and undesired echoes.

A 32 or 50 kHz sonar (under the same conditions and power) can penetrate water to deeper depths than higher frequencies due to the fact that water's natural ability to absorb sound waves is greater for higher frequency sound than it is for lower frequencies. This means that the strength of the bounced signals would be comparatively stronger for lower frequencies than for higher frequencies, which would give a better-detailed picture on the sonar screen. Therefore, generally a 32 or 50 kHz unit is used in deeper salt-water applications

Bibliography

http://www.eaglegps.com/tutorial/sonar/default.htm
http://www.encyclopedia.com/articles/12083.html
http://www.lowrance.com/marine/tutorial/howitworks.asp
http://www.fwkc.com/encyclopedia/low/articles/s/s024000223f.html
http://www.comptons.com/encyclopedia/ARTICLES/0150/01705984_A.html
http://www.indepthconsulting.com/Uses_of_Sidesx.html
http://ens.lycos.com/ens/mar2000/2000L-03-17-07.html
http://www.apl.washington.edu/programs/LUIS/LUIS.html
http://www.naval-technology.com/projects/oksoy/