

# **Acoustic Technology for Underwater Communication**

## **Introduction**

With 70% of Earth's surface being covered by water, the need for an effective method of underwater wireless communication exists in applications such as ocean exploration, data collection, seabed mapping, military efforts, and pollution monitoring. Radio waves can only properly travel at extra low frequencies, requiring large antennae, and optical waves suffer from scattering and do not travel far distances [1]. While it has its own shortcomings, acoustic technology is the ideal solution for underwater communication over long distances, due to the ability of sound to travel far distances in the water. This paper reviews the engineering behind and implementation of acoustic technology for underwater wireless communication, as well as its applications.

## **Acoustic Technology**

Acoustic technology is implemented in water bodies through the placement of loudspeakers and hydrophones (underwater microphones). These microphones take sound waves that travel over distances as their input, and read it in.

### **Speed of Sound**

While the speed of sound in the water is much faster than the 343 m/s in the air, it is very dependent on factors such as temperature and hydrostatic pressure. The speed of sound in the water varies most in the thermocline layer, a thin zone characterized by a rapid change in temperature and pressure. Above the thermocline layer, sound waves refract downwards. Below the layer, temperature remains constant but pressure increases, refracting the sound waves upwards [2]. This up and down refraction of sound waves is what enables sound to travel hundreds of miles without losing considerable energy.

### **Bandwidth of Sound**

Sound propagates as a pressure wave, but over longer distances, a lower frequency must be used to ensure complete data transfer. Acoustic communications are generally confined to bandwidths lower than those compared to radio communications on land [3]. The longer the distance is that the wave must travel, the smaller the frequency used must be. 5-10 kHz frequency is typically used for communication within a kilometer, but for short distances, frequency is usually in the 100 kHz range [1].

## **Implementations of Acoustic Communication Technology**

## **Sonar and Military Purposes**

Sonar technology uses a combination of acoustic pulses and time measurement to calculate distance. Active sonar systems use an acoustic projector [3] to generate pulses of sounds to probe the sea, and the echoes that return (as well as the time it takes them) are processed to calculate information about distance and mapping. Active sonar is often used by naval vessels and submarines for detection and tracking purposes, as well for mapping the ocean floor and identifying objects. Sonar technology is most effective when hydrophones are deployed in large groups, called arrays, to make a “sonar net” [4].

Passive sonar systems comprise mostly of the receivers that listen for acoustic signals produce by objects travelling in the ocean. Sound waves can be analyzed over time to determine an object’s distance and velocity [3]. Passive systems have been placed by the military on the ocean floor for constant monitoring of the water, and they are also present on ships’ hulls.

## **Commercial Products**

### **Voice Communication**

Acoustic technology can be used to encode voice and speech data and transfer it through a body of water. These systems are employed in the commercial sector for divers as well as by the U.S. Military for secure underwater telephones. Casio’s Logosease device [5] uses bone conduction, i.e. sensing the vibrations in a user’s skull, to translate the speech signals into data that travels by the means of acoustic signals. These acoustic signals are picked up by the transceiver on another diver’s Logosease device, where it is decoded and played back as audible speech [6]. This device will work effectively when 50-100 meters away, and up to a depth of 41 meters. The Casio Logosease lineup starts at US \$1500. There is a similar product available by Ocean Technology Systems, using the same underlying technology, which starts at \$399.

### **Acoustic Modems**

The Sonardyne Acoustic Modem [7] is a product that is designed to ensure the seamless transfer of data. Essentially, a modem can be attached to any sensor that would traditionally be measuring underwater data such as temperature and depth. Two modems can be paired together acoustically, and this allows the transfer of data through a distance in the water. The data rate is adjusted according to the environment the modem is in to ensure the fastest and most stable transfer: transfer rates range from 9000 bps down to 200 bps. If used correctly, this product is able to ensure minimal latency and error-free data delivery [7].

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