

Underwater RF Communication Methods

Introduction

Current underwater wireless communication systems generally use one of three transmission methods: acoustic, optical, and RF. All three methods have their own limitations on range and data-rates relative to above water wireless transmission due to the difficulties imposed by sending signals effectively through water. RF is the least utilized mode of underwater wireless communication due to the fast attenuation of high-frequency (greater than 3MHz) electromagnetic waves sent through water, and the need for large antennas and high-power equipment in lower-frequency systems [1]. Nevertheless, practical RF systems do exist, and the technology continues to advance. This paper reviews current implementations of underwater RF communication systems.

Commercial Applications of Underwater RF

Current applications of underwater RF communication exist in inexpensive toy RC submarines, higher priced hobbyist RC submarines, as well as more expensive underwater monitoring and data collection systems. Hobbyist RC submarine transmitters and receivers are available to consumers within the \$50-\$500 range, examples of this being the SubCommander VI Receiver at \$58 and the Futaba 6-Channel Radio System at \$299. These products operate at 75MHz at up to six meters under freshwater [2]. Cheap toy submarines exist in the \$10-\$50 range, but boast very little diving depth: there is a toy available at Amazon.com for \$20 operating at 40MHz that will work at up to one-meter depth.

More uses of underwater RF technology exist in a higher price bracket for systems used to monitor cracks in oil pipelines, track or recover data from underwater sensors, and communicate with divers. WFS Technologies offers the Seetooth-Video, which can provide real-time video data to surface operators with a range of three meters under seawater [3]. Other systems offered by WFS Tech suggest communication ranges up to 40 meters below water.

Technology of Underwater RF Communications

The basic concept of RF communication developed for use in the atmosphere is to encode information as a modulation of a high frequency signal called a carrier. The electromagnetic waves produced at the transmitter travel through the air where a receiver can receive the signal via antenna and then demodulate it to retrieve the information contained in the carrier [4]. The technology of underwater RF communications is based on adapting the standard atmospheric transmission methods to work despite the fast attenuation of underwater electromagnetic waves. A method that has been used since the development of radio systems on submarines is to transmit at low frequencies (3-300Hz), which attenuate less quickly in water. These systems are historically large, require a lot of power, and have limited bandwidth. The size of an antenna increases inversely with the frequency being broadcast so sending information at the low frequencies that can penetrate seawater requires a large antenna. Magnetic coupled loop antennas can provide more compact solutions to this problem [5].

Future

In 2016 DARPA proposed a method of achieving low-frequency communication with compact mechanical antenna systems that can be carried by divers. The technology relies on mechanically moving magnetic bar to create low frequency signals [6]. Other methods have been proposed to use the multipath channels available at water-air and water-seafloor interfaces to circumvent the direct path through water.

- [1] C. M. G. Gussen, "A Survey of Underwater Wireless Communication Technologies," *Journal of Communication and Information Systems*, vol. 31, no. 1, pp. 242–255, 2016.
- [2] Futaba Corporation, 1998.
Datasheet for RC Transmitter
- [3] WFS Technologies, "Seetooth Video," *wfs-tech.com*. WFS Technologies LTD.
- [4] D. Grini, "RF Basics, RF for Non-RF Engineers", MSP430 Advanced Technical Conference, 2006.
- [5] "Technology in Focus: Underwater Electromagnetic Propagation ," *hydro-international.com*, 01-Jan-2008. [Online]. Available:
<https://www.hydro-international.com/content/article/underwater-electromagnetic-propagation>.
[Accessed: 25-Oct-2017].
- [6] "Underwater Radio, Anyone?," *DARPA.mil*, 16-Dec-2016. [Online]. Available:
<https://www.darpa.mil/news-events/2016-12-16>. [Accessed: 25-Oct-2017].