Underwater Communications using Electromagnetic Waves - (EMCOMMS)

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Objectives

The nature of the ocean environment and its vast size has necessitated the development of sophisticated equipment and techniques for various underwater applications including diver-to-diver communications, ROV/AUV docking, communications and oil and gas explorations. To facilitate scientific exploration a wide variety of systems and vehicles have been developed to operate within the shallow continental shelf region or in deep oceans. For successful underwater electromagnetic (EM) wave operation, knowledge is required of the wave transmission properties of seawater over all distances both short and long. This information is required for such activities such as: sensor systems, imaging, position fixing, measurement of speed, obstacle detection and avoidance, guidance, communication of data/voice and remote control.

To investigate, for the first time, electromagnetic wave propagation through seawater for high carrier frequencies (1 – 5MHz) up to a distance of 1km. The objectives are:

- To transmit and recover digital data at high bit rates (1Mbits/s).
- To transmit text and video images at standard camera frame when using data compression.
- To compare EM wave communications systems with the capabilities of an acoustic system.

Results

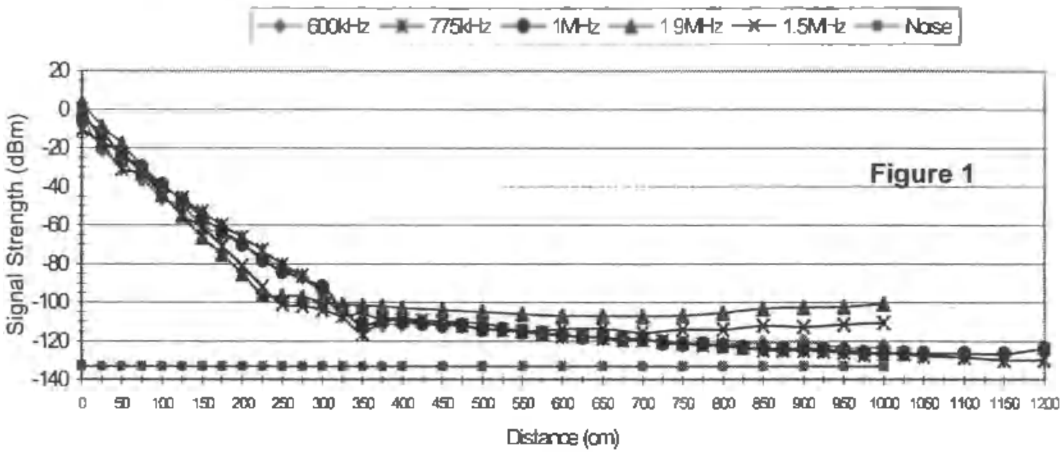
The outcome from the theoretical studies indicated that seawater has a molecular dipole lossy dielectric structure as well as a conductivity of approximately 4S/m. In the near field, because of the proximity of the electrodes, conduction currents exist whilst in the far field the influence of the electrodes is minimal and under these conditions dielectric molecular dipole displacement (nullification) currents exist. Conduction is a continual loss process whilst nullification is a single and much smaller loss process in response to a change of electric field. Its magnitude is given by the Debye equation [1].

Frequency f (MHz)	Losses for 1000m propagation (dB)			Total Signal Loss (dB)
	Near Field Optimised	Far Field Diffraction	Far Field Attenuation	
0.1	- 60	- 52	0	- 112
1	- 60	- 62	0	- 122
5	- 60	- 69	- 2	- 131
10	- 60	- 72	- 8	- 140
20	- 60	- 75	- 31	- 166

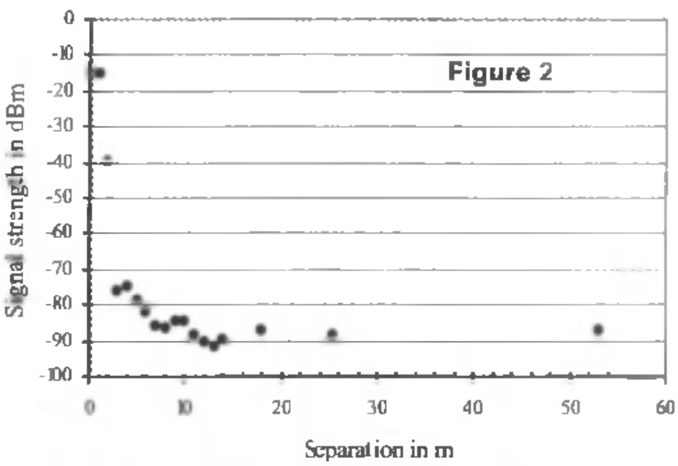
Table 1 Propagation capabilities of EM waves

Table 1 shows the estimated attenuation in both the near and far fields with allowance for diffraction losses. For example at 1MHz, a signal loss of –122dB will be attained mainly through near field loss and the far field diffraction loss. The through water attenuation is only estimated to be a few dBs.

Experimental investigations have been carried out with various techniques and methods of propagating an EM waves through seawater have been studied. In addition various types of antennae have been investigated including loop, dipole, folded dipole at different sizes. The results of our study, figures 1 and 2, show that EM waves propagation in seawater within Liverpool Marina Dock is possible at frequencies higher than that in the acoustic techniques and in the range of MHz [2].



Potential exploitation by end users



There is a strong requirement to avoid using divers to undertake sub-sea activities. The preferred role is intervention by using autonomous robotic systems, both vehicles and manipulators. The obtained results will allow EM waves to be used for the first time to transmit data and images through seawater. By establishing high-speed data rates, the actions of the robot can be up quickly undertaken thus ensuring a safe working environment. Once these techniques are perfected then it is possible to establish deep water systems to recover oil and gas at depths well below the dive limit of 200m. Even within the dive limit, the ability to remotely control sub-sea equipment will reduce the burden on the diver hence allowing longer missions to be undertaken with less physical effort being expended by the diver.

As well as high-speed data communications, EM waves can also be used for a wide range of activities for which ultrasonic waves have previously been used. These include such techniques as range finding and anti-collision navigation of sub-sea vehicles. Additional systems for pollution monitoring can be developed based upon RF transmission.

References

[1] Thuéry, J (1992) Microwaves: industrial, scientific and medical applications, ISBN 0-89000-448-2.

[2] Shaw, A (2004) IEEE Transactions on Antennas and Propagation, to be publish in April.