Deep Underwater Compatible Wi-Fi Antenna Development

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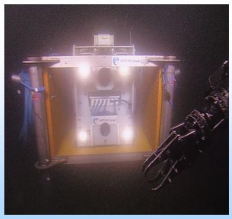
Objective

The goal of this work in progress is to respond to communications needs, such as short-distance, low-cost underwater broadband communications, for example in deep underwater observatories

Applications

- Environment monitoring in shallow or deep underwater.
- High data rate transmissions over short distances : real time video, large data files.
- Observatories, ROV or AUV wireless links.



Specification of constraints

- Fast wireless transmission of large files such as video from a computer or video transmitted in real time between two terminals.
- Cost competitive with existing solutions (wireless acoustic or laser transmissions, mechanical wired connections).
- Taking into account the very high hydrostatic pressure (compatible with oceanic trench exploration) and bio-pollution.
- The variability of the electrical properties of the sea with geographic location (salinity, temperature) and the moment (time, season).
- Positioning of the transmitter / receiver.
- Integration into the existing equipments in this context.

Acknowledgement

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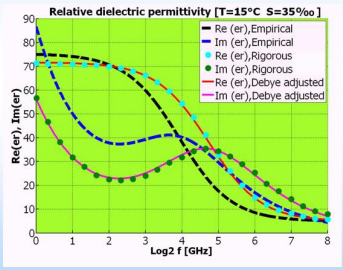
Electrical parameters of seawater

Debye formulation (1st order) :

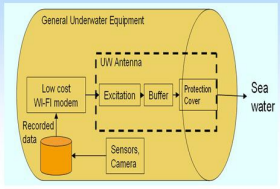
$$\varepsilon_r = \varepsilon_\infty + \frac{\varepsilon_s - \varepsilon_\infty}{1 - i2\pi\tau f} + i\frac{\sigma}{2\pi\varepsilon_0 f}$$



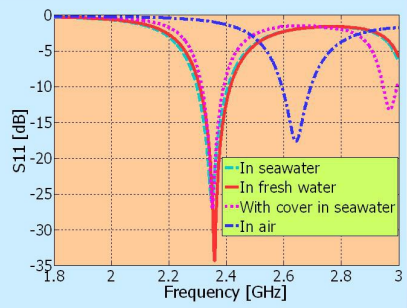
	ε_s	ε_∞	τ (ps)
Empirical model	75.3	4.9	65.8
Adjusted model	71.6	4.9	37.5
Variation	4.8 %	0 %	43.1 %

Author (Model type)	Attenuation
Stogryn (Empirical)	11 dB/cm
Somaraju & al. (Rigorous)	7.2 dB/cm

Antenna concept

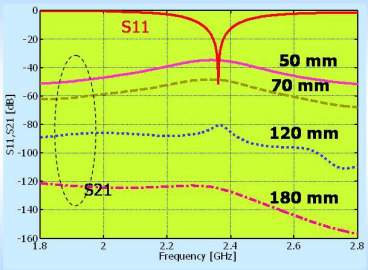


Return loss

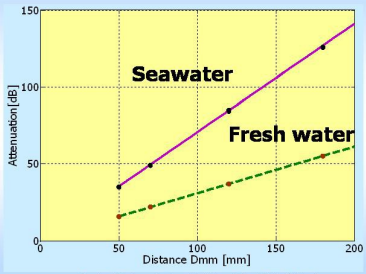


Simulation (Ansoft/HFSS)

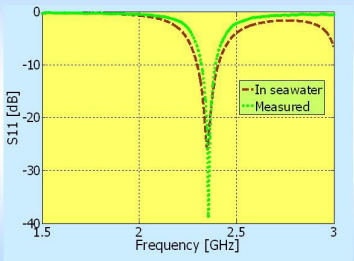
Electromagnetic analysis (HFSS / FEM) of transmission performance according to the distance



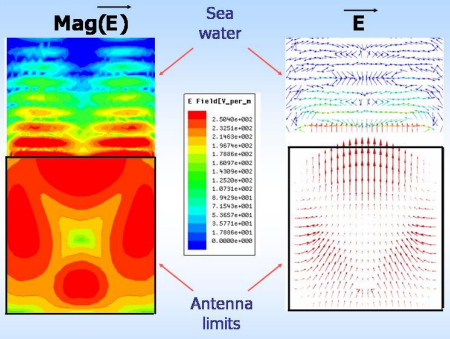
Sea water (T=15 °, S=35 ‰)



2.4 GHz (T=15 °, S=35 ‰)



Simulation/Measurements



Distribution of the electric field inside and outside of the antenna radiating 1W in the sea water

Conclusion

- **A new concept of radio antenna is proposed for underwater communication, low cost and compatible with 2.4 GHz Wi-Fi standard (current estimated range from 10 to 15 cm).**
- **EM study of the water in several conditions (T,S) has been carried out to support the electromagnetic study of the antenna in this environment.**
- **Initial measurements with a preliminary prototype confirm that the system has a high stability: no shift of the nominal frequency appears with either fresh or salt water.**

Perspectives

- The development of an advanced prototype is ongoing and will be measured in experimental basins. It will make it possible to vary the real range of the transmission and the beam pattern of the antenna. The EM model for sea water will also be compared to the theory.
- Improvement of the antenna bandwidth will have to be carried out to fully support the Wi-Fi standard.
- Certain complementary adjustments of the antenna will enable its integration into general underwater equipment

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