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Antenna Design for Shallow Freshwater Applications

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Abstract: Underwater communication technology is not as developed as free-space (terrestrial) communication. Some research are being done but most of the study's concentrating on antenna used in seawater application. An array antenna to be used in shallow water is designed. The frequency used is 405 MHz that allowed those commercial devices with such frequency to be used in shallow freshwater in terms of communicating purpose. This research study will involve several steps which are: antenna design, simulation, producing prototype, testing prototype and result analysis. The software used for designing and simulating the antenna is CST Studio Suite. In terms of hardware, the design is by using microstrip array antenna. The advantages of this design is ease of construction, lightweight, low cost and extremely thin protrusion from surface. The key features make microstrip antenna popular in free-space applications. The result of the prototype testing will be discussed.

Key words: Underwater antenna, underwater communication, microstrip antenna, antenna array, CST Studio Suite, prototype

INTRODUCTION

It has been studied that most of the systems in communication engineering are developed to be used in free-space instead of underwater. However, in these recent years, more and more research are being done to develop a good underwater communication system (Sporer *et al*., 2015). Some of the applications for underwater communications are tactical network between naval platform, diver communication, autonomous underwater vehicle, ocean observatory and many more. For example, an international project called ESONET, a proposed subsea component of the European GMES (Global Monitoring for Environment and Security) to provide strategic long-term monitoring capability in Geophysics, Chemistry, Biochemistry, Oceanography, Biology and Fisheries (Mendez *et al*., 2011). Other examples are North America's NEPTUNE (Northeast Pacific Time-Series Undersea Networked Experiments), Japan's ARENA and Sweden's FOI (Mendez *et al*., 2011).

However, most of the designs are for saltwater applications. As the characteristics of saltwater is different than freshwater, different technologies are used for those applications. In saltwater, acoustic waves are used to send signal to overcome the attenuation problem (Hao *et al*., 2011). In shallow water, instead of acoustic wave, Electro Magnetic (EM) is used. They are unaffected by turbidity and pressure gradients and it is immune to acoustic noise (Che *et al*., 2010). Furthermore, the traditional underwater acoustic communication systems have been based on non-coherent detection techniques such as FSK which have high reliability rather than bandwidth efficiency (Chavhan and Sarate, 2013).

Previously, EM never been chosen for underwater communication solution (Sendra *et al*., 2013). This is because the high signal attenuation due to the conductivity of the water. However, the main advantages of EM waves compare to acoustic waves is it do not need the movements of particles of medium to be propagated

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(Hao *et al*., 2011; Sendra *et al*., 2013). Underwater communications based on EM waves are faster and can be used in higher working frequencies which results in a higher bandwidth.

For the research, it is proved that EM is suitable for higher frequencies as the proposed design is to be work at 410 MHz. Previous research shown that there are three unlicensed frequencies work best for underwater communication system which are: 6.7 MHz, 433 MHz and 2.4 GHz (Abdou *et al*., 2011). The 2.4 GHz are chosen because the frequency is widely used for WiFi, internet and Bluetooth connection.

Different types of antenna are already being tested for freshwater applications in previous research. Curved spiral antenna is mounted on pocketbook mussel (*Lampsilis cardium*) in river water (Llamas *et al*., 2015). For a spiral antenna, it is the combination of its plane geometry and location of differential radiating elements in that plane that leads to its broadband characteristics. Thus, if one disturbs the location of these radiating elements, these properties are compromised (Llamas *et al*., 2015). A vibrator antenna and a loop antenna are also being tested. Although, a vibrator antenna may have a reduced signal to noise ratio, it can be employed over greater distances (Hao *et al*., 2011).

A microstrip array design is chosen because of its advantage. Microstrip antennas attractive features such as low profile, light weight, small volume and low production cost (Sabban, 2010). In addition, integrating the microstrip feed structure with the radiating elements on the same substrate attains the benefit of a compact low cost feed network. However, losses in the microstrip feed network form a significant limit on the possible applications of microstrip antenna arrays in mm wave frequency range (Milkov, 2000).

MATERIALS AND METHODS

Antenna design: Microstrip is used for the proposed antenna (Fig. 1). The advantages of this design is ease of construction, lightweight, low cost and extremely thin protrusion from surface. The key features make microstrip antenna popular in free-space applications. The material was tested to be able to function in freshwater with the used of buffer. Buffer for the design of proposed antenna is liquid with dielectric constant (ε_r) in range of 7-8. Aniline (C_6H_7N) with dielectric constant value 7.8 is used for the prototype. The detailed geometry of proposed antenna is shown in (Table 1).

Table 1: Geometry of proposed antenna

Geometry	Centimeter (cm)
Length (antenna)	16
Width (antenna)	17
Length (feeder)	12
Width (feeder)	0.2

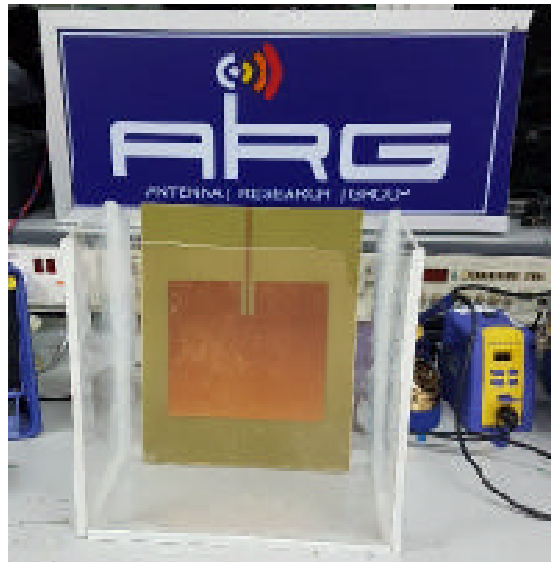

Fig. 1: Prototype of the antenna design

RESULTS AND DISCUSSION

The prototype was tested in three environments; free space (air) in water without buffer and in water with buffer. The simulation result of the antenna was carried out via. CST microwave studio which is a full wavelength numeric electromagnetic simulation tool. Figure 2a, b show the testing done in water environment. The S11 parameters for the antenna for each environments were tested using FieldFox microwave analyser.

For free space (air) environment, the test showed that the antenna was able to function but not in wanted frequency. Both measured and simulated frequencies are shifted to higher frequency. The measured result was 490 MHz meanwhile the simulated frequency was 460 MHz. Figure 3a shows the S11 parameters for the prototype in free air environment.

No attainable result produced when the prototype tested directly inside water without buffer as in Fig. 3b. It shows that the prototype was not complete and could not function without buffer inside water. When aniline is used as buffer for the prototype, the result obtained as in Fig. 4. The measured result for the prototype was 405 MHz.

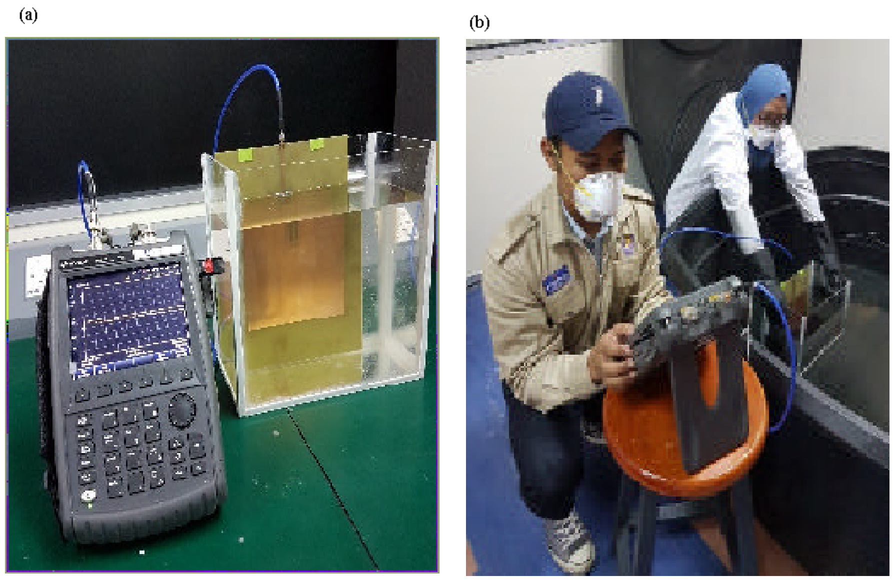

Fig. 2: a) Testing prototype without buffer in water and b) Testing prototype with buffer

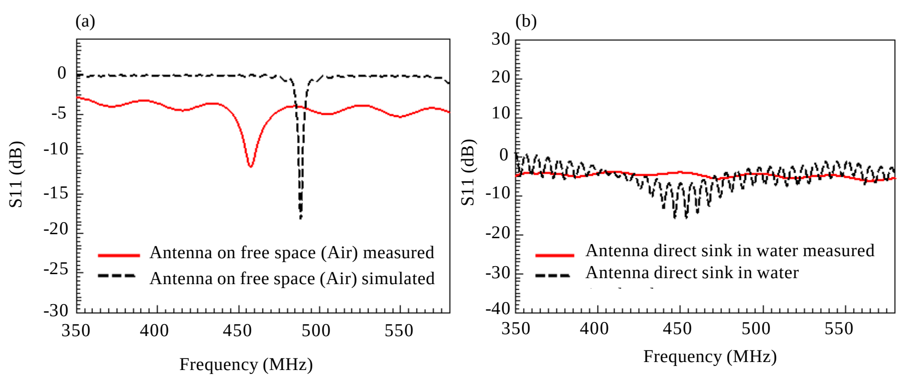

Fig. 3: a) S-parameter antenna on free space (air) and b) S-parameter antenna inside water without buffer

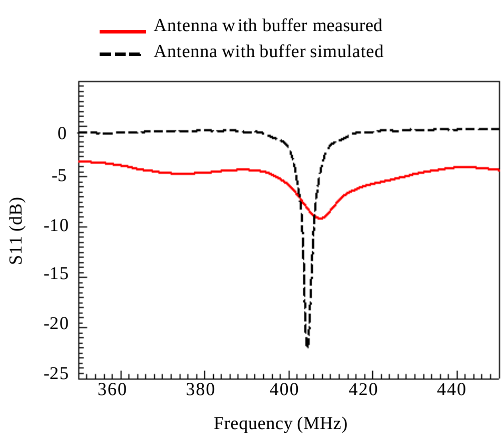

Fig. 4: S-parameter antenna with buffer inside water

CONCLUSION

The proposed design for the antenna is able to function in shallow freshwater in 405 MHz frequency. The choice of buffer used play significant role in order for the prototype to function. Further testing is needed to obtain the radiation pattern to conclude the effectiveness of the proposed antenna design.

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