WAVELENGTH PREDICTION IN SALT SEAWATER SURFACE

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ABSTRACT

Abstract Wavelength propagation behaviour in salt seawater needs accurate prediction especially with the technological revolution promising which is based on the exceeding demand for connectivity. The salt seawater model SSM for the wavelength scattering prediction is essential for the modern implementation and application of wireless communication such as precise interference computation, signal diversity, and liquid antenna. This study proposes a distinguished model that considers signals transmitted in gigahertz at stark seawater salinity such as in the Gulf region. It shows the disturbance relation and opposite correlation between the model elements such as frequency, salinity, incident angle, and wavelength in both the time and frequency domain over the marine surface. The model offers the capability of salt seawater and gives high attention to the salinity parameter when considering designing a wireless coast link.

Keywords: *scattering, salinity, wavelength, frequency, propagation*

1. INTRODUCTION

Degradation in water quality is the most significant cause of lower water availability and consequently reduces its utilization, while salinity is a major water quality problem in many natural resources in the world from a negative point of view. On the other side, salt seawater could play an indispensable role in electrical conductivity as well as storage under specific circumstances which indicates a unique massive feature rarely provide in other similar materials [1]. Hence modelling the salt seawater during the technological revolution could be a paramount concept to cover various aspects. One of the most important components in salt seawater is the wavelength attitude in different situations and among several parameters. Due to the tremendous information era, gigahertz frequencies become inevitable in modernization, where the signal behaviour would contribute that revolutionizing digitalization. As stated before, studying deeply the wavelength phenomenon electromagnetically in an open water environment covers 70% universally whereas saltwater particularly represents more than 95% of the water resources available to serve the modern upcoming life consider unavoidable and should become in front of the scene [2] [3]

The rough water surface considers the main subject when acting with the wavelength, while the scattering behaviour determines the roughness properties [4]. Previously the scattering in Electromagnetic waves has been an intensive study for many years ago with many measurements and approaches that have been achieved. Despite the huge amount of examination and experimental, the seawater surface scattering was not completely solved due to limitations analytical of the salt seawater parameter such as salinity which is considered a crucial factor from the wavelength behaviour perspective [5] [6].

Most of the studies concentrated on calculating the attenuation in a marine environment without profoundly investigating different water properties which are diverse from one place to another. For example in [7] the absorption and scattering characteristics of seawater have been analyzed, and the effects of loss caused by beam expansion are investigated, the result showed that the light attenuation of underwater communication depends fundamentally on the nature of the ocean specification and the article neglected mentioned the factors that might be straightforward impact the finding. Also, the paper [8] a prototype using the polarized-light scattering method to detect the suspended particles which were deployed in Daya Bay at the edge of the South China Sea during the end of 2017, the paper result showed that the prototype can detect the concentration of the particles in water based on the water formation which is different from area to another, while the follow up the amount of the particles could be under consideration especially when surrounded by the sand or rock environment. In the same line, the Underwater Wireless Optical Communications Link in [9] utilising acoustic techniques which have made notable progress to pass through the underwater links but the not robust enough and more sensitive to noisy medium, among all these studies the blocked road of underwater wireless communications is that the carrier transmission massively depends on water composition and how would tackle with the wavelength disturbances. Consequently, the author in [10] demonstrated that the standard of different seawater parameters inevitably gives diverse outcomes when considering the stark environment such as the Red Sea and Gulf Arabian seawater and hence boosts to study of each zone according to the environmental condition.

Continuously with the previous studies, when the signal bounce from the seawater such as evaporation and elevation ducts, the papers [10] [11] [3] well conducted the expected scenarios and provide a hind that the seawater characteristics could play a vital role in wireless connections with considering to other parameters such as the frequency utilising and the transmitter power. Even though the revolution of the Reconfigurable Intelligent Surface recently [11] [12], the behaviour of the wavelength has to dominate the model and for a flawless paradigm the calculation should be based on the different wavelengths due to the various seawater composition.

As stated before, the scattering in the electromagnetic waves in the salt seawater has been an undeniable research topic for many decades and is still not satisfactorily resolved particularly in a stark environment such as the Gulf region where the salinity started from 35 PSU and reaches up to 90 PSU in lagoon [13]. This study considers the wavelength scattering in salinity seawater which is considered a unique investigation to obtain the contribution model that could serve various sectors in similar areas globally.

2. SEAWATER SURFACE ATTITUDE

The novelty of the gulf water modelling would be performed to explore and reveal meaningful channel characteristics that will permit the design of wireless communication systems on the coastline. However, the scattering behaviour determines the rough surface way of acting with the wavelength and the properties of the way being transmitted. In addition to that, frequency, and the incident angle both specify how the surface looks electromagnetically.

Accurately, the ray around the sea environment (multipath channel) could be a line of sight, specular reflection, or diffuse scattering according to the medium factors condition. The next equation explains the three ray types of marine settings.

$$H(v,t) = H_{\mathrm{los}}(v,t) + \rho_{\mathrm{s}} H_{\mathrm{coh}}(v,t) + \rho_{\mathrm{d}} H_{\mathrm{ncoh}}(v,t) \quad (1)$$

where los is the line-of-sight ray path, ρ_{s} and ρ_{d} represent the power ascribed to coherent (specular) and non-coherent (diffuse) multipath components, respectively.

The three equation parts explicate the beam radiation conduct in holistic probability layouts. The line of sight has been represented in the area above the ground station which represents the minimum interference pattern since the ground reflection has less or no impact on the direct beam to generate interference. This zone is dominated by free-space path loss while the scattering surface is usually described by a probability distribution as a function of average surface height, the variance of surface height, and correlation distance, in addition to the dielectric constants that capture the electrical properties of the surface such as conductivity in salinity percentage. Whereas the relation between the wavelength and the surface η could be given by the number of wavelengths and the surface properties as below:

$$\eta = ks \quad (2)$$

$$= 2\pi/\lambda \oint E \, da \, Q/\varepsilon_{\mathrm{o}} \quad (3)$$

where E is the electric field at the surface, da surface area element, Q charge is enclosed in the surface and ε_o permittivity [5] [14] while for deep knowledge and profound impact much appreciated that the surface is a constant shape and well-characterized the scattering surface part. However, increasing the wavelength leads to decreasing the roughness term as well as nearby the power transmitter station conduct to show the surface rougher than the far end station.

In the same line of context and according to the surface roughness, the expectation of the different outcomes is based on the scattering situation. The more the surface rougher the more signal diffuses and vice versa the less surface rougher the more coherent signal specular. The upcoming figures demonstrate the concept.

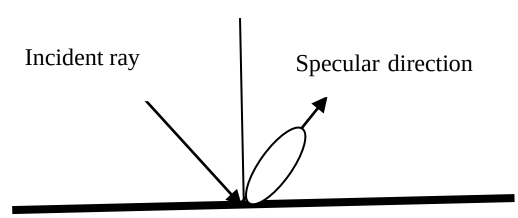

Figure 1: The smooth surface

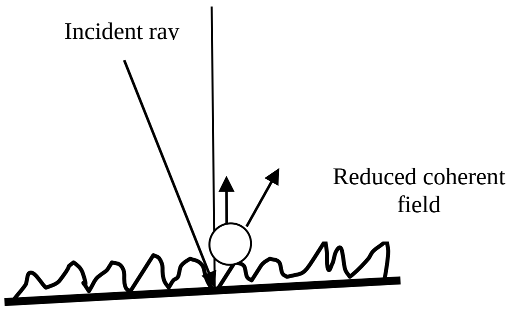

Figure 2: The rough surface

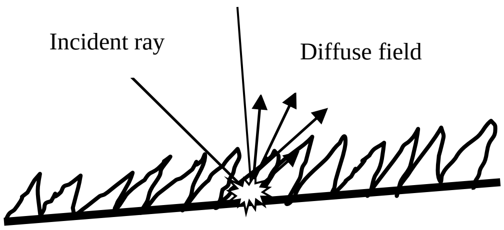

Figure 3: Highly rough surface

From the figures, would be clear to classify the surface types as smooth, rough, and very rough which treat with the wavelength signal according to the roughness specifications, whereas the bounced beam could be in specular or diffuse direction based on the surface and the beam properties itself such as frequency, distance, and phase shift. In the Gulf region case, the most significant parameter that could affect the seawater surface is the salinity according to [15] [1]

The Salinity Seawater Model SSM take into account the critical parameters with the most familiar parameters to ensure that could provide a guard up when dealing with the stark coastline connection coupled with indispensable features to the marine telecommunication design tools such as Ellipse and path loss which are still below considered to accommodate a range of the factors.

$$\text{SSM} = \frac{2\pi}{\lambda} \oint E \, da \frac{Q}{\varepsilon_o} \; \alpha \, \tau \cos\theta \qquad (4)$$

where α is the salinity percentage, τ coefficient correction, and θ is the bounce shift under the cosine function to estimate diffuse light proportion, despite it being too broad for the focused specular reflection.

The presented simulation results are for seawater scattering surface of salinity between 35 to 90 PSU, frequency from 1 to 30 GHz and the phase shift from 30 to 90 degree

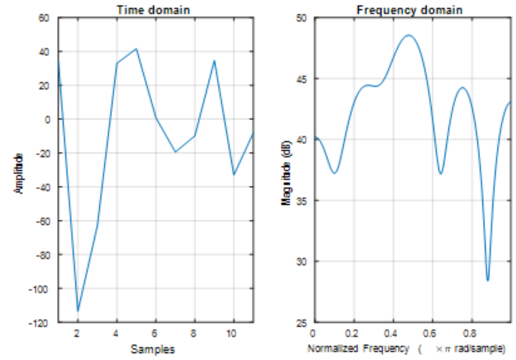

Figure 4: Wavelengths behaviour in salt seawater via time and frequency domain

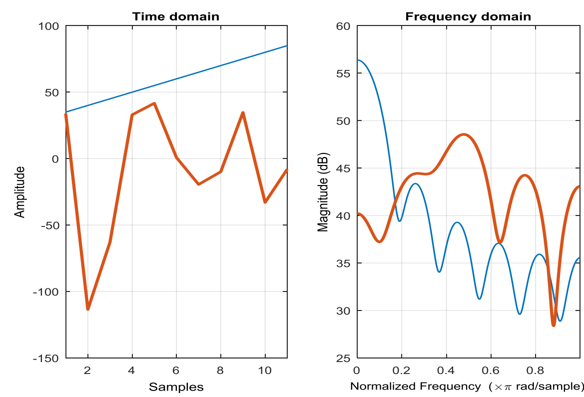

Figure 5: Wavelengths in salt seawater with various salinity levels

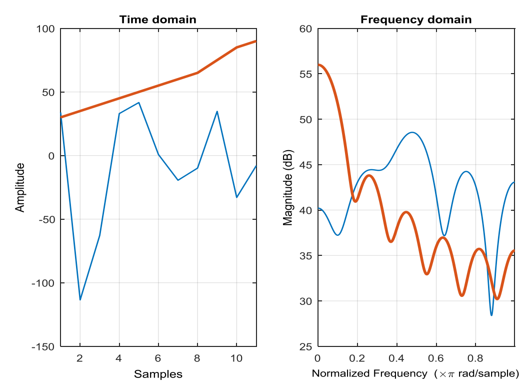

Figure 6: Wavelengths in salt seawater with different incident angles

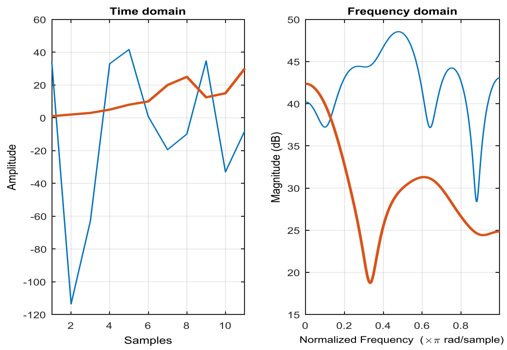

Figure 7: Wavelengths in salt seawater through different frequencies

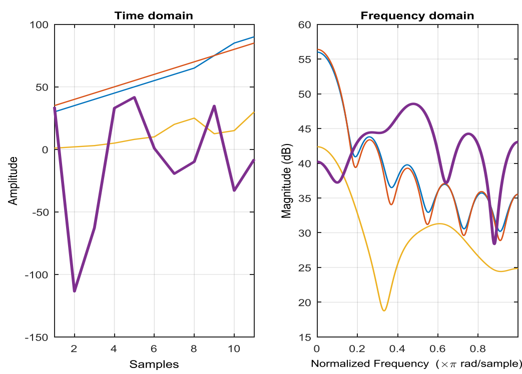

Figure 8: Wavelengths in salt seawater compared to salinity, frequency, and phase

3. RESULTS AND DISCUSSION

To predict the conduct of wavelength when it hit the salt seawater, a heavy simulation has been implemented using various values that were defined earlier to specify the states of the ray in the sea environment. Looking at a framework from the frequency perspective can often afford an intuitive understanding of the qualitative manner of the system, while a time domain shows how a wave changes with the time samples. In addition to that, Y-axis at both a time and frequency domain shows the Magnitude and Amplitude to exploit the quantity of variable and the displacement on a wave measured.

The figures analysed through MATLAB software simulation to explain the massive association entanglement between the elements, for instance in figure 4 shows a holistic correlation between the wavelength's behaviour in salt seawater via time and frequency domain added to provide the readers fashion mutually when transforming the platform between time and frequency domain.

Whereas the inverse relation is clear in figure 5 when the wavelengths are severely prone to degradation with high frequencies, and that gives proof to increasing frequencies leads to more fluctuation in the wavelengths. Again, the opposite relation appears in figure 6 between the wavelength in salt seawater and different incident angle which is defined as the angle between a beam incident on a seawater surface and the vertical line to the surface at a specific point of incidence. Moreover, the aggressive decay is clearly shown in figure 7 among the wavelengths in salt seawater and the several frequencies that conducted notable time-domain influences. The combination of effective parameters has been demonstrated in the final figure to distinguish between the parameter's influences as well as to contribute to the entire model by clarifying the impact of each parameter in the time and frequency domain.

Overall, the model indicates the different wavelength behaviour for seawater radiation environment and makes awareness of the propagation way in salt seawater.

4. CONCLUSION

This work shows the wavelength propagation conduct prediction at the stark salt seawater surface using the Gigahertz band which is require a distinctive consideration that has not been addressed prior. It has also been shown that in the case of a high frequency more signal disturbances could happen in addition to the inverse relation with the phase angle when the ray bounced. Comprehensively, the study predicted the signal behaviour in stark salt seawater via the different surface properties and provides an endeavour vividly to accommodate the peculiarities of the salt seawater capabilities. Future work will be to think about seawater's intelligent reflection surface owing to the various water composition.

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