Analysis on the Influence of Shortwave Communication in Different Ground Forms

Qian-Bo ZHUANG[a], Ming-Ming CUI[b], and Xi-Liang LIN[c]

China Satellite Maritime Tracking and Control Department, Jiangyin, China
[a]*nwy1986@163.com,* [b]*nwy1986@163.com,* [c]*dylxl9123@sina.com*

Abstract: The reasons for the different size of the transmitting power and the different effects of different ground forms on the signal power loss are analyzed in detail. A shortwave communication device includes first and second carriers are given respectively. With the flexible connecting portion, relative position of the first and second carriers can be changed freely to expand the transmission range and enhance the transmission.

1 Introduction

In shortwave communication we must use the 1000W radio transmitter, because the power of 125W radio is too small to meet our needs [1-4]. In the East China Sea, 125W radio is also fully able to meet the communication needs, and most of time we just need turn to 1/2 POWER FULL [5-6]. Why do we ask the power of 125W radio to be smaller when we are farther away from the seaboard [7-12]. According to the analysis, we believe that this phenomenon is mainly caused by the different multi-hop ground reflection loss that is due to the different forms of the ground. Here we will explain it from three aspects.

2 Theory Analyses

2.1 Short Wave Propagation

Shortwave communication uses a radio frequency of 1.5 to 30MHz. Short wave propagation mainly divided into two types, ground wave and sky wave. Sky wave can achieve long distance communication with ionosphere reflection, and ground wave spread along the earth's surface, and the surface of the earth is a conductor resistance, when traveling waves in it, there is a part of the electromagnetic energy is consumed, and with the increase of frequency, wave loss increases gradually. Because the ground large attenuation on shortwave, so ground wave only a short distance.

So, the spread of shortwave is mainly dependent on the sky wave propagation, which mainly depends on the ionosphere communication. In this propagation process, short wave can be transmitted to the receiver by one hop, which means one reflection by the ionosphere. And it also maybe pass to the receiver with two hops, which means first reflection by the ionosphere, second reflection by the

ground and third reflection by the ionosphere again. Even with three hops or four hops, the short wave can reach the receiving end. According to statistics, with three hops are the most situations.

2.2 The Transmission Loss of Shortwave Channel

In the short wave radio transmission, energy loss mainly comes from three aspects:

Propagation loss in free space

Ionosphere absorption loss

Multi-hop ground reflection loss.

The loss of free space propagation is due to the fact that the radio waves are gradually moving away from the emission point, and the energy is growing in the space, so that the electric field strength of the receiving point is weakened as the distance increases.

The ionosphere absorption loss is due to the fact that the ionosphere absorbs a portion of the energy during the reflection of short wave through the ionosphere to the receiving point, and the signal is depleted. The absorption loss of the ionosphere is related to the electron density and the gas density. The greater the electron density is, the more the probability of electrons colliding with the gas molecules will become, so the greater the energy is absorbed. The greater the density of the gas is, the more the number of collisions per electron per unit of time will become, so the greater the loss increases. In addition, the absorption loss is also related to the frequency of the radio wave. The higher the frequency is, the smaller the absorption loss will become. The lower the frequency is, the greater the absorption loss will become.

As mentioned above, in the propagation of the sky wave, the radio waves need multiple reflections, and in the mode of multi-hop propagation (i.e., two or more reflections), the propagation loss not only takes into

account the fact that the radio waves enter the ionosphere twice, but also consider the loss of ground reflection. A large number of experimental data show that this kind of signal loss due to ground reflection is related to the polarization of the radio waves, operating frequency, ray elevation and geological conditions. And when the ground form is sea water and land, the difference of the surface conductivity σ is great.

It can be seen that in these three aspects of energy loss, the first two is not much different in shortwave communication of different waters.

Considering that the ship is mainly located in the marine area, we will do analysis over the land and the ocean. Combined with the above analysis, we can conclude that the transmission power required for short wave communication when the ship is in the sea area is smaller than that when the ship drove out the East China Sea. This is mainly due to different ground forms, the seawater and the land, leading to different multi-hop ground reflection loss.

2.3 The Comparison of the Multi-Hop Ground Reflection Losses Caused By Two Different Ground Forms

In the engineering calculation of multi-hop ground reflection loss, it can be assumed that the incident wave is messy polarization wave, and the energy of radio wave is evenly distributed on the horizontal polarization and the vertical polarization. According to these contents, the formula is calculated as follows [13].

$$L_g = 10 \lg \left(\frac{|R_V|^2 + |R_H|^2}{2} \right) \quad (dB) \qquad (1)$$

Where R_V denotes the reflection coefficient of the vertical polarization, and R_H is the reflection coefficient of the horizontal polarization.

R_V and R_H can be calculated by the following formula:

$$R_V = \frac{\varepsilon_r' \sin \delta - \sqrt{\varepsilon_r' - \cos^2 \delta}}{\varepsilon_r' \sin \delta + \sqrt{\varepsilon_r' - \cos^2 \delta}} \qquad (2)$$

$$R_H = \frac{\sin \delta - \sqrt{\varepsilon_r' - \cos^2 \delta}}{\sin \delta + \sqrt{\varepsilon_r' - \cos^2 \delta}} \qquad (3)$$

where δ denotes the Ray elevation, ε_r is the Relative complex dielectric constant of the ground ($\varepsilon_r' = \varepsilon_r - j60\lambda\sigma$), σ is the Ground conductivity $(\Omega \bullet m)^{-1}$, and λ is the Wavelength (m).

Considering that the ship is mainly located in the marine area, the ground forms are set to sea water and dry soil. The values of and in the case of several ground forms are shown in the table below.

Table 1. The values of ε_r and σ in the case of several ground forms

Ground form	The range of values		Average values	
	ε_r	$\sigma_{/}(\Omega \bullet m)^{-1}$	ε_r	$\sigma_{/}(\Omega \bullet m)^{-1}$
Sea water	80	1～4.3	80	4
Fresh water in Rivers or Lakes	80	10^{-3}～2.4×10^{-2}	80	10^{-3}
Wet soil	10～30	3×10^{-3}～2.4×10^{-2}	10	10^{-2}
dry soil	3～4	1.1×10^{-5}～2×10^{-2}	4	10^{-3}

The relevant values are substituted into the formula to calculate the multi - hop ground reflection losses in two different ground forms of seawater and dry soil, and compare them.

In the vertical direction of the antenna, the angle between the maximum radiation direction and the ground is called the vertical emission direction or the elevation angle of the antenna. The directional pattern of the logarithmic cycle antenna is approximately independent of the operating frequency.

Let us suppose that, elevation angle $\delta = 30°$, and wavelength $\lambda = 30$m. The values of ε_r and $\sigma_{/}(\Omega \bullet m)^{-1}$ are set to their average values. After calculation, it is of the form of sea water.

$$|R_V| \approx 1, |R_H| \approx 1, \frac{|R_V|^2 + |R_H|^2}{2} = 1 \qquad (4)$$

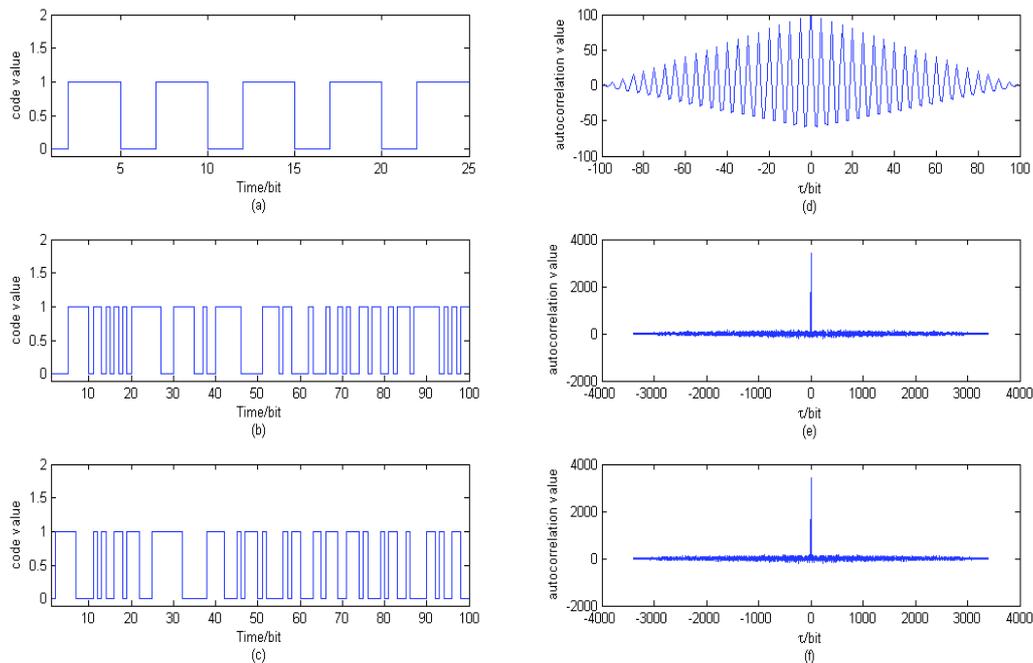And in the form of dry ground, it is expressed as follows.

$$|R_V| \approx \frac{\sqrt{73}}{73}, |R_H| \approx \frac{8}{13}, \frac{|R_V|^2 + |R_H|^2}{2} = \frac{1}{5} \qquad (5)$$

According to the parameter hypothesis above, in the formula of the multi-hop ground reflection loss can be obtained.

$$L_g = 10 \lg \left(\frac{|R_V|^2 + |R_H|^2}{2} \right) \quad (dB) \qquad (6)$$

During which the value of $\frac{|R_V|^2 + |R_H|^2}{2}$ is 1 and 0.2 in the two ground forms of seawater and dry soil. And this formula represents the ratio of the reflected radio signal power to the incident radio signal power. Although some simplification has been made in the calculation process, it is still possible to see that the multi-hop ground reflection loss in the form of dry ground is much greater than that in the form of seawater.

3 Simulating

According to table 1, it is easily to find that the number of ones in the sequence is about 50% not related to the lengths of the sequences. The time domain properties and auto-correlation characteristics of the physical random sequence and sequence after spreading are described in Figure 1.

Figure 1. The time domain properties and auto-correlation characteristics of the physical random sequence before and after spreading

Through the analysis above, it is concluded that the difference of the multi-hop ground reflection loss in different ground forms is the main reason for the large difference of the transmission power required for shortwave communication in different sea areas.

4 Conclusions

In this paper, we mainly analyze the reasons for the different size of the transmitting power, and focus on the different effects of different ground forms on the signal power loss. Testing results proved the physical random sequence spreading sequence has the same autocorrelation properties as the physical random sequence itself not related to the periodicity of t In this paper, we mainly analyze the reasons for the different size of the transmitting power, and focus on the different effects of different ground forms on the signal power loss he plaintext though the time waveform has significant difference, which proves that physical random sequence can effectively realize the information spreading.

Acknowledgment

References

1. Wang Y, Tao T. Shortwave communication technology. National Defense Industry Press. 2002; 2(1).
2. Zhang X, Li N. New Technology of Shortwave Communication. People 's Liberation Army Press. 1997; 12(1).
3. Rong D, Jin F. Modern wireless communication. Electronic Industry Press. 2007.
4. Qin T, Zhao M. The Principle, Technology and Application of Wireless Local Area Network. Xi'an University of Electronic Science and Technology Press. 2004.
5. Wang T, He B. Short distance wireless and mobile communication network. Electronic Industry Press. 2006.

6. M. K. Simon, J. K. Omura, R. A. Scholtz, et al., Spread Spectrum Communications Handbook, Beijing: Post & Telecom Press, 2002.

7. G. Xao, C. Liang, Y. Wang, Pseudorandom Sequences and Applications, Beijing: National Defence Industry Press, 1985: 167-183.

8. M. Stipcevic and R. Ursin, An On-Demand Optical Quantum Random Number Generator with In-Future Action and Ultra-Fast Response, Scientific reports, 5:1-8, 2014.

9. A. Figotin, A random number generator based on spontaneous alpha-decay, PCT patent application WO0038037A1.

10. M. Stipcevic and B. Medved Rogina, Quantum random number generator based on photonic emission in semiconductors, Rev. Sci. Instrum. 78, 045104:1–7 (2007).

11. J. G.Rarity, P. C. M. Owens and P. R. Tapster, Quantum random-number generator and key sharing, J. Mod. Opt. 41, 2435–2444 (1994).

12. A. Stefanov, N. Gisin, O. Guinnard, et al., Optical quantum random number generator, J. Mod. Opt. 47, 595–598 (2000).

13. W. Li, I. Reidler and Y. Aviad, Fast Physical Random-Number Generation Based on Room-Temperature Chaotic Oscillations inWeakly Coupled Superlattices, Physical Review Letter, 111, 044102, (2013)