Experimental Study of Propagation Characteristic for Maritime Wireless Communication

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1. Introduction

Wireless communication is one of the most important communication system at sea. But insufficient knowledge of radio channel characteristics over sea limits the development of wideband wireless communication systems for maritime applications. In maritime communication, the presence of sea and nearby islands gives rise to multi-path fading. Due to the difficulties to determine base station position for maritime wireless communication and the cost of satellite communications in the marine environment, the analysis of propagation characteristics on coast and sea is very essential for broadband wireless communication .

An experimental study on wave propagation in Korea West Sea at 2.58 GHz is presented in this paper. Measurement setup and associated measurement procedure are described in section 2. while k-factor and propagation curve results are analyzed in the sections 3. and 4. respectively.

2. Equipments, Measurement Setup and Procedure

The main equipments used for this measurement are spectrum analyser, omni-directional receiving antenna and directional transmitting antenna. For this measurement a software has been developed using MATLAB Instrument Control Toolbox. Two experiments are done in this study. For the first experiment, transmitting antenna is a 8×1 array and the weight of the ship is 84 ton. Where as for the second experiment transmitting antenna is a 8×8 array, having very narrow beam-width in comparison with antenna used in the first experiment and the weight of the ship is 24 ton.

Except antenna, power divider, and ship, the measurement setups for both experiment are same. Details of transmitting antenna systems for both measurement setups are given in the Table 1. The transmitting antenna used for these experiments is fixed at 48 m above the ground and the latitude & the longitude are $36°19'31.19''$ N & $126°30'29.48''$ E respectively. The map of the measured environment, antenna location and the direction of beam is shown in Fig. 1. The face of the radiated beam is between the Sapsido island and Nokdo island (see Fig. 1).The distance between the transmitting antenna at port and the receiving antenna at ship is 25 km for the first experiment and 35 km for the second experiment. The block diagrams of transmitting and receiving system are shown in Figs. 2 & 3 respectively. In order to observe the path loss, amplitude of the received signal is measured five times in a second during the movement of the ship. And for the K-factor, amplitude of the received signal in a particular location is measured more than 300 times per minute.

3. K-factor at a Certain Distance

Rician K factor is very important to understand the behavior of a short-range wireless channel and it is also usefull to determin bit error rate of a channel among other useful metrics [4]. It also determines the distribution of the received signal amplitude. The Rician K-factor is defined as the ratio of signal power in dominant component over the scattered power and given by

Figure 1: Map of the measured environment

Table 1: Details of transmitting system

Frequency=2.58 GHz		
Output Power=37.5 dBm		
Antenna Parameters	For First Experiment	For Second Experiment
Array	8×1	8×8
Gain	16 [dBi]	27 [dBi]
Beamwidth (horizontal)	20.6°	6.3°
Beamwidth (vertical)	58.3°	6.7°

$$K = \frac{A^2}{2\sigma^2} = \frac{(|\langle S_{21} \rangle|)^2}{\langle |S_{21} - \langle S_{21} \rangle|^2 \rangle|} \tag{1}$$

where S_{21} is the scattering parameter measured at a certain distance and $\langle S_{21} \rangle$ is the expectation value of the measured S_{21}. The values of K-factor at a certain distance for both the cases are given in Table 2. The K-factors of first experiment are higher than that of the second experiment. This difference is mainly due to degrees of the shaking caused by different in weight of the ship.

4. Compare of Propagation Curves

$ITU - R\ P.1546 - 4$ recommendation describes a method for point-to-area radio propagation predictions for terrestrial services in the frequency range 30 MHz to 3000 MHz. It is intended for use on tropospheric radio circuits over land paths, sea paths and/or mixed land-sea paths between $1 - 1000\ km$ length for effective transmitting antenna heights less than 3000 m. The method is based on interpolation/extrapolation from empirically derived field-strength curves as functions of distance, antenna height, frequency and percentage time. The calculation procedure also includes corrections to the results obtained from this interpolation/extrapolation to account for terrain clearance and terminal clutter obstructions.

Propagation curves in ITU-R p.1546-3 are associated with the effective radiated power of magnitude 1 kW for a particular frequency. But in this study, receiver power has been measured. And the relation between the field-strength of the data in ITU-R p.1546-3 and received power is given by

$$p_r = 10 \log \left(\frac{E^2\,(V/m) \times \lambda \times G_r\,(times)}{480\pi^2} \right) \quad [dBm] \tag{2}$$

where E is the field-strength of the $ITU - R\ p.1546 - 3$ data at 2.58GHz, λ is the wavelength and G_r is the gain of the receiving antenna. The difference between the measured data and ITU-R data is compensated with proper values. Offset value for the first experiment is 12.75 dBm and for the second experiment is 2.65 dBm. The propagation curves from measured data are compared with $ITU - R\ p.1546 - 3$ shown in Figs. 4 and 5.

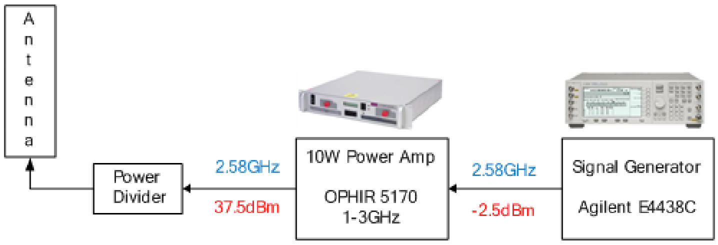

Figure 2: Experimental setup of transmitting system

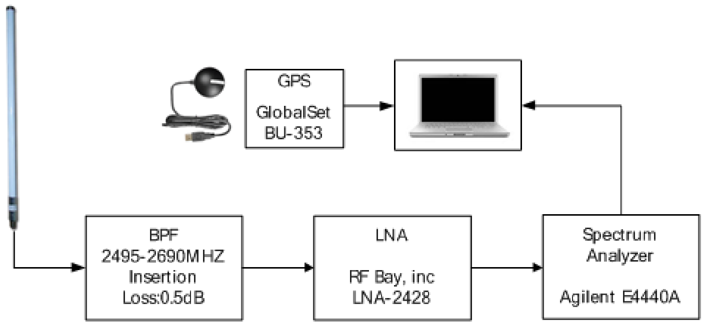

Figure 3: Experimental setup of receiving system

5. Conclusions

In this experimental study, firstly, Rician K-factor is computed from the measured value of S_{21} at various distance in two different experiment in sea environment. Next, propagation curves from measured data are compared with curves using data available in ITU-R p.1546-3 for both the cases of experiment in Figs. 4 and 5. For both experiment, the propagation curves from measured data are well matched with curves using data of ITU-R p.1546-3.

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Table 2: Rician K-factor			
First Experiment		Second Experiment	
Distance(km)	K-factor [dB]	Distance(km)	K-factor [dB]
5.27	9.808	5.32	-0.778
9.91	8.188	9.61	4.536
14.98	7.103	14.20	6.683
19.99	9.034	19.39	2.400
24.87	9.868	24.70	4.93
		28.96	8.538
		32.15	6.430

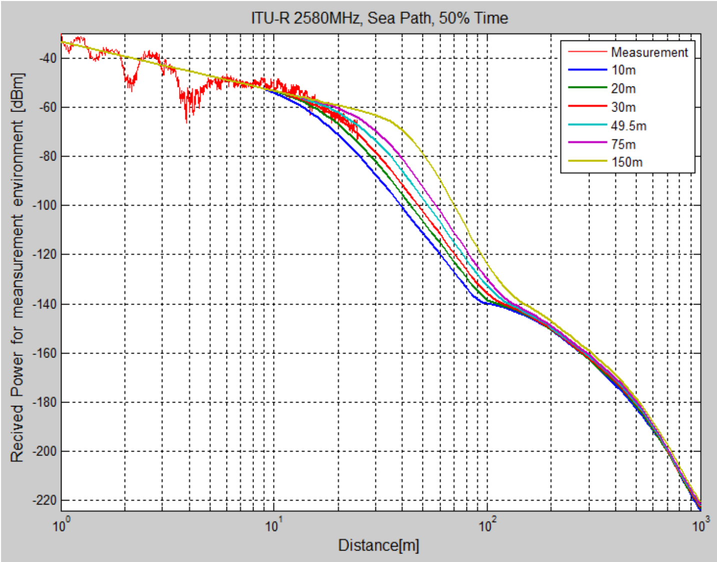

Figure 4: Propagation curves of first experiment are compared with the ITU-R p.1546-3 data

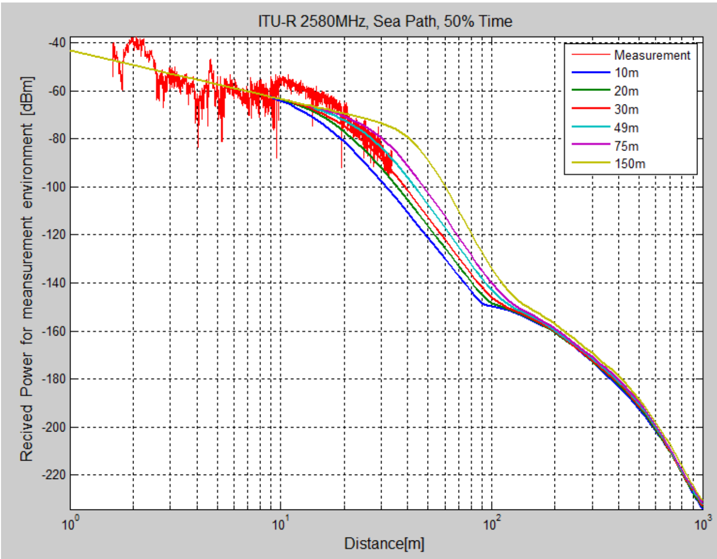

Figure 5: Propagation curves of second experiment are compared with the ITU-R p.1546-3 data