Study of the Millimeter-wave Propagation Characteristics in the Railway Environment

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Abstract – **Broadband wireless communication systems have been studied in both fields of the fixed point communication and the mobile communication. Authors are studying on the application of millimeter-wave to the ground-to-train communication system for high speed train. In this paper, we show the test results of 40 GHz band millimeter-wave propagation characteristics in the railway environment with a focus on propagation loss in the elevated line and snow attenuation.**

Index Terms — **40 GHz band Millimeter-wave, propagation characteristics, distance attenuation for elevated railway section, snow attenuation, ground-to-train communication system.**

1. Introduction

Recently, millimeter-wave band has been attracting attention from the expectation that broadband communication will be realized. In the railway environment, the millimeter-wave can be used in various situations, but its actual use is not quite widespread. Therefore, authors are studying how to apply the millimeter-wave to the ground-to-train communication system of high speed trains [1][2].

In this paper, we report the test results of the characteristics of the propagation of the 40 GHz band millimeter-wave to be used in the railway environment.

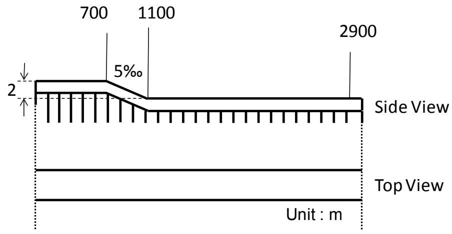
2. The characteristics of the attenuation by distance

As for the propagation characteristics of the 40 GHz band millimeter-wave in the railway environment, those in the tunnel and the open space have been reported [1]. However there has been no report of those in the elevated railway section which is considered to be a typical railway environment. Therefore, we carried out measurement tests to obtain those in the elevated railway section.

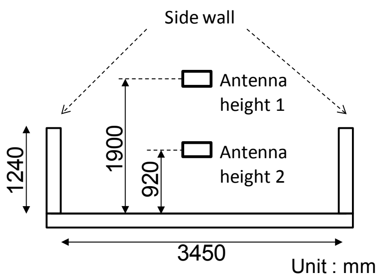
(1) Test environment

Out of necessity to conduct the measurement test in the elevated railway section, we selected a railway section whose longitudinal cross section is as is shown in Fig. 1. The selected test line has a descending slope of 5 ‰ in the section between about 700 m and 1100 m from the starting point. The length of the section is about 3000 m, the width of the viaduct is 3450 mm and the height of the side walls are 1240 mm.

In the measurement, a transmitter transmitted the CW that was set at the 0 m point. The receiver moved from a point of 10 m to a point of 2900 m at a speed of about 15 km/h. The antenna used for the transmitter and that used for the receiver are standard horn antennas, and they have vertical polarization. As for the height of the antennas, two cases were examined, namely, 1900 mm (higher than the side walls) and 920 mm (lower than the side walls) for both of the transmitter and the receiver. The test configuration is shown in Fig. 2.



(a) Side view and Top view



(b) Sectional view

Fig. 1. Outline of the test line

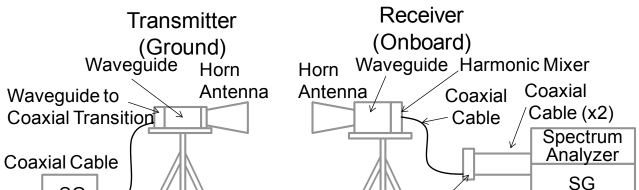


Fig. 2. Test configuration

(2) Test results

The test results are shown in Fig. 3. As shown in the test results, the propagation loss in the case of an antenna height of 1900 mm and that of 920 mm are almost the same up to a point of about 700 m where the slope begins. But, in the slope zone (700 -1100 m), the propagation loss in the case of an antenna height of 1900 mm is larger than that of 920 mm. On the other hand, that of 920 mm is larger than that of 1900 mm from the end of the slope zone up to a point of about 1700 m. For this reason, the influence of waves reflected by the structure is considered. We are planning to carry out the verification using the Ray-tracing simulation.

At either antenna height, it is possible to transmit the 40 GHz band millimeter-wave up to about 3000 m in sunny condition.

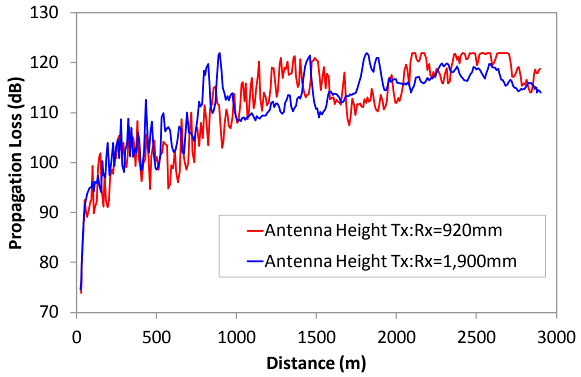


Fig. 3. Test Result of the propagation loss

3. The characteristics of the attenuation by snow

When we design the radio link of the ground-to-train communication system using the millimeter-wave in snowy regions, it is necessary to allow a margin considering the influence of snow. As for snow attenuation, the results of a study conducted using 50-75 GHz band millimeter-wave have been reported [3], but there is no report of a study conducted using 40 GHz band.

In this section, we assume the case where snow covers the antenna surface. We report the result of tests which were conducted in order to clarify the relationship between the signal attenuation characteristics and snow thickness, or moisture content.

(1) Test environment

The tests were carried out in a cold room in which the temperature was kept at -5 to 0 degrees Celsius. The test configuration is shown in Fig. 4. The antenna used for the transmitter and that for the receiver are both standard horn antennas, and have linear polarization, because the circular polarization has been reported [4]. The transmitted wave is the CW.

(2) Test results

The test results are shown in the Fig. 5. When the moisture content of the snow was 0 %, the attenuation due to the thickness of the snow was nearly 0 dB. However, if the moisture content is not 0 %, the attenuation is increased with increasing moisture content. For example, when the thickness of the snow was 10 mm and its moisture content was 14.6 %, the attenuation was about 30 dB.

Thus, it is necessary to allow margins according to the attribute of the snow falling in the area where the communication system is to be applied and to design the antenna structure so as to prevent snow from covering the antenna surface.

4. Conclusion

In this paper, we reported the test results of 40 GHz band millimeter-wave propagation characteristics in the railway environment in terms of the propagation loss in the elevated line and the snow attenuation. As a result, we were able to obtain knowledge advantageous to the design of radio links.

In the future, we are planning to carry out the verification using the Ray-tracing simulation and build up further data accumulation, with the aim of realizing a ground-to-train communication system using the 40 GHz band millimeter wave.

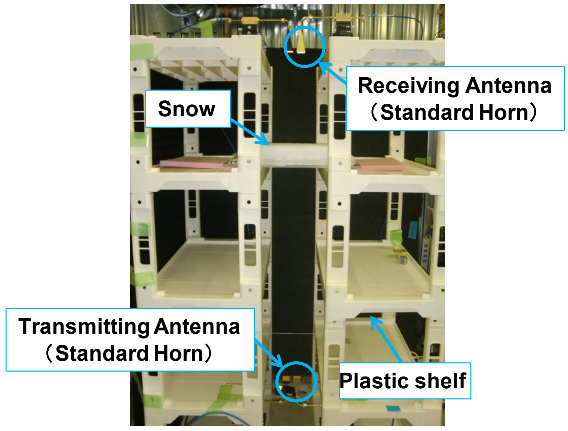


Fig. 4. Test configuration of the snow attenuation

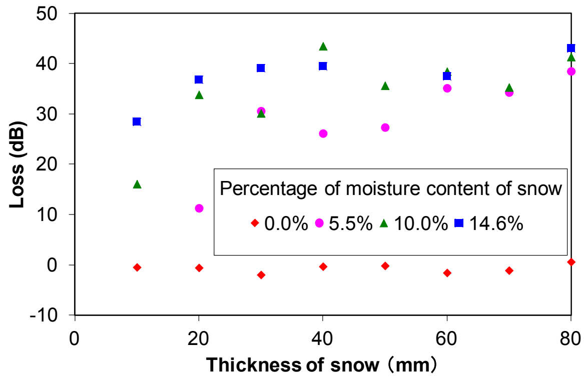


Fig. 5. Test result of the snow attenuation

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