Influence of Bragg Scattering on UWB Signal Reflection from a Periodic Surface

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1 Introduction

In indoor and outdoor propagation environments, the non-specular scattering from walls is often not negligible. Bragg scattering [1] may be significant for periodic structures such as brick walls, metallic shutters and blinds. In particular, its frequency dispersive property may influence the transmission property of the UWB system. In our previous work [2], [3], we have already considered the theoretical simulation and experiments, and confirmed the Bragg scattering in the experiment in the similar manner as the simulation. In this paper, we focus on the influence of Bragg scattering upon the specular reflection, and compare the results between the periodic surface and the flat surface of the objects.

2 Experiment setup

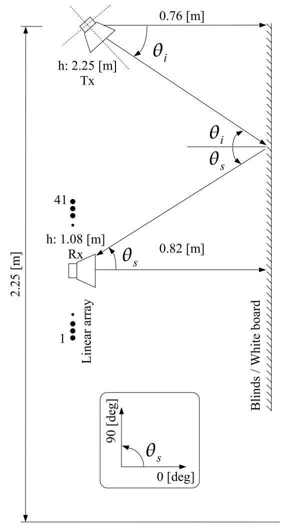
Figure 1 shows the measurement setup. The measurements have been performed with a vector network analyzer to determine the complex radio channel transfer function $H(f) = S_{21}(f)$. Selected parameters are listed in Table 1. The transmitting antenna was mounted on a fixed pole and the receiving antenna was vertically scanned to measure the direction of arrival (θ_s). We used a metallic window blind (Case A) and a metallic white board (Case B) to compare the difference between the periodic and flat surfaces. The details are shown in Figs. 2.

3 Experiment results

For Case A, since Bragg scattering has frequency dispersive properties, we show the frequency-angle power spectrum (Fig. 3) and frequency-delay spectrogram (Fig. 4) separately. Figures 3 and 4 were computed by using beamforming and short period inverse Fourier

Table 1 Specifications of the experiment

Bandwidth	3.1 to 10.6 [GHz]
Frequency sweeping points	751
Spatial sampling in the Rx position	41 points in vertical linear array whose element spacing is 1 [cm]
Type of antennas	Double-ridged guide horn
Polarization	Vertical-Vertical
Calibration	Function of VNA
SNR at receiver	about 50 [dB]



θ_i: Incident angle
θ_s: Scattered angle

Figure 1 Experiment setup

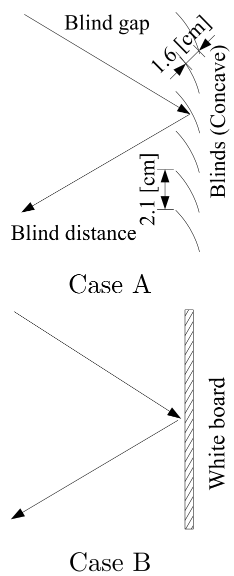


Figure 2 Target objects

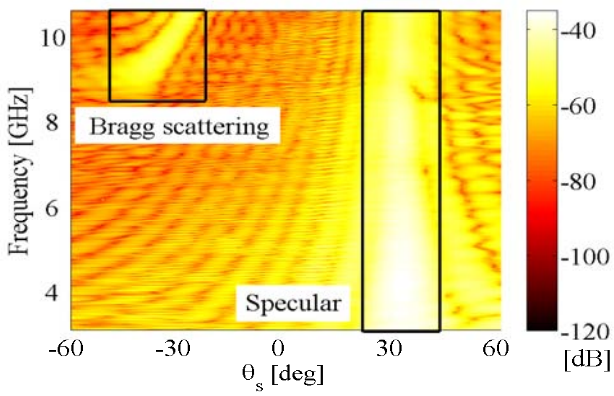


Figure 3 Frequency-angle power spectrum of Case A

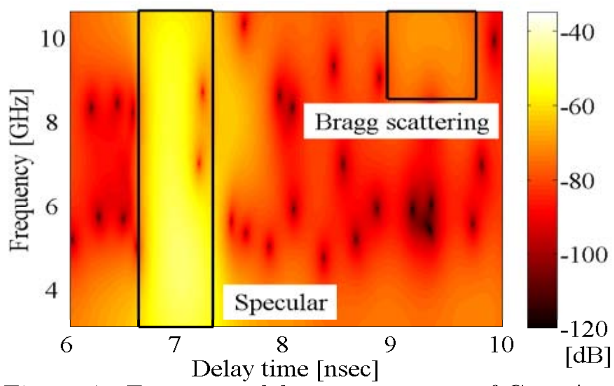


Figure 4 Frequency-delay spectrogram of Case A

Table 2 Results of Cases A and B

	CaseA		CaseB	
	Specular	Bragg scattering	Specular	Bragg scattering
θ_s [deg]	33	-50 to -25	33	-
Delay [nsec]	7.0	9.0 to 9.8	7.0	-
Frequency range [GHz]	whole	above 8.5	whole	-
Gain [dB]*	-42.59	-68.23(mean)	-40.26	-

(* Tx and Rx antenna gains are included)

transform respectively. Bragg scattering and the specular reflection can be found as marked areas in these figures. For Case B, no Bragg scattering was found since the reflecting object (white board) was a flat surface, and its specular reflection was found at the same position as Case A.

4 Analysis of specular paths and Bragg scattering

The specular path was detected by using a matched filter both in the angular and delay domain, and its path gain values for both cases are shown in Table 2. Figure 5 shows the transfer function of specular path of both cases. Since the materials of the objects for Cases A and B are different, they have different loss. The loss of Case A is approximately 2 dB greater than Case B, and it can be confirmed at frequencies lower than 8.43 GHz in Fig.6. From 8.43 to 9.48 GHz, a significant peak can be observed at 8.98 GHz due to the influence of Bragg scattering. For the part greater than 9.48 GHz, there is almost no effect from Bragg scattering, but the penetration loss of Case A should be considered, because the half wavelength ($\lambda/2$) at these frequencies are smaller than the blind gap (about 1.6 cm), and therefore the specular path at these frequencies can go through the blind gap.

For Bragg scattering, it cannot be detected as well as a path. The frequency dispersion of Bragg scattering resulted in a relatively long delay spread and a wide angular spread (Table 2), and no significant peak can be observed. Bragg scattering, therefore, may deteriorate UWB waveforms and degrade the UWB transmission performances.

5 Conclusions

In this paper, an analysis of specular reflection and Bragg scattering using UWB signal were presented. The specular path gain were compared and discussed between Cases A and B. The frequency dispersive property of Bragg scattering was experimentally and analytically confirmed, and its influence upon the UWB transmission was discussed.

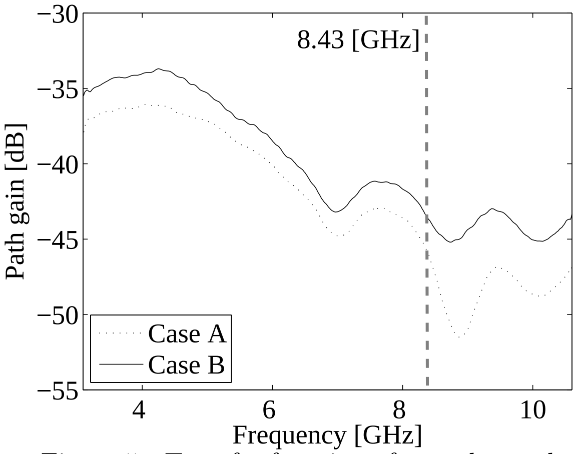


Figure 5 Transfer function of specular paths

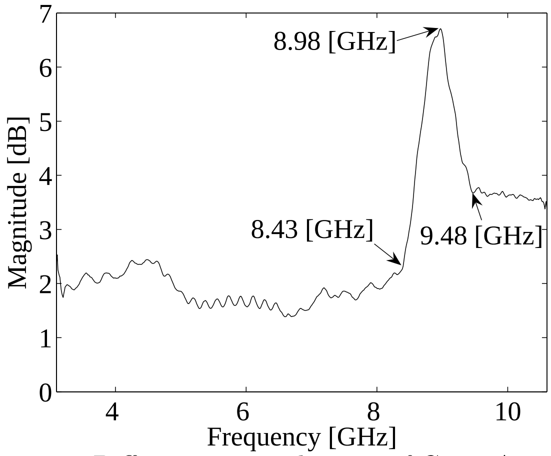


Figure 6 Differences in path gains of Cases A and B

References

[1] M. Born and E. Wolf, “Scattering from inhomogeneous media,” in Principles of Optics 7th (expanded) edition,” Cambridge University Press, pp.705–708, 2001,

[2] N. Lertsirisopon, H. Tsuchiya, M. Ghoraishi, J. Takada, and T. Kobayashi , “Investigation of the Bragg Scattering of UWB Signal from the Window Blind : (1) Theoretical Investigation,” 2006 IEICE General Conference, B-1-2, Mar. 2006.

[3] H. Tsuchiya, N. Lertsirisopon, M. Ghoraishi, J. Takada, and T. Kobayashi , “Investigation of the Bragg Scattering of UWB Signal from the Window Blind : (2) Experimental Investigation,” 2006 IEICE General Conference, B-1-3, Mar. 2006.