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Measuring System for Ku-Band Satellite-Diversity (Sat. D) Characteristics and Short-term Measured Examples

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Abstract *- This paper deals with the Ku-band satellite-diversity (Sat. D) characteristics for cost-effective Ku-band VSAT satellite communication system. The Ku-band Sat. D characteristics are measured by using low cost measuring system, which is constructed with IF band receiver, A/D converter and personal computer (PC). The measured data are compared with the spectrum analyzer measuring system, and relatively good agreement can be obtained between two measuring methods. By using this measuring system, short time Sat. D characteristics data between Broadcasting Satellite (BS) and Super-Bird-B(SB-B) can be obtained for rain and snow attenuation events. Those events can be explained geographically by comparing weather radar images.*

1. INTRODUCTION

Signal attenuations caused by rain or snow are a major problem in satellite communication systems operating at frequencies above 10 GHz. Many methods such as site diversity (SD)[1], up-link transmitting power control and bit rate control system etc. have been proposed to overcome this problem.

Recently, very small aperture terminal (VSAT) systems have become popular[2]. For the system design of the VSAT network, it must be constructed and overcoming rain attenuation discontinuity as economically as possible.

The Sat. D system is expected to be a viable alternative for achieving high quality VSAT communication system. Problems are how Sat. D characteristics can worked on the VSAT system and how to obtain the short-term or long-term Sat. D data from multiple satellite signals. In the following sections, low cost measuring system for rain and

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snow attenuation and considerations of Sat. D data are discussed.

2. PRINCIPLE OF THE Sat. D SYSTEM

Conventional SD systems are constructed with two earth-stations (ES) separated by about 10 km and access to one satellite transponder, as shown in Fig. 1. In such an SD system, there are some problems, such as the high cost of a long distance entrance line, complex switching timing control and the necessity of an adequate distance between two earth-stations.

On the contrary, the Sat. D system, as shown in Fig. 2, is constructed with two earth stations in the same location and each antenna dish access to the different satellite transponders, respectively. The systematic merits of the Sat. D system can be pointed out as follows;

(1) As an entrance line is not necessary, the system configuration is simpler and low cost earth segments can be realized.

(2) The switching control of the earth-stations can be carried out by very simple methods in one place.

3. MEASURIG METHOD FOR THE Sat. D CHARACTERITICS

Typical propagation characteristics measuring system is constructed with spectrum analyzer. However, this measuring system is relatively expensive. New measuring system used here is shown in Fig. 3. As shown in Fig. 3, measuring system is constructed with 1.0 mØ antenna, IF band receiver, A/D converter, coupler and PC. Measured IF receiver AGC analog signals are converted by A/D converter to digital signals and stored in PC. Measured data are processed by the EXCEL program for every one second.

The accuracy of this measuring method is compared with the spectrum analyzer measuring system, and shown in Fig. 3. As shown in Fig. 3, new measuring system has sufficient accuracy, compared with expensive method. As a result, almost 1/10 low cost measuring system can be obtained. Available measuring channels are about 12.

4. MEASURED RESULTS OF THE Sat. D CHARACTERISTICS

Measuring satellites are BS(110°E) and SB-B(162°E), that operate at the 14/12 GHz band. As ES elevation angle is about 45° and a height of the zero-degree layer is almost 4 km, the maximum transmission path difference at the zero-degree layer is expected about 5 km.

Fig. 4 shows time series of simultaneous attenuations for two satellite signals affected by rain attenuation. As shown in Fig. 4, the time delayed attenuation characteristics between two satellites can be clearly observed with orbital separation angle of 52°. Fig. 5 shows a Sat. D characteristics processed by PC. Higher signal level satellite is selected for accessing satellite.

Fig. 6 shows the radar image near ES. Heavy rain clouds can be observed near ES, and those clouds introduce the Sat. D characteristics. Fig. 7 shows the relation between short-term unavailability and rain attenuations, with and without Sat. D system. Unavailability improving factor about 20 can be obtained with 3 dB threshold level. Fig. 8 shows a snow attenuation example in Jan 25, 2004. The Sat. D characteristics can be also observed in Fig. 8.

5. CONCLUSIONS

The propagation characteristics for the Sat. D system for rain and snow attenuations were measured by using low cost measuring system. From measured results, the relatively large improvement factor of short-term unavailability by introducing the Sat. D system for rain attenuation value, e.g. 20 can be obtained. The Sat. D system has many systematic merits, such as no-necessity of an entrance line, easy control of diversity switching etc. Long-term data accumulation should be continued for more solid system design data for introducing the Sat. D system.

ACKNOWLEDGMENT

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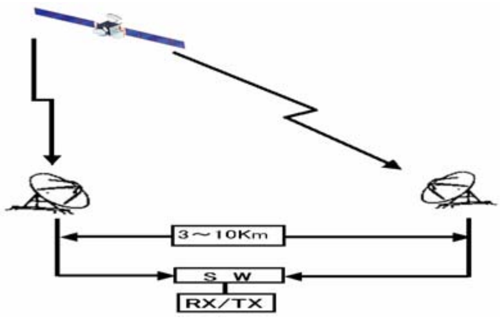

Fig. 1 Site Diversity (SD) system,

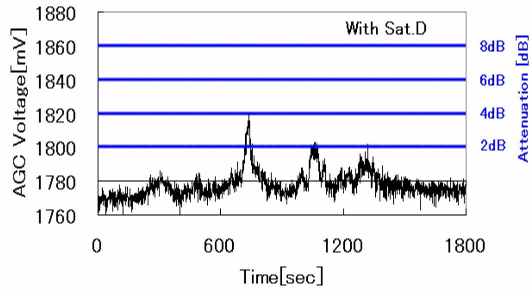

Fig. 5 Sat. D system characteristics example.

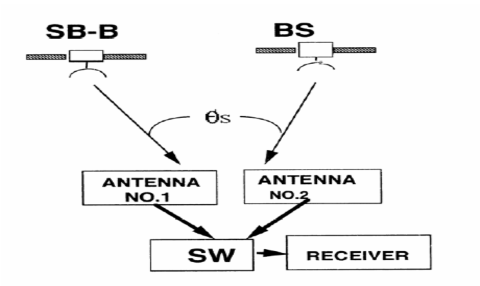

Fig. 2 Satellite Diversity (Sat. D) system.

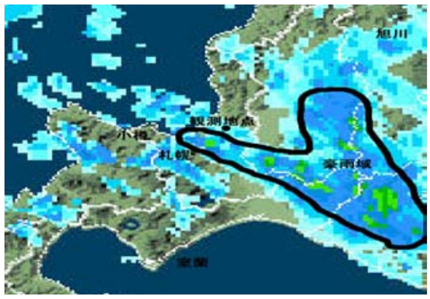

Fig. 6 Rain cloud image from Weather Satellite, in Oct. 2,2003

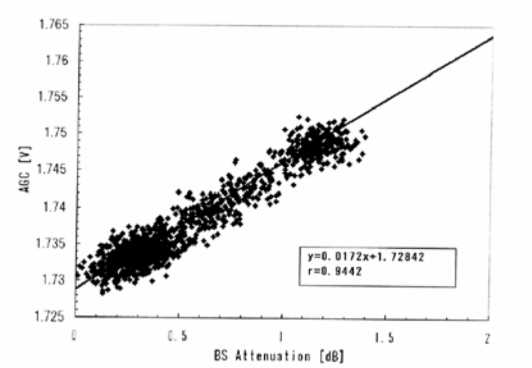

Fig. 3 Comparison between Spectrum Analyzer system and proposed measuring system.

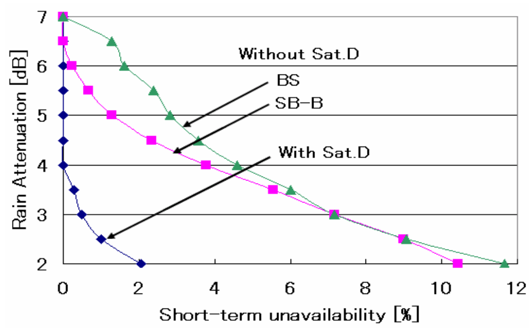

Fig.7 Relations between short time link unavailability and rain attenuation.

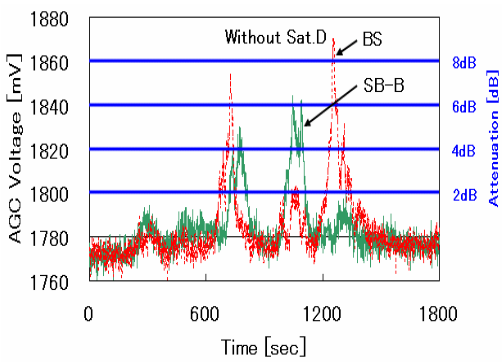

Fig. 4 Rain attenuation example for BS and SB-B satellites in Oct. 2, 2003.

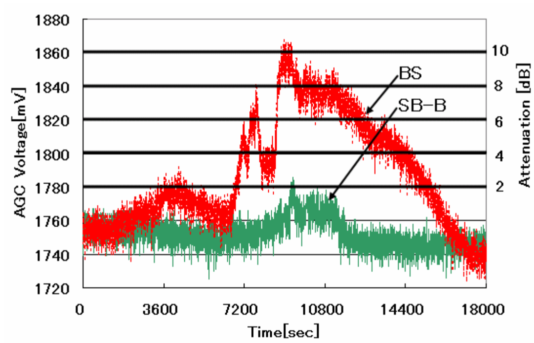

Fig. 8 Snow attenuation example of BS and SB-B satellites