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Comparison of Satellite Visibility Improvements between Satellite Diversity (Sat. D) System and Time Delayed Diversity (TDD) System in Hokkaido Urban Cities

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Abstract- This paper deals with comparison of digital broadcasting satellite visibility capabilities between* the *satellite-diversity system satellite-diversity (Sat. D) system and time delayed diversity (TDD) system in three Hokkaido urban cities. Those two systems are examined for overcoming the urban signal attenuations due to buildings and trees etc. Both systems data were measured by using the GPS (Global Positioning System) satellite. Southern orbital arc GPS satellite signals with elevation angle about 40° to 50° data are used for propagation characteristics measurements, rather than actual geostationary satellite orbit (GSO) satellite. From measured data, it can be clarified that about 40% satellite visibilities without Sat. D or TDD systems can be improved about 70~80% satellite visibilities. The improvement factors are affected by densities of buildings or trees, row of buildings along the streets, latitude positions of measured satellites.

1. Introduction

Digital satellite communication and broadcast technologies are now highly developed and high quality, distance-independent services have expanded over very wide areas[1~4]. Recently, digital mobile broadcasting satellite systems scheme using the L-band GSO satellite has been proposed. For designing digital broadcast system from geostationary satellite, it must overcome urban signal attenuations due to buildings and trees etc. and clarified attenuation characteristics in different urban cities. To overcome urban signal attenuations in urban area, gap-filler and the Sat. D system [5] have been proposed. The Sat. D system can achieve relatively large improvement of satellite visibility, however, two satellites must be used with real time broadcasting. Therefore, newly proposed TDD system, which receives two channels with different times, is one of the most hopeful candidates.

In this experiment, the Sat. D system data and the TDD system data in urban three cities in Hokkaido have been measured by using the GPS satellite signals. Measured data are processed to assess the possibility of the TDD system utilization for the GSO satellite and the Sat. D system. From the experimental results, it can be clarified that the improvement factor by the TDD system is relatively large, even-though two radio channels will be required and real time broadcast can not realized.

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2. Concept of the Sat. D system and TDD System

The Sat. D system, as shown in Fig. 1, is constructed with two satellites orbital separation angle is defined as θs and two mobile receiver in the same location,. Mobile receiver receives both satellites at certain location, where one satellite signal is are attenuated by buildings etc, however, another satellite is not attenuated by buildings etc. therefore, satellite visibilities can be improved by the Sat. D system.

The new concept of the TDD system is shown in Fig. 2. As shown in Fig. 2, the TDD system is constructed with two radio channels. First channel (f1) is real time broadcast signal and second channel (f2) is time delayed (τ) broadcast signal. Mobile receiver receives both channels at certain location, where satellite broadcasting signals are attenuated by buildings etc. After several minutes, mobile station receiver receives both channels at different location, where satellite broadcast signals are not attenuated. In mobile receiver, real time signal and delayed time signal are combined and switched to higher quality channel. By the effect of the TDD system, the availability of digital mobile broadcast satellite system can be improved.

The problems are what kind of measuring method should be used and how satellite visibility can be improved by those systems.

3. Measuring and processing methods of the GPS data

To measure the TDD and Sat. D systems characteristics from the GSO satellite signals, the GPS signal measuring method is adopted in this experiment. This method has many merits, i.e., cheap equipment cost and easy measurement of various data about satellites and receiver position (latitude, longitude and height etc.). The accuracy of the GPS S-mode signal can be obtained with accuracy about 10 m. The measured data are stored in PC, and can be processed for various kinds of the TDD system characteristics.

4. Measured Sat. D and TDD Systems characteristics

Measuring system is constructed with the GPS antenna, receiver and satellite signal level measurement equipment, compact personal computer. Three large citied in Hokkaido, i.e. Sapporo, Asahikawa and Otaru, which are northern parts of Japan.

Fig. 3 shows an example of the GSO satellite visibility in urban area in the Sapporo city without the TDD and Sat. D systems, with elevation angle is about 45°. Satellite visibility percentage is calculated from averaged value for distance about 100 m and plotted by changing width of lines, where thick line is good visibility and thin line is poor visibility. The total satellite visibility percentage is about 40 %.

Fig. 4 shows an example of the Sat. D system characteristics with two satellites orbital separation θs = 20° . In Fig. 4, it can be clarified that averaged satellite visibility percentage can be improved from 40% (without Sat. D system) to about 80 % (with Sat. D system) by introducing the Sat. D system.

Fig. 5 shows an example of the TDD system characteristics with delayed time τ=6 minutes. In Fig. 5, it can be clarified that the satellite visibility can be improved to total

satellite visibility percentage is about 70 % by introducing the TDD system.

Fig. 6 shows an example of the GSO satellite visibility in urban area in the Asahikawa city without the TDD and Sat. D systems, with Elevation angle is about 45°. The total satellite visibility percentage is about 50 %.

Fig. 7 shows an example of the Sat. D system characteristics with orbital separation θs = 20°. In Fig. 7, it can be clarified that the satellite visibility can be improved to total satellite visibility percentage is about 93 % by introducing the Sat. D system with orbital separation θs = 100° .

Fig. 8 shows an example of the TDD system characteristics with delayed time τ=6 minutes. In Fig. 8, it can be clarified that the satellite visibility can be improved to total satellite visibility percentage is about 80 % by introducing the TDD system.

By using the Sat. D system and TDD system, satellite visibility percentage can be improved about twice. However, the effect of the Sat. D system and TDD system will be influenced by many factors, e.g. orbital separation θs , delayed time (τ) between two channels, vehicle speed, blocking object and density in urban area etc.

5. Conclusions

By receiving GPS signal, the Sat. D and TDD system characteristics for GSO satellite in urban three citied can be clarified. The followings results are clarified.

(1) By using the TDD system, satellite visibility can be improved from 40% to 70% for GSO satellite, and 77% to 90% for quasi-zenith satellite system in urban Sapporo city.

(3) Even though the TDD system requires two radio channels, by introducing the TDD system, improvement for attenuation or shielding by building in urban Sapporo city can be expected.

Further studies should be continued for more detail propagation characteristics data and measurement for various cities.

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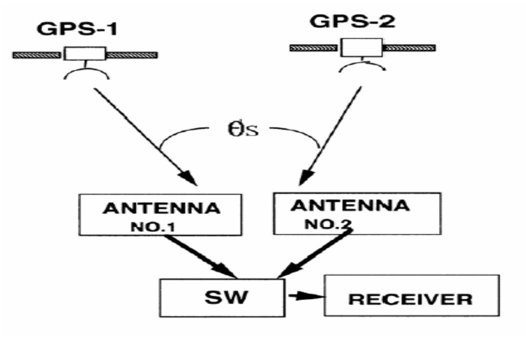

Fig. 1 Concept of the Sat. D system.

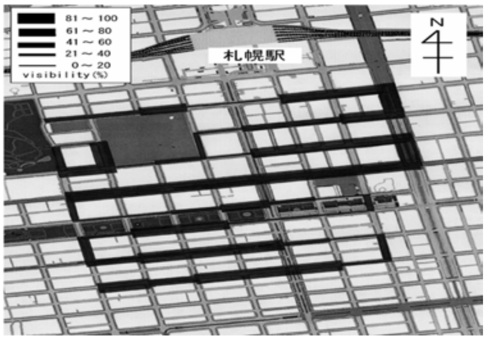

Fig. 3 Satellite visibility example for Sapporo without Sat. D and TDD

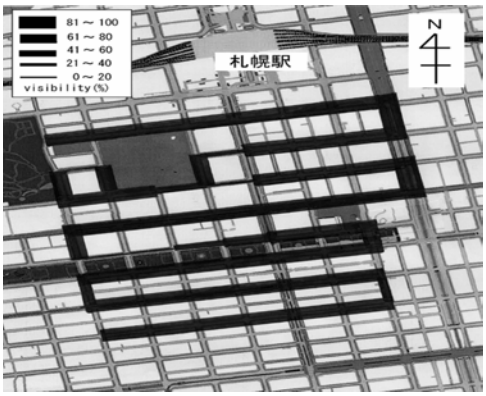

Fig. 4 Satellite visibility example for Sapporo with Sat. D

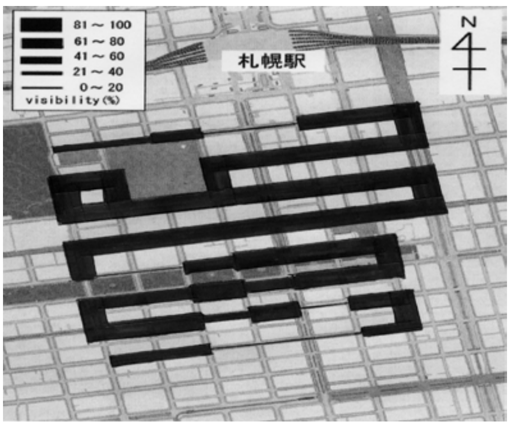

Fig. 5 Satellite visibility example for Sapporo with TDD

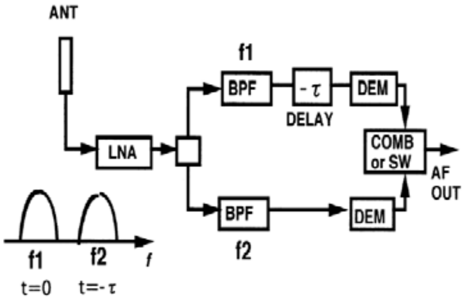

Fig. 2 Concept of the TDD system..

Fig. 6 Satellite visibility example for Asahikawa without Sat. D and TDD

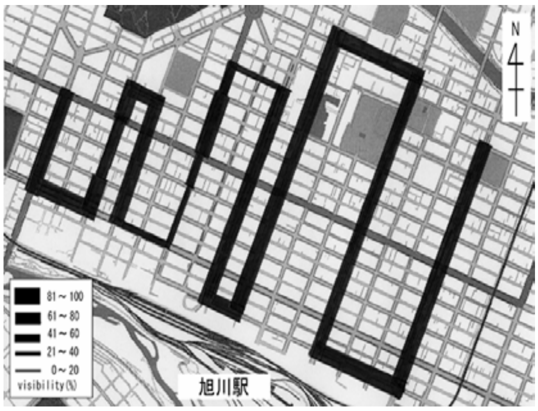

Fig. 7 Satellite visibility example for Asahikawa with Sat. D

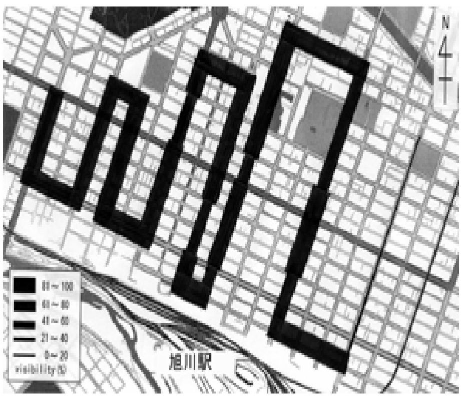

Fig. 8 Satellite visibility example for Asahikawa with TDD