SYSTEMATIC CONSIDERATIONS OF MULTIPLE SATELLITES DIVERSITY ON 14/12 GHz BAND IN SNOWING CLIMATES

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Abstract - This paper deals with the possibilities of the satellite diversity (Sat.D) system for VSAT earth station in snowing climates. Three satellite down-link signals are measured in experiments, i.e., JCSAT-1, JCSAT-3 and Broadcasting Satellite (BS) and diversity gains are obtained by the Sat.D simulation program. From the obtained Sat.D results for snowing attenuation in snowing climates, it becomes clear that the Sat.D would be utilized effectively for the VSAT system, rather than conventional site diversity (SD) system.

1. INTRODUCTION

To overcome the signal attenuations due to rain or snow is most severe problems in satellite communication system operating at frequencies above 10 GHz fixed-satellite service bands. Many methods were discussed for long times, e,g., site diversity (SD), up-link transmitting power control, satellite transmitting power control, frequency diversity and PSK signal phase control or bit rate control system and so on.

Recently, very small aperture terminal (VSAT) systems have been expanded very widely. The Hokkaido Integrated Telecommunications (HIT) network has been studied with constructing satellite communication systems and low cost SHF band terrestrial radio networks. By using the HIT network, economical and highly functional services, including expansion of the network to rural areas can be realized [1]. As for the system design of the HIT network, it must be constructed as economically as possible. Furthermore, to apply the 14/12 GHz band VSAT system, it must first overcome rain attenuation discontinuity of satellite links, which is most difficult problem to the 14/12 GHz band.

To resolve these problems, several strategies were considered: (1) Networking with satellite communication and low cost SHF terrestrial wireless networks, (2) The packet communication ultra small aperture terminal (PC-USAT) system[1], where the packet length is changed in accordance with rain attenuation and thereby allowing a rain margin of several dB, (3) Low bit rate medical information (e.g., electrocardiogram, temperature, blood pressure, pulse rate, etc.) and a still-picture simultaneous transmission system, (4) Optimum design for determination of the rain margin, and so on.

The concept of the HIT network is shown in Fig. 1. A small (1-2m) earth station receives signals from a large (3-5m) earth station using a 14/12 GHz band satellite and distributes the signals to optical fiber or SHF band terrestrial radio networks and subscribers. The large earth station (medical or educational center) is located in a big city and small earth stations may be located in remote areas.

In the HIT network,antenna size is assumed as around one meter in diameter. In this small antenna earth station system, the C/N levels is small and rain margin becomes small values.

However, requirement for higher network availability will be required. In this case, conventional SD will not adequate, then other new methods will be required. The satellite diversity (Sat.D) will be one of the hopeful alternatives for VSAT communication system.

2. PRINCIPLE OF SATELLITE DIVERSITY (Sat.D) SYSTEM

2.1 SITE DIVERSITY (SD) AND ITS PROBLEMS

Conventional SD is constructed with two earth stations separated from 3 to 10 km each other and access to one satellite transponder, as shown in Fig. 2. In this SD system, there are some problems for applying to the HIT network as follows;

(1) Long distance entrance line between two earth stations is necessary. In general VSAT system, the cost of earth station is very low, then, the cost of entrance line will big penalty for constructing low cost network.

(2) Switching timing control of the SD will have difficulties, because of separation distance of two earth stations.

(3) Adequate distance must be required for achieving high communication qualities, then the quality of the system depends on the SD distance.

2.2 PRINCIPLE OF Sat.D SYSTEM AND ITS SYSTEMATIC MERITS

The Sat.D system,in Fig. 3, is constructed with two earth stations in same setting place and each access to the different satellite transponders, respectively. Lower attenuation level satellite transponder is selected by system switch. The systematic merits of the Sat.D system can be pointed out as follows;

(1) Long entrance line is not necessary, then, the system configuration will becomes simple and low cost earth segments can be realized.

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

(3) The availability of the network can be improved by introducing the Sat.D system.

(4) When other earth stations in the HIT network are settled in long distance place, the simultaneous rain or snow attenuation occurrence probability is very small values. Then the satellite transponder for the Sat.D system can be commonly used (or shared), and utilizing cost per one earth station can be divided by the number of earth stations. As a results, the cost of Sat.D system could be limited at small values and with lower network availability. To clarify the systematic possibilities for introducing the Sat.D system in the HIT network, experimental data were gathered as follows.

3. EXPERIMENTS FOR Sat.D CHARACTERISTICS MEASUREMENTS

The measuring earth stations and satellites construction are shown in Fig. 4, where three satellites (i.e., JCSAT-1, JCSAT-3 and BS) operate at the 12 GHz frequency band. The earth station antennas diameter are 1.0, 1.0 and 1.2m, respectively. The received signals are processed by spectrum analyzer or BS decoder. The output signals from spectrum analyzer or AGC output of the decoder are digitalized by A/D converters and processed by the personal computers, then memorized in hard disks.

The orbital positions of JCSAT-1, JCSAT-3 and BS are 150°E, 128°E and 110°E, respectively. Then the maximum orbital separation is 40 degrees. As the earth station elevation angle is almost 45° and height of zero-degree layer is almost 4 km, the maximum transmission path difference at zero-degree layer is about 5 km.

The rain attenuation occur below the zero-degree layer, on the contrary, the snow cloud will grow higher than zero-degree layer.

Then, some different attenuation characteristics will be expected. Those data had not obtained yet.

3.2 MEASURING RESULTS

In Fig. 5, time series of simultaneous attenuations for three satellite signals are shown. The upper one of Fig. 3 shows the snowfall rate, which is converted into the water rate by heating snow on rainfall gauge. The received signals from JCSAT-1, JCSAT-3 and BS are shown in order. As shown in this Fig. 5, the attenuation different characteristics with time can be observed, even though the small orbital separation between JCSAT-1 and JCSAT-3 (orbital difference is 22 degrees).

Fig. 6 shows the scattergram of the simultaneous attenuation in the JCSAT-3 and BS. Those data were gathered for 240 hours. From Fig. 6, satellite diversity effect can be expected from widely distributed data points.

Fig. 7 shows the three satellite signals attenuation distributions and joint distributions (Sat.D characteristics) between two satellites (JCSAT-1 and JCSAT-3, JCSAT-1 and BS, JCSAT-3 and BS) and three satellites Sat.D characteristics.

From Fig. 7, it becomes clear as follows;

(1) Improvement of time avilavility by introducing the Sat.D system is from 1/10 to 1/100. This improvement factor is equal or larger value than conventional 10 km site diversity system[1].

(2) The statistical gains of the Sat.D system are from 2.5 dB (0.1%) to 3.0 dB (0.01%). This value seems small value, however, it means that if 3dB margin is contained in PC-USAT system, the availability of 0.01%/year can be achieved for the HIT network.

(3) The difference between two satellites Sat.D system and three satellites Sat.D system is almost 0.5 dB. This value is rather small value than assumed value in pre-experimental stage.

(4) The Sat.D gain for snow attenuation is extremely large value. By continuing those experiments, the Sat.D gain for rain attenuation must be clarified, and also long time Sat.D characteristics should be obtained.

4. CONCLUSION

The propagation characteristics for the Sat.D system in snowing season were measured by using three satellites and discussed from systematic aspects. The improvement factor of the system availability is larger value than pre-experimental expected value. The Sat.D system has many systematic merits, e.g., no-necessity of entrance line, easy control of diversity switching and easy earth station maintenances and so on.

Long time data accumulation should be continued for more solid system design data.

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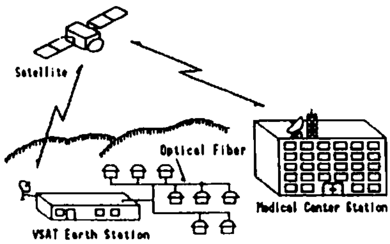

Fig. 1 HIT network concept.

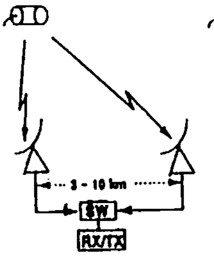

Fig. 2 Site Diversity (SD) system.

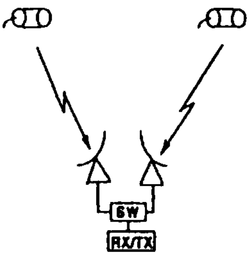

Fig. 3 Satellite Diversity (Sat.D) system.

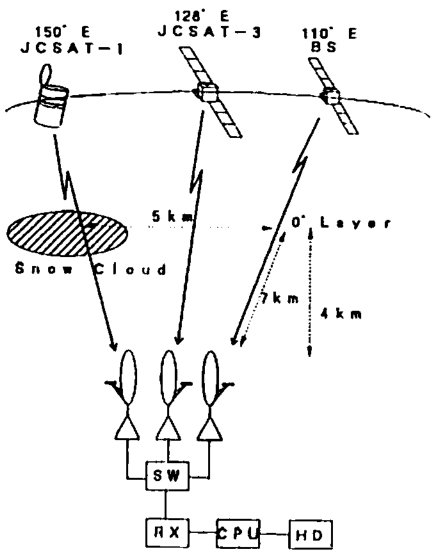

Fig. 4 Construction of Sat.D experiments.

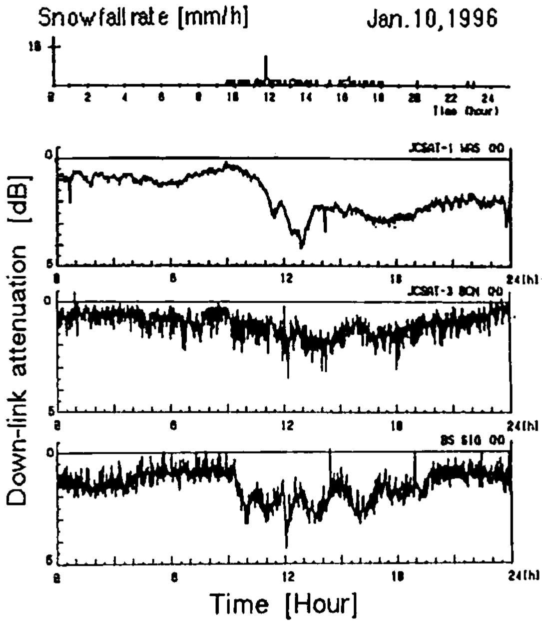

Fig. 5 Example of simultaneous time series of snow attenuations. (Jan.10,'96)

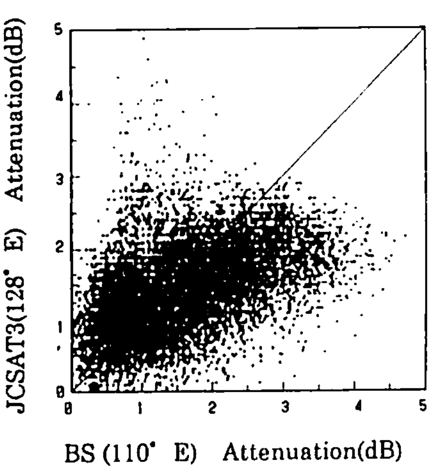

Fig. 6 Scattergram of the simultaneous attentions between JCSAT-3 and BS.

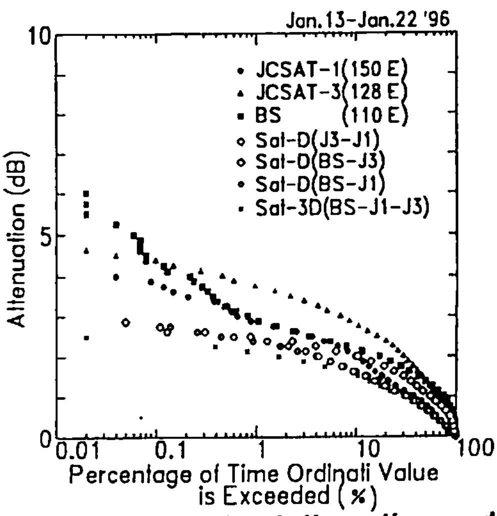

Fig. 7 Satellites signal attenuations and joint distributions.