MULTIPURPOSE SATELLITE DATA RECEIVING ANTENNA

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1. INTRODUCTION

Since it is inadequate to make observations from the ground, even by using sounding rockets and baloons, and to fully understand the vast Antarctic, it is recognized that the data from various polar-orbiting satellites such as EXOS-D, MOS-1 and other satellites to be launched in the future will greatly accelerate the progress of these fields of science.

A 11-meter Cassegrain antenna has been installed in a spherical radome in the main station at Syowa as a subsystem of the satellite receiving facility.

The antenna also has capabilities for VLBI [1] and radio astronomy. A cross point (reference point) position is provided for this purpose.

This paper discusses the key technologies used in the design and presents the major performance parameters.

2. ANTENNA CONFIGURATION

The entire 11-meter antenna enclosed by a spherical radome eliminates all environmental forces, and brings various benefits under severe weather conditions. The antenna mount is a two-axes AZ/EL type.

Usually to track polar-orbiting satellites, the antenna mount needs to point to any direction in the canopy. In Antarctica, however, the loci of the satellites are almost duplicated, so that even the zenith locus is not traced, slightly inclined loci where the antenna elevation angle is less than 87 degrees can present any data covered by the zenith track.

Also, the simple two-axes AZ/EL mount makes it possible to accomodate an equipment enclosure much larger than in the X/Y mount or the three-axes AZ/EL mount maintain lightweight features.

The basic design concept of the antenna is to minimize the weight under extremely low temperature and high wind environments. Satisfying these requirements, the following factors must simultaneously be implemented in the design :

1) Dimensions and weight of packing components must be strictly controlled, assuming helicoptor transportation. (SIKORSKY S61)
2) Antenna erection period is limited to seveval days.
3) The antenna hub enclosure must house at least two 19-inch racks with one operator.
4) Almost no adjusting and testing time is allowed at Showa Base.

These requirements directly affect the antenna design as an optimized configuration.

3. REFLECTOR & STRUCTURE

The first approach in the structure design was to use only aluminum members for the reflector section, as the weight reduction of this section not only contributes to the total weighting requirement, but also provides a large hub enclosure.

The second approach was to eliminate the alignment work. To preserve the main reflector profile ensured in the factory alignment work, design and experiments

were made for a special trestle which ensure surface accuracy better than 0.4 mm RMS without repeating alignment work.
To eliminate the drive gear meshing at the site, the positioning of the drive mechanism is designed by means of a positioning adaptor which provides a machined inlaid surface to fix the drive mechanism.
Several other key design experiments were carried out in developing the structure.

4. FEED SYSTEM

Fig.1 shows the block diagram of the feed system. The S-band TE21/TE21* mode coupler is a branching section which consists of two groups of four coupling holes arranged on the wall of the conical taper section of the multi-flared horn.
Two coupling hole groups are arranged on the periphery and offset by 45 degrees so as to sense the orthogonal TE21 modes for autotracking. Since such a simple coupling hole arrangement has no capability of mode selecting, the coupling coefficient for the TE21 mode waves must be controlled to an allowable insertion loss for the TE11 mode wave.
With a trade-off calculation, the coupling coefficient of the TE21 mode wave was determined as -5dB, as this figure is sufficient to ensure a tracking accuracy of better than one-tenth beamwidth while maintaining an insertion loss of the TE11 mode waves at less than 0.1dB.

The S-band OMJ is another turnstile junction which has four coupling holes arranged to have equal angular displacements of 90° on the wall of the circular tapered waveguide. In each hole, an array of resonant whiskers rejects coupling of X-band waves by more than 40dB. The X-band TM01 mode coupler is a multi-hole directional coupler which detects only the TM01 mode components. The quater-wave plate and the OMT receive orthogonally polarized dual circular waves in the X-band. In this feed configuration, more than twenty higher-order mode waves are generated in the X-band at the S-band mode coupler and the OMT sections.
Although the resonant whisker array is included in the coupling slot, the coupling slots obviously spoil the smooth surface of the waveguide wall.
The radiation patterns of the primary pattern are degraded when the S-band branching devices are incorporated in the primary feed, and their shapes can be adjusted by changing the lengths of the interconnecting waveguide between the TE21 mode coupler and the OMT, evaluating the gain and sidelobe characteristics by means of the computer calculations.

5. OVERALL ANTENNA PERFORMANCE

The RF performance parameters were measured on a test pedestal using boresight signals. Then, the entire antenna was installed in the spherical radome prior to shipment, and evaluated receiving signals from a polar-orbiting satellite. In the same manner, the measurement was repeated at Showa Base by receiving the boresight signals and the satellite signals.
Fig.2 shows the antenna under test without the radome.
The major parameter performances are listed in Table-1. The sidelobes and the tracking chain were confirmed using the boresight facilities at Showa Base. Fig.3 shows the sum and difference patterns. The tracking and pointing performances were measured by receiving signals from MOS-1(Marine Observation Satellite). In Fig.4, the X-band tracking chain are shown, when the S-band tracking system is operated. In Fig.5, the angle error voltages of two tracking systems are shown, with the antenna driven in the program mode.

6. CONCLUSION

The multipurpose S & X band antenna has been successfully installed at Showa Base in Antarctica. The performance evaluations have been performed by adjustment and tests through three phases, and confirmed that the all performance paramets fully meet the requirements of the receiving system for the polar-orbiting satellite and also the VLBI application.

7. ACKNOWLEDEMENTS

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Table 1 Major Performance Parameters

(A) Antenna			
1) Total weight	: 22 tons (Packing Unit 1.4 ton max.)		
2) Pointing coverage	: Azimuth±360°, Elevation 0° ～90°		
3) Drive speed	: Azimuth 10deg./sec, Elevation 6deg./sec.		
4) Frequency range	: S-band (2.20 ～2.32 GHz) X-band (7.86 ～8.60 GHz)		
5) Gain	: 46.2dB at 2.2GHz, 57.3dB at 7.86GHz		
6) Polarization	: Dual CP-Ports Axial Ratio 1.2dB max.		
7) Antenna noise temperature	:	S-band	X-band
	At EL 5°	70° K	51° K
	EL 10°	61° K	39° K
	EL 15°	58° K	35° K
8) Beam/null alignment	: less than 0.04° in S-Band less than 0.02° in X-Band		
9) Pointing accuracy	: 0.02 deg. rms		
(B) Radome			
1) Configuration	: 17-meter dia. (570 triangular sectors)		
2) Total weight	: 8.5tons		
3) Membranes	: Kevler-fibre reinforced EPDM		
4) Insertion loss	: 0.7dB in S-band 1.1dB in X-band		

Refernce

(1) K. Kaminuma : "VLBI AT SYOWA STATION, ANTARCTICA", Proceedings of the Japanese Symposium on Earth Rotation, Astrometry, and Geodesy.

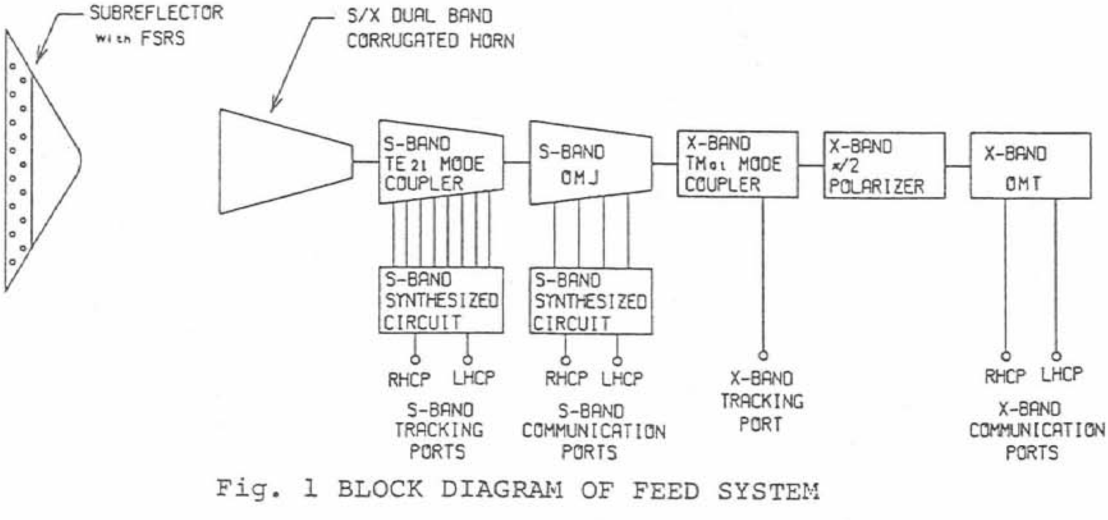

Fig. 1 BLOCK DIAGRAM OF FEED SYSTEM

Fig.2 ANTENNA UNDER TEST
AT INPLANT

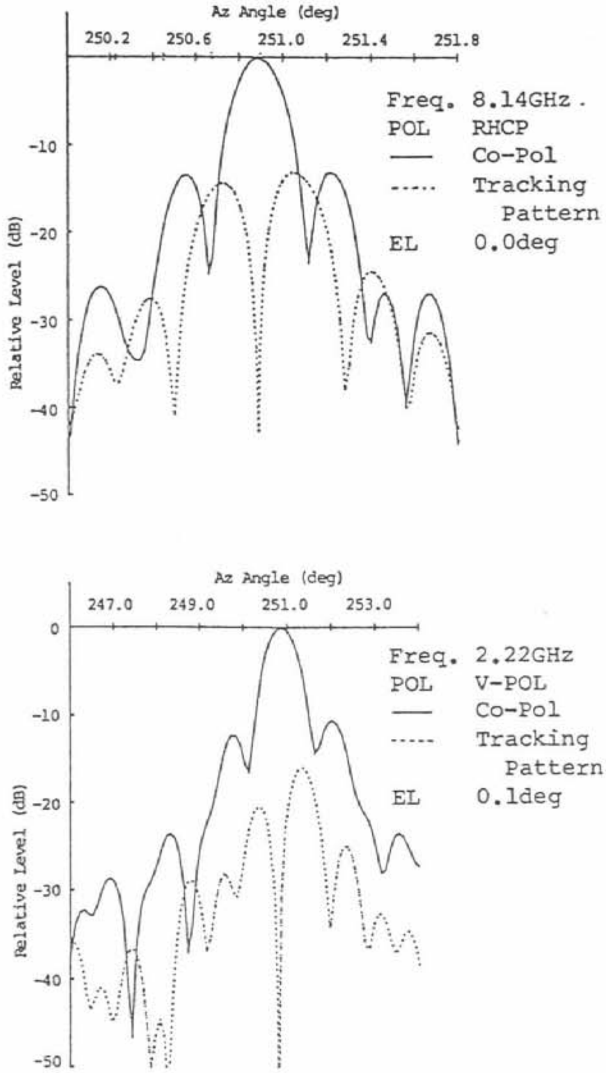

Fig.3 MEASURED ANTENNA PATTERN
WITH RADOME

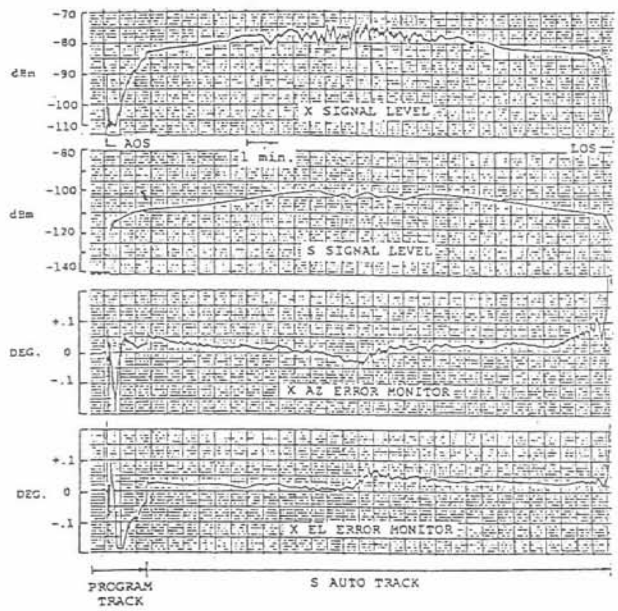

Fig.4 MEASURED AUTO TRACKING DATA

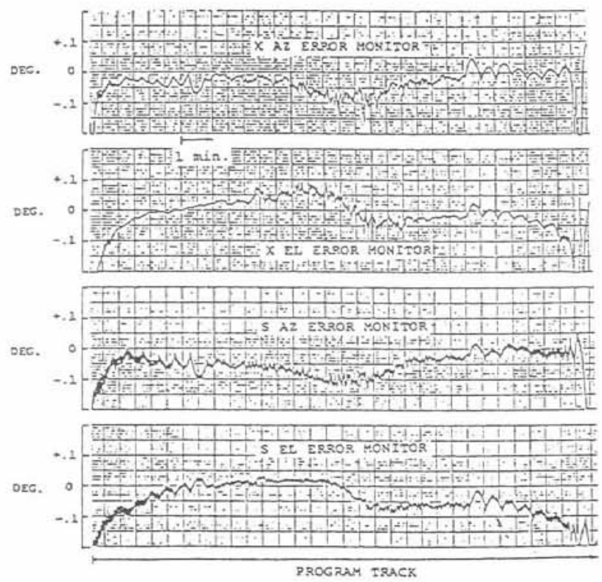

Fig.5 MEASURED PROGRAM TRACKING DATA