B—3—1 INTELSAT V 4 & 6 GHz EARTH COVERAGE ANTENNAS*

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1. Introduction

INTELSAT V is the latest in a series of commercial communications satellites designed for the INTELSAT organization. The first spacecraft is scheduled to be launched in late 1979.[1] On INTELSAT V, four frequency bands are employed 14 and 6 GHz bands are received by the spacecraft and 11 and 4 GHz bands are transmitted. In this paper, 4 and 6 GHz Earth Coverage (E. C.) Antennas are discussed, especially from the view point of low Axial Ratio (AR).
Both antennas will serve the entire earth disk as observed from the spacecraft, and 4 GHz transmitting antenna will have a ±2 degrees gimbal mechanism which will be used in the case of ±2 degree off-set of spacecraft.

2. Design Description

The 4 and 6 GHz E. C. Antennas are designed to meet all the requirements defined by INTELSAT V Program. The electrical requirements are summarized in Table 1. The main feature is to get low AR. Trade off study was done by considering band width, coverage area, dimension and weight. And finally, the flar-iris type dual mode horn antenna was selected because of low AR and simple structure.[2] This antenna consists of five basic components respectively:

(a) Conical horn
(b) TM11 Mode Converter (flare iris type)
(c) Polarizer (combination type of post and squeezed waveguide)

(d) Reflection absorber (Ortho Mode Transducer - OMT -)
(e) Transition (rectangular to circular waveguide)
The conical horn is made of multiple layers of high modulus Carbon Fiber Reinforced Plastics (CFRP) because of light weight and small thermal expansion coefficient. The inner surface of CFRP Horn is metalized in order to reduce AR and losses. The aperture cover and thermal blanket are used in order to protect the antenna from space environment.
The mode converter is made of Titanium (Ti) in order to reduce the thermal stress of the flange of CFRP horn because the thermal expansion coefficient of Ti is about one half of that of Aluminum (Al), so if Al is used for mode converter thermal stress of CFRP horn becomes large. The polarizer is also made of Ti in order to reduce the temperature dependence of AR.
The OMT and the transition are made of Al because of light weight and easy fabrication.

3. Test Results

The qualification test of the 4 and 6 GHz E. C. Antennas have been successfully finished and it was verified that the performance met all the requirements. The electrical performances of the antennas are summarized in Table 1. A part of measured curves of AR are shown in Figure 1. The measured values of AR shown in Table 1 include the contributions of dual mode horn, polarizer, range reflection and other measurement error.
In order to analyze the above contributions, the each antenna was measured by using four-orientation measurement method.[2] The results are shown in Table 2. It was confirmed that the contribution of each item in Table 2 had the good consistency with design value.
The photograph of the qualification models of 4 and 6 GHz E. C. Antennas is shown in Figure 2. The dimensions before attaching the aperture cover are 315 dia x 1055 mm for 4 GHz and 193 dia x 700 mm for 6 GHz, and the total weights of each antenna are 2.1 kg and 1.0 kg, respectively.

References

(1) R.J. Rusch and D.G. Dwyre "INTELSAT V SPACECRAFT DESIGN" 27th International Astronautical Congress, ANAHEIM, CALIFORNIA, U.S.A. Oct 10-17, 1976.

(2) T. Katagi, et al, "A Circularly Polarized Dual-Mode Horn Antenna for Communications Satellite" 1977 IEEE/AP-S International Symposium. AP-S Session II, 0940, June 21.

Note *
This paper is based upon work performed under the sponsorship of the International Telecommunications Satellite Organization (INTELSAT). Any views expressed are not necessarily those of INTELSAT.

Table 1. Summary of Performance

Item	Requirement		Measured Value	
	4 GHz	6 GHz	4 GHz	6 GHz
Frequency Band (MHz)	3955-4200	6180-6425	3955-4200	6180-6425
Polarization	RHCP	LHCP	RHCP	LHCP
Coverage Area (circular)	18°	22°	18°	22°
Swept Frequency Axial Ratio	≤ 0.4dB	≤ 0.4dB	≤ 0.34dB	≤ 0.32dB
Swept Frequency Gain	≥ 16.5dB	≥ 14.8dB	≥ 17.0dB	≥ 15.6dB
Swept Frequency VSWR	≤ 1.15	≤ 1.15	≤ 1.11	≤ 1.03
Gain Variation over a chord 0.4° wide	≤ 1.2dB	≤ 1.2dB	≤ 0.4dB	≤ 0.4dB

Table 2. Breakdown of Axial Ratio

Contribution of	AR (Worst Value)	
	4GHz Antenna	6GHz Antenna
Dual mode horn	0.143 dB	0.166 dB
Degradation due to dimensional unsymetry of horn	0.045	0.061
Polarizer	0.071	0.040
Range Reflection	0.091	0.038
Other error (RMS)	0.019	0.017

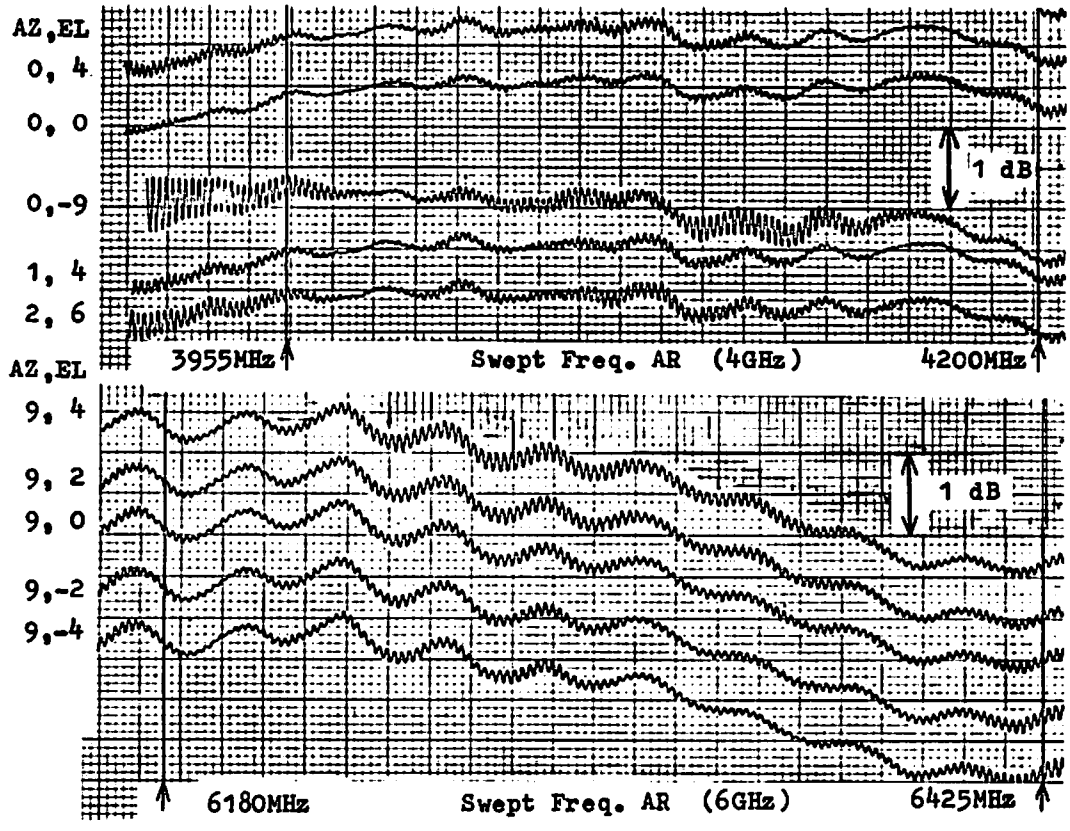

Figure 1. Swept Frequency AR data.

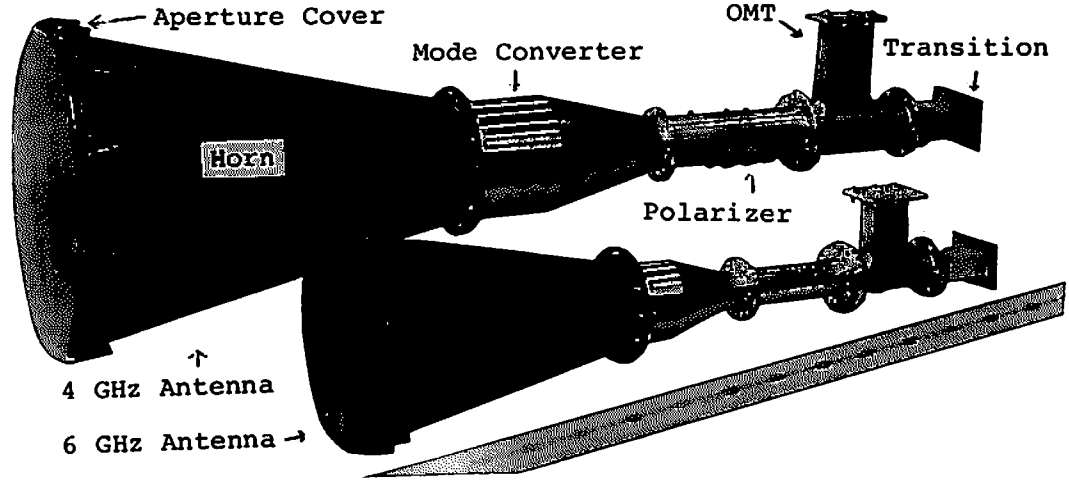

Figure 2. 4 and 6 GHz Earth Coverage Antennas.