MICROSTRIP SEQUENTIAL ARRAY ANTENNA FOR S-BAND INTER-SATELLITE DATA RELAY USING ETS-VI

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1. Introduction

Inter-satellite data relay will be employed on Japanese Engineering Test Satellite-VI (ETS-VI) to be launched in 1992. The S-band Inter-satellite Communication (SIC) antenna is under development for the purpose. The antenna is a multibeam phased array antenna with one transmit beam and two receive beams formed by an on-board Beam Forming Network (BFN). The antenna has 19 subarrays each of which is composed of 7 radiating elements as shown in Figure 1, and the phase of each subarray is controlled by a phase shifter in the BFN. Since the antenna is required to have good circular polarization and low VSWR over the wide frequency band, each subarray adopts a sequential array arrangement[1].

This paper describes the experimental results of the subarray intended for use of the ETS-VI.

2. Wideband Circular Polarization by Sequential Array

In case of an N-element planar array antenna shown in Figure 2, the n-th element is located at an arbitrary position but with orientation angle of

$$\Phi n = p(n-1)\pi/N \quad \text{(rad.)} \tag{1}$$

where p is an integer and $1 \leqq p \leqq N-1$, with respect to the first element #1, and is fed with a differencial phase shift of Φn. Assuming that the electric field radiated by #1 element in the boresight direction is elliptical and expressed as

$$\vec{E}_1 = a\vec{U}_1 + jb\vec{V}_1 \tag{2}$$

where $\vec{U}_1$ and $\vec{V}_1$ are orthogonal unit vectors, and a, b are the amplitude of the components. Then the boresight field $\vec{En}$ radiated by the n-th element becomes

$$\vec{En} = [(a\cos\Phi n - jb\sin\Phi n)\vec{U}_1 + (a\sin\Phi n + jb\cos\Phi n)\vec{V}_1]\exp(j\Phi n) \tag{3}$$

Therefore, the total boresight field E radiated by the array is expressed as

$$\vec{E} = \sum_{n=1}^{N} \vec{E_n} = (a+b)N(\vec{U_1} + j\vec{V_1})/2 \qquad (4)$$

For VSWR characteristic of the sequential array, it is understood that, assuming the input power is divided equally and the reflection coefficient of the elements are the same, sequential array configuration provides no reflection in the boresight direction at the input terminal because the reflected waves from the n-th element have a differential phase shift $2\Phi n$[1].

3. Experimental Result of Subarray

The experimental model is a 7-element subarray with a diameter of approx. 330 mm. It is composed of circular patch radiators on the substrate of 10 mm thick NOMEX honeycomb as shown in Figure 3. Each circular patch is fed with two feed points through the feed network printed on the back of the substrate, and is provided sequential rotation to improve the axial ratio and VSWR. Each patch has two small notches to compensate the cross polarization components generated by the asymmetrical feeding [2].

Figure 4 shows the measured result of VSWR. VSWR is less than 1.3 over the frequency range of 2.1 GHz to 2.3 GHz. Figure 5 gives the frequency characteristic of axial ratio. It shows that less than 0.7 dB in the boresight and less than 1.5 dB anywhere within 10 degree circle over the same frequency range is achieved. Spin linear radiation pattern and the gain of the subarray are shown in Figures 6 and 7, respectively. All the data support the effectiveness of the sequential arrangement of the subarray.

4. Conclusion

Experimental results of the microstrip sequential array for SIC antenna is reported. The effectiveness of the sequential array arrangement for better axial ratio and VSWR is verified. The SIC antenna will be launched on Japanese ETS-VI in 1992.

References

[1] T. Teshirogi, et. al., "Wideband Circularly polarized Array Antenna With Sequential Rotation and Phase Shift of Elements", Proc. of ISAP'85, No. 024-3, pp. 117-120.

[2] T. Teshirogi, et. al., "Development of 19-Multibeam Array Antenna for Data Relay Satellite", Proc. of ISAP'85, No. 112-4, pp. 381-384.

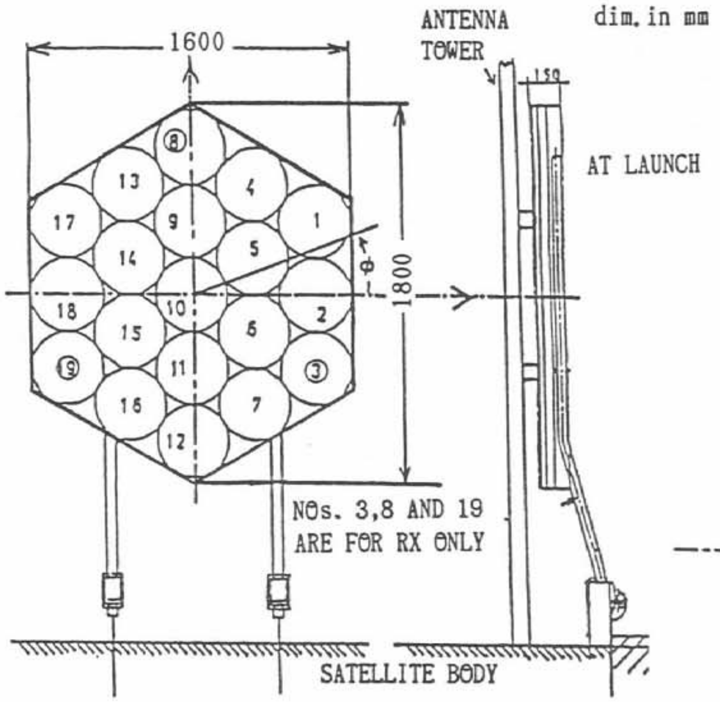
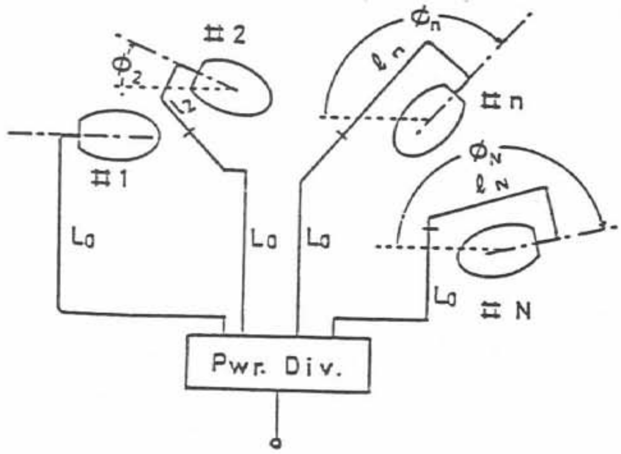


FIG. 1 SIC ANTENNA



$$L_n = L_0 + \ell_n$$
$$k_0 \ell_n = \phi_n = (n-1)\, p\, \pi / N$$
$$k_0 = 2\pi f_0 \sqrt{\varepsilon \mu}$$

FIG. 2 SEQUENTIAL ARRAY

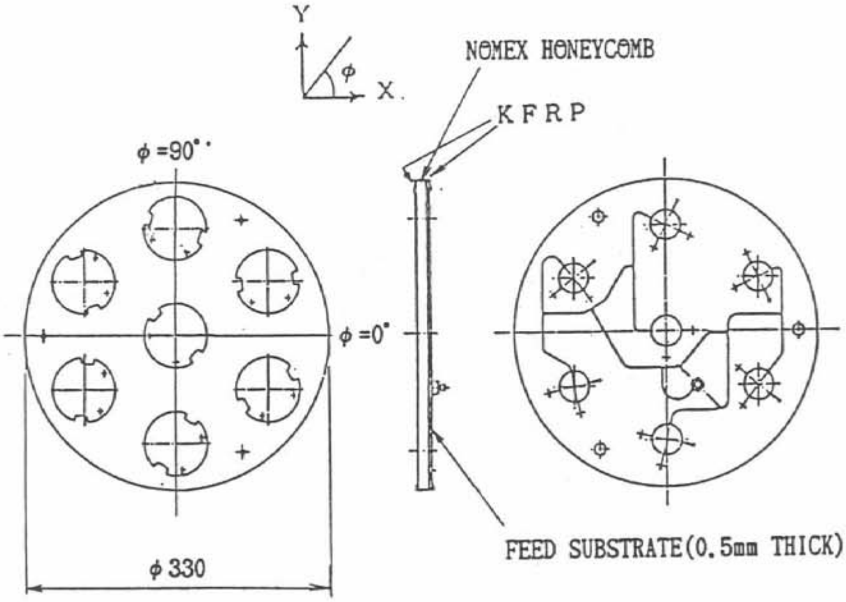


FIG. 3 CONFIGURATION OF A SUBARRAY

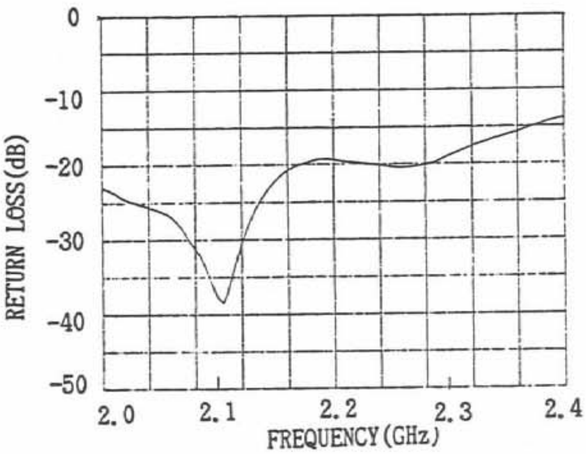


FIG.4 RETURN LOSS

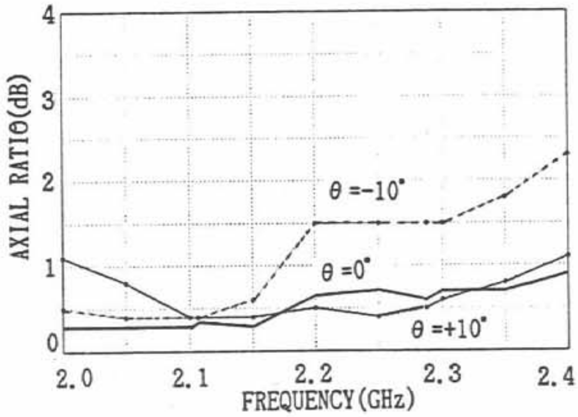
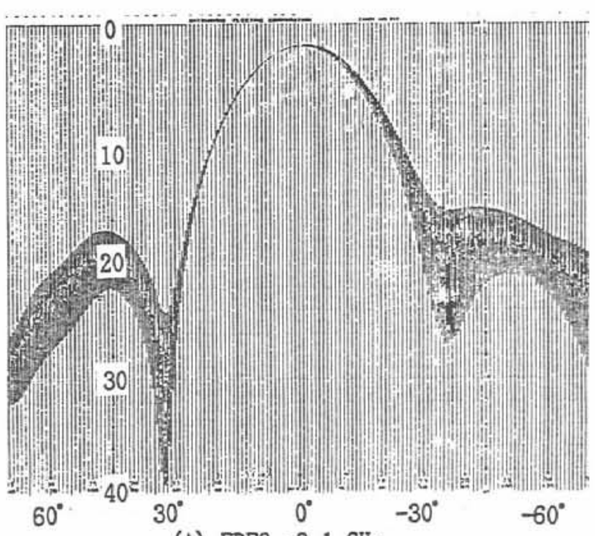
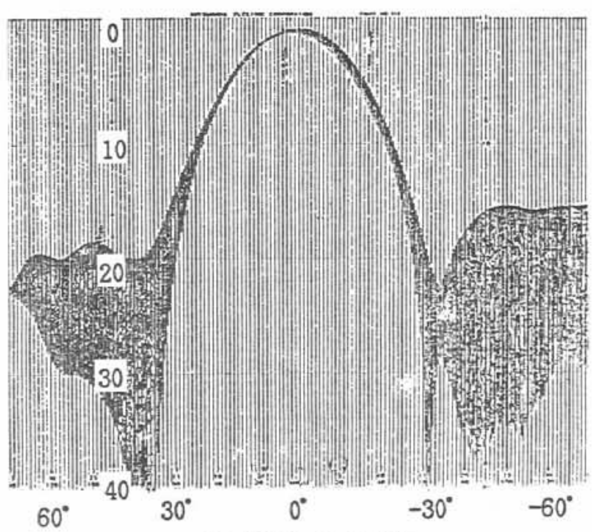


FIG.5 AXIAL RATIO



(A) FREQ.=2.1 GHz



(B) FREQ.=2.3 GHz

FIG.6 RADIATION PATTERN (ϕ=0° PLANE)

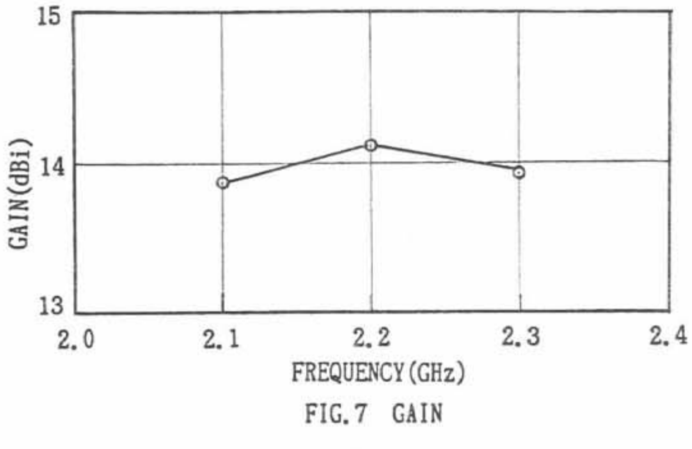


FIG.7 GAIN