RESEARCH AND DEVELOPMENT OF A SYNTHETIC APERTURE RADER ANTENNA

Akira AKAISHI*, Nobuyoshi IMURA*, Hitoshi MISUTAMARI*
Yoshiteru OGATA*, Yasumasa HISADA**, and Yasuyuki ITOH**

* Mitubishi Electric Corporation, Kamakura Works,
325 Kamimachiya, Kamakura-shi, Kanagawa, Japan

** National Space Development Agency of Japan, Tsukuba Space Center,
2-1-1 Sengen, Sakura-mura, Niihari-gun, Ibaragi, Japan

1. Introduction

A synthetic Aperture Rader (SAR), one of the promising microwave sensors for earth observation, is being researched and developed by National Space Development Agency of Japan (NASDA) for ERS-1 (Japanese Earth Resources Satellite-1). The design goals during the research and development phase are resolution of 25m x 25m, 75Km swath from orbit of about 570Km, frequency of 1275MHz and off-nadir angle of 33 degrees.

This paper presents the configuration of SAR antenna and the test results of R&D model. During testing, critical electrical and mechanical performance tests were performed successfully.

2. Design Description

Aperture dimension of 2.06m x 11.92m is required to satisfy the system requirements. By reason of fairing restrictions of the launch vehicle, the antenna must be a deployable antenna which is divided into eight equal 1.39m x 2.06m panels consisted of 128-element microstrip array. Fig.1 shows the SAR antenna and Table 1 and Table 2 show the principal requirements.

The center arm to the satellite sidewall. The antenna panel consists of a sandwich structure with a radiation panel and a support panel. The radiation panel is a 128-element microstrip array antenna, and consis of a 6mm thickness honeycomb sandwitch structure with KEVLAR outer skin, CFRP inner skin and NOMEX honeycomb core. The support panel thickness is 15mm. One side of the CFRP F/W skin is used not only for the outer skin of the support panel but also for the ground plane for the microstrip antenna.

In order to minimize storage volume, all the feed components are embedded in the support panel. An RF flexible joint is used for electrical connections between the panels. A microstrip line, a low loss coaxial cable and a boxed strip line are used to the corporate feed network. Fig.2 shows the electrical configuration of the antenna.

3. Test Results

As developed components and models, a 128-element panel, feed components, a deployment model and a thermal distortion model were manufactured.

The 128-element panel, shown in Fig.3, is to confirm the electrical performance of one antenna panel because the eight antenna panels are electrically the same design. Table 3 shows the test results of the panel. The newly developed feed components are the boxed strip line made of CFRP and the RF flexible joint shown in Fig.4. The design aims of them are to realize low loss and light weight feed components. Table 4 shows the test results of the feed components.

SAR mission success depend on the safe deployment of the antenna.

Therefore the deployment test was performed. Its object is to demonstrate the functioning of the delopment system and to confirm that the SAR antenna can withstand the mechanical loads. Fig. 5 shows the deployment model and Table 5 shows the test results of deployment.

The thermal distortion of the panel is also the important issue, because it causes the electrical performance degradation. So that, the thermal distortion model which is the same configuration as a flight model, was manufactured and thermal test was performed.

The deformation of the panel was 1.8 mm rms which include the manufacturing and thermal (at -50°C) deformation.

4. Conclusion

The R&D model of SAR antenna is being researched and developed through. From the results of the feasibility study and tests by FY1984, it is concluded that the SAR antenna design can be applied on the SAR for ERS-1 and its tests has been successfully carried out.

5. References

(1) Y. Hisada, Y. Itoh, A. Akaishi and N. Imura, "The Results of Partial Eperimental Manufacturing of Synthetic Aperture Radar Antenna", Paper of TG on Antenna and Propagation, Jun. 1982, Vol. A·P83-39, PP73-79.

(2) N. Imura, A. Akaishi, Y. Hisada and Y. Itho, "A R&D Model of Synthetic Aperture Radar Antenna", Proceeding of IGARSS'84 Symposium, Strasbourg, 27-30 Aug. 1984, PP573-578.

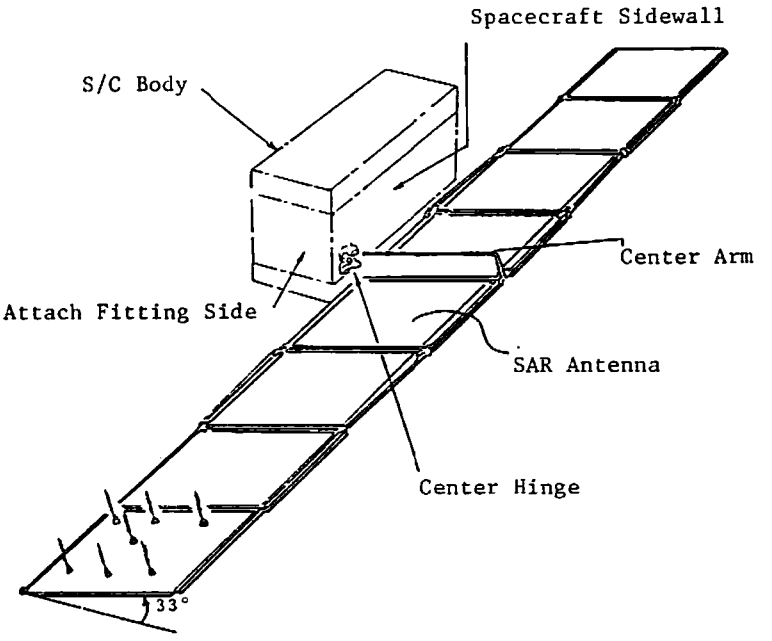


Fig. 1 SAR Antenna

Table 1 Electrical Requirements

Items	Design Goals	Remarks
1. Frequency	1275MHz	
2. Band Width	$\geq$ 12MHz	
3. Polarization	H-H	Linear
4. Gain	$\geq$ 33.5dBi	
5. Beam Width		
E-plane	$\leq$ 1.05deg	Azimuth
H-plane	$\leq$ 6.4 deg	Range
6. Side loabe		
E-plane	$\leq$ -11.5dB	Azimuth
H-plane	$\leq$ -16.1dB	Range
7. VSWR	$\leq$ 1.5	
8. Power Handling	$\geq$ 1.5KW	Peak
9. Off-nadir	33deg	
10. Aperture Dimensions	11.92mm x 2.06m	Electrical

Table 2 Mechanical Requirements

Items	Design Goals	Remarks
1. Dimensions	$\sim 3m^{L}$, $\sim 0.3m^{H}$	Stowed
2. Weight	$\leq$ 135Kg	
3. Fundamencal	$\geq$ 35Hz	Stowed
Resonant Frequency	$\geq$ 0.2Hz	Deloyed
4. Flatness	$\leq$ 3mm rms	Each panel
	$\leq$ 25mm	Antenna plane
5. Acceleration		
Lift-off	7.2G (thrust)	
	6G (lateral)	
MECO/POGO	22G (thrust)	
	3G (lateral)	
6. Sinusoidal	10G (5~35Hz)	Thrust
	1.5G (35~100Hz)	
	6G (5~30Hz)	Lateral
	1G (30~100Hz)	
7. Random Vibration	19.6Grms	120sec/axis
8. Acoustics	145dB overall	120sec

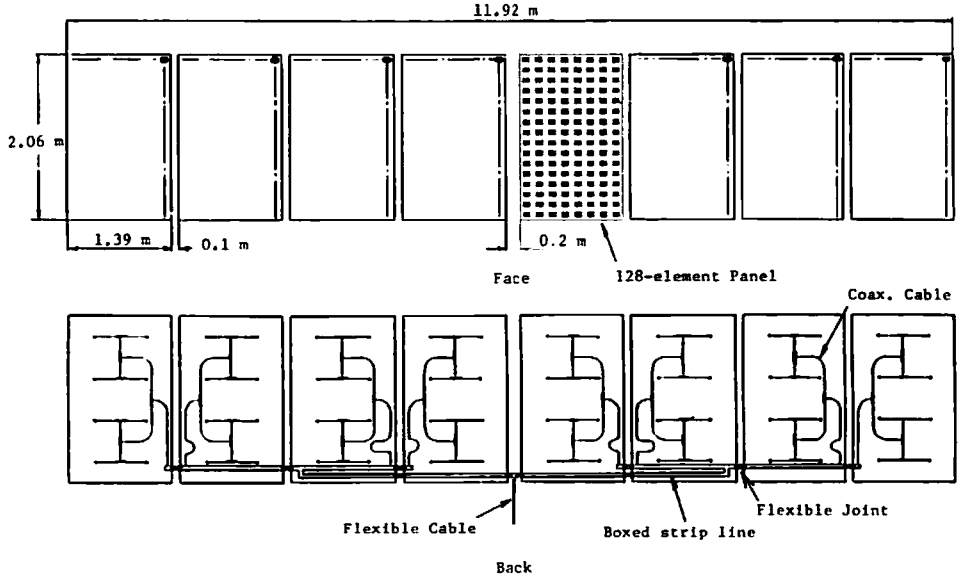


Fig. 2 Electrical Configuration

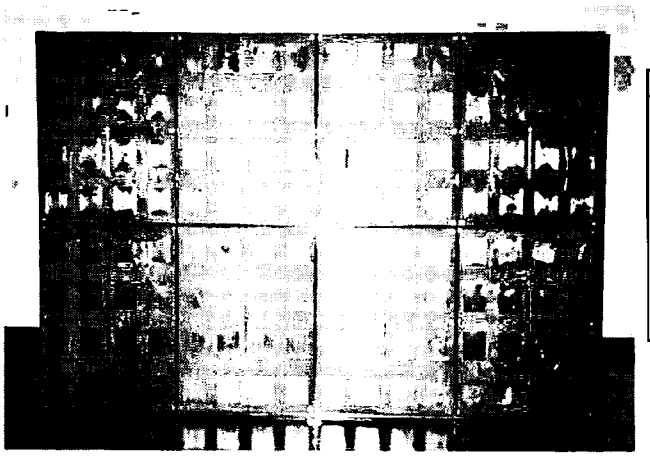


Fig. 3 128-Element Panel

Table 3 Test Basults of 128 Element Panel

Items	Reqvurenebts	Test Results
1. Beam Width		
E-plane	≤ 8.8°	8.7°
H-plane	≤ 6.4°	6.3°
2. Side Lobe		
E-plane	≤ -11.5dB	-12.7dB
E-plane	≤ -16.0dB	-17.9dB
3. Cross Pol.	≤ -20 dB	-26.1dB
4. VSWR	≤ 1.4	1.27
5. Gain	≥ 25.5dBi	26.0dBi

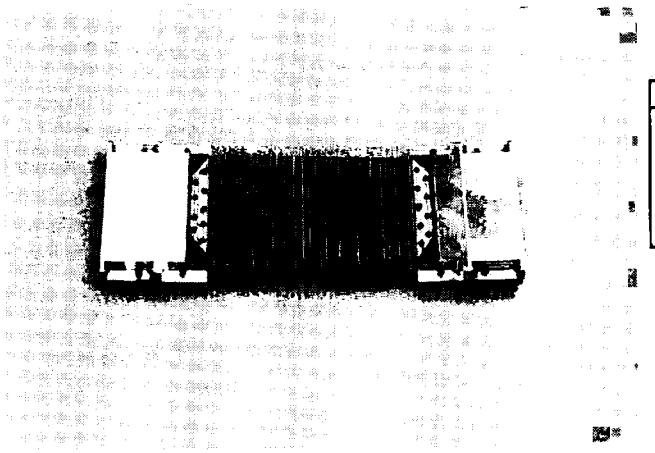
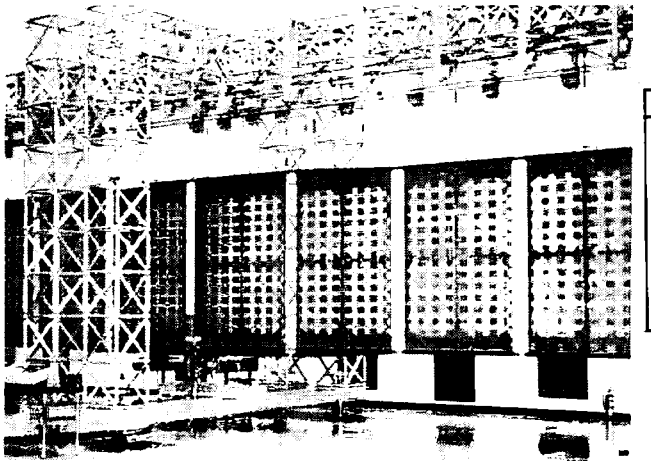


Fig. 4 Flexible Joint

Table 4 Test Results of Feed Components

Items	boxed strip Line	Flexible Joint
1. VSWR	≤ 1.25	≤ 1.05
2. Loss	0.16dB	0.03dB
3. Dimensions	$65.6^{W}x1322^{L}$	$65.6^{W}x180^{L}$
	$x12.5^{H}$mm	$x12.5^{H}$mm
4. Weight	449.3g	82g



Fog. 5 Deployment Model

Table 5 Test Results of Deployment

Items	Analysis	Measured
1. Deployment Time	19.0 sec	19.5~23.0sec
2. Final Velocity of Angle	31.7deg/sec	26~35deg/sec
3. Surface Accuracy	-	≤ 7mm
4. Lacch-up Repeatability of Hinge	-	≤ 0.03deg