

NFAM RESULTS OF SAR ANTENNA
ENGINEERING MODEL FOR ERS-1

Hideo HINO* , Yoshiaki NEMOTO* , Ryoichi KURAMASU**
Hitoshi MIZUTAMARI*** , Yoshiyuki CHATANI*** , Takashi KATAGI***

* Technology Reserch Association of Resources Remote Sensing System(RRSS),
Minato-ku, Tokyo, Japan

** National Space Development Agency of Japan, Minato-ku, Tokyo, Japan
(He was with RRSS until September 1988)

*** Mitsubishi Electric Corporation, Kamakura Works, Kamakura, Japan

1. Introduction

The synthetic aperture rader (SAR) antenna for ERS-1(Japan Earth Resources Satellite-1) is a large deployable antenna with aperture dimension 12m×2m. To evaluate far-field performance of such kind of antenna, planar near field antenna measurement(NFAM) technique is very effective because it is not necessary to move or rotate the antenna.

This paper shows NFAM results of SAR antenna engineering model. Especially, the theory and procedure of direct gain measurement method is highlighted.

2. SAR Antenna Configuration

SAR antenna engineering model is shown in Fig.1. The antenna aperture dimension is 12m ×2m. The antenna consists of eight antenna panels, to be deployable. Each panel is a 128-element microstrip array antenna composed of honeycomb sandwich structure. [1]

3. Direct Gain Measurement

By the theory proposed by Kerns [2], the transmission equations for the case where an antenna under test(AUT) is transmitting and a probe is receiving as illustrated in Fig.2 is

$$b'_o(P) = F' a_o \int t_{1o}(K) \cdot s'_{o2}(K) e^{j\gamma d} e^{jK \cdot P} dP \quad (1)$$

In this equation, $b'_o(P)$ represents the output of probe at position P, F' is the impedance mismatch factors, a_o is the input to AUT, $t_{1o}(K)$ is the plane wave transmitting coefficients of AUT, and $s'_{o2}(K)$ is the plane wave receiving coefficients of the probe.

Using the Fourier inverse transform, we obtain

$$t_{1o}(K) \cdot s'_{o2}(K) = \frac{e^{-j\gamma d}}{4\pi F' a_o} \int b'_o(P) e^{-jK \cdot P} dK \quad (2)$$

The gain of the AUT is given by using $t_{1o}(K)$ [3],

$$Ga(K) = \frac{4\pi y_o \gamma^2 |t_{1o}(K)|^2}{\eta_o (1 - |\Gamma_a|^2)} \quad (3)$$

Therefore if we obtain $t_{1o}(K)$ as absolute value, we also obtain the gain of the AUT. For the boresight ($K=0$) gain of AUT, equation (3) is described as

$$Ga(0) = \frac{4\pi y_o \gamma^2 |t_{1o}(0)|^2}{\eta_o (1 - |\Gamma_a|^2)} \quad (4)$$

And $s_{oz}(0)$ can be described by using probe gain G_p ,

$$|s_{oz}(0)| = \left| \frac{y_o (1 - |\Gamma_a|^2)}{4 \pi \eta_o k^2} G_p \right|^{1/2} \quad (5)$$

Substituting (2) and (5) to (3), we obtain,

$$G_a(0) = \frac{1}{(1 - |\Gamma_a|^2) |F'|^2 (1 - |\Gamma_p|^2) G_p} \left(\frac{4 \pi}{\lambda^2} \right)^2 \left| \int \frac{b'_o(P)}{a_o} dP \right|^2 \quad (6)$$

Input power a_o to the AUT is obtained from the received level d'_o measured by connecting the generator and the receiver ports directly as illustrated in Fig.3. In this case a_o is

$$a_o = \frac{(1 - |\Gamma_g|^2) (1 - |\Gamma_l|^2)}{|1 - \Gamma_g \Gamma_l|^2} d'_o \quad (7)$$

So we obtain the gain of AUT directly by measuring near field data $b'_o(P)$, probe gain G_p , reflection coefficients $\Gamma_a, \Gamma_p, \Gamma_g, \Gamma_l$, and directly connected level d'_o , without using standard gain horn antennas.

4. Test Results

The NFAM system in MELCO is shown in Fig.4. A large X-Y scanner with effective scanning area 13m \times 8m has been used. (as illustrated in Fig.5)

The far field radiation pattern in E-plane (AZ plane) is shown in Fig.6. In Fig.6, "measured" denotes the pattern transformed from measured near field data, and "calculated" denotes the calculated pattern using measured amplitude and phase of feeding networks embedded in the antenna panels. The far field radiation pattern in H-plane (EL plane) is shown in Fig.7. The measured pattern is in good agreement with the calculated pattern in the range $\pm 30^\circ$.

The antenna gain measured by the direct gain measurement technique is shown in Table 1 with other electrical performance. The measured gain also is in good agreement with the calculated values and satisfies the requirement of 33.5dBi in specified frequency band.

5. Conclusion

The far field performance of SAR antenna engineering model has been measured from planar near-field data, and all the results satisfy the requirements. Effectiveness of the direct gain measurement technique has also been verified.

※ The present study is a part of the national research and development project on observation system for Earth Resources Satellite-1, conducted under the program set up by the Agency of Industrial Science and Technology, Ministry of International Trade and Industry.

6. References

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- [2] D.M. Kerns, Plane-Wave Scattering-Matrix Theory of Antennas and Antenna-Antenna Interactions. Nat. Bur. Stand. Monograph 162, June 1981.
- [3] A.C. Newell, R.D. Ward and E.J. McFarlane, "Gain and Power Parameter Measurements Using Planar Near-Field Techniques", IEEE Trans. Antenna Propagat., pp792-803 June 1988.

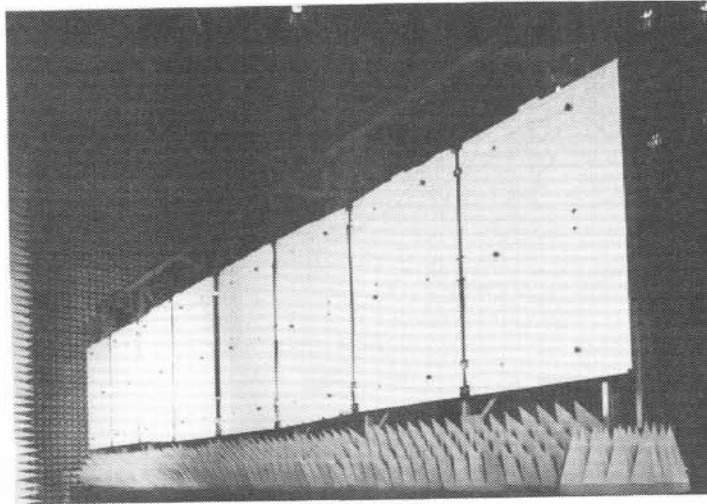


Fig.1 SAR antenna engineering model

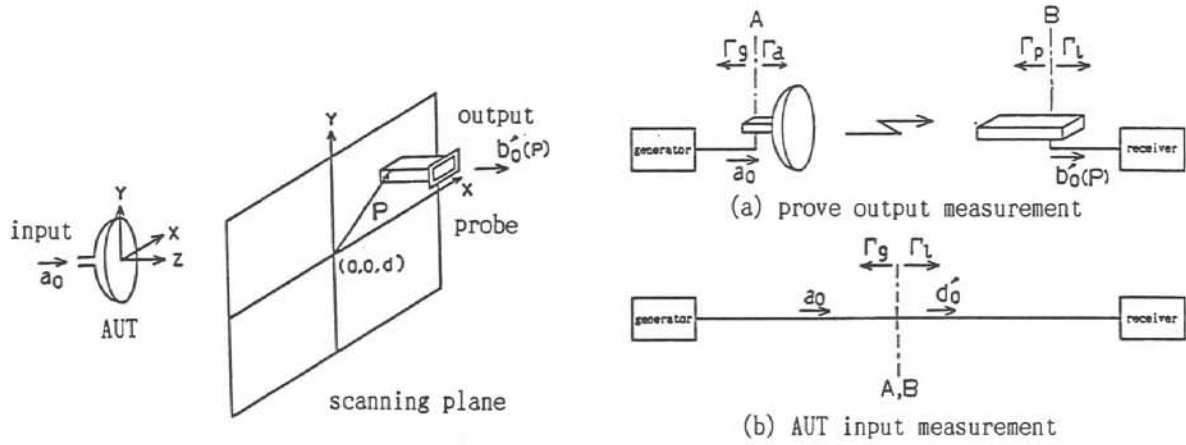


Fig.2 Coordinate system of planar NFAM Fig.3 Schematic of input and output measurement

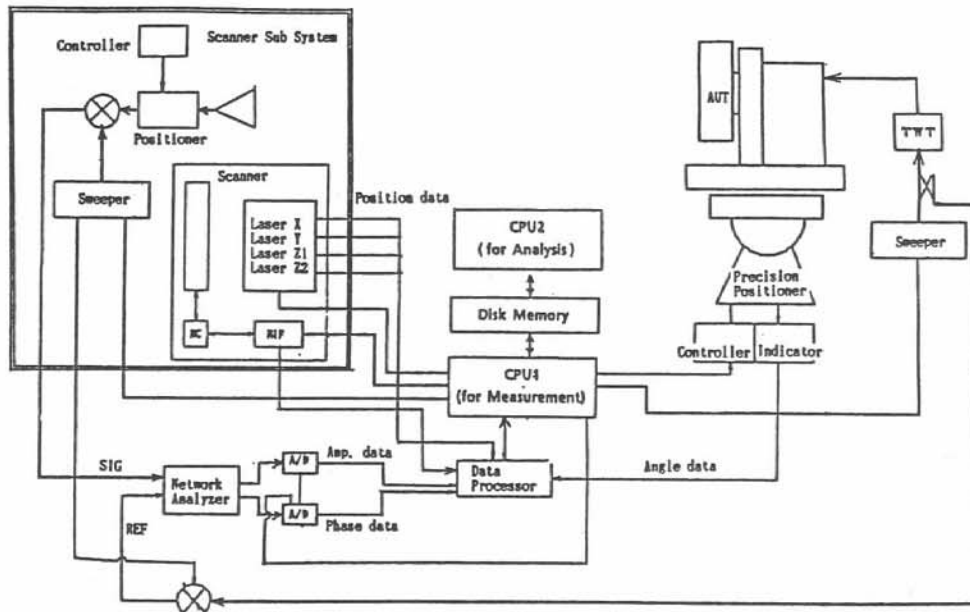


Fig.4 NFAM system

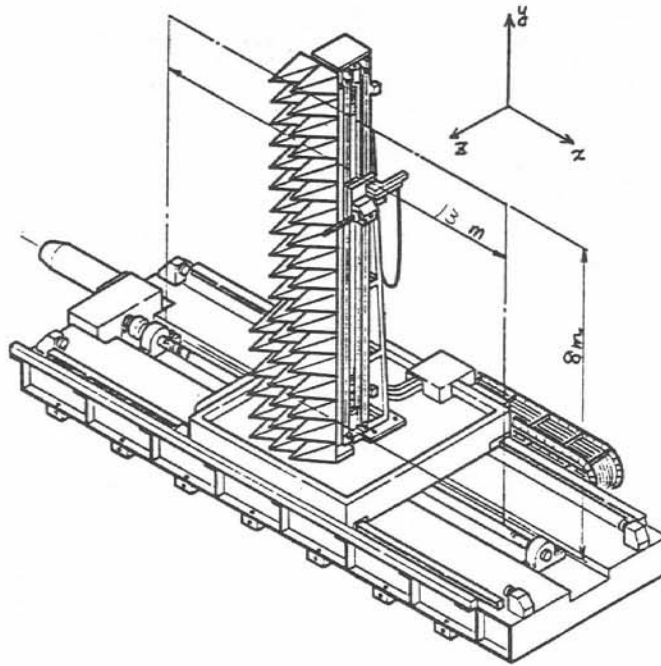


Fig.5 X-Y scanner

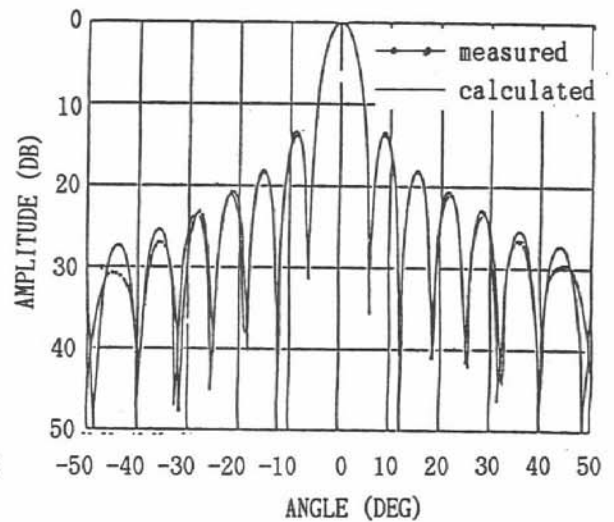
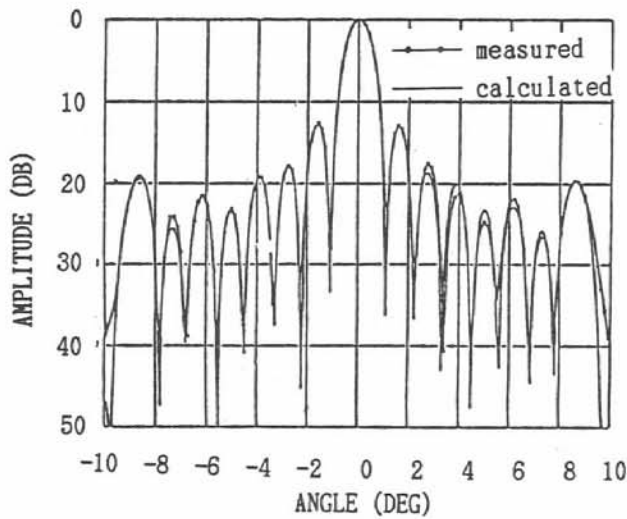


Fig.6 Far field pattern in E-plane (F=1275MHz) Fig.7 Far field pattern in H-plane (F=1275MHz)

Table 1 NFAM results of SAR antenna engineering model

ITEM	REQUIREMENT	1267.5MHz	1275.0MHz	1282.5MHz
VSWR	≤ 1.5	1.28	1.35	1.48
B.W	H-plane	$\leq 5.6^\circ$	5.48°	5.44°
	E-plane	$\leq 1.05^\circ$	0.99°	0.98°
Side-lobe level	H-plane	$\leq -11.5\text{dB}$	-13.64	-13.90
	E-plane	$\leq -11.5\text{dB}$	-12.35	-12.57
Gain	$\geq 33.5\text{dBi}$	34.05	33.98	34.05