A Prototype Array-fed Shaped Reflector Antenna for 21-GHz Band Broadcasting Satellite

Susumu Nakazawa, Masafumi Nagasaka, and Shoji Tanaka
Science & Technology Research Laboratories of NHK (Japan Broadcasting Corporation),
1-10-11 Kinuta, Setagaya-ku, Tokyo, 157-8510, Japan

***Abstract* - The 21-GHz band is expected to be used to transmit signals of the next-generation broadcasting services. Thus, we have developed a wide band transponder configured with an array-fed reflector antenna that enables to combine enough power for large capacity signal transmission. In addition, it can also alter its radiation pattern to mitigate fading. We proposed an array-fed shaped reflector antenna that is an assembly of a feed-array and dual shaped reflectors. Here we evaluate the radiation patterns of the prototype proposed antenna.**

***Index Terms* — 21-GHz band BSS, phased array antenna, beam forming network, fading mitigation technology.**

1. Introduction

Satellite broadcasting in the 21-GHz band is expected to be able to transmit multi-programs of 8K SHV and the other advanced services [1]. Achieving a high data rate, we assume the allocation of two 300-MHz-class wide-band channels in the 21.4–22.0 GHz band [2]. It is required to be approximately 2 kW for a channel of the total output power of the onboard high power amplifiers while receiving with a small user terminal antenna whose diameter is 45cm [3].

We have developed an array-fed imaging reflector antenna (array-fed IRA). It consists of a feed array and dual parabolic reflectors. Since the radiated pattern of the feed array is magnified with dual parabolic reflectors, it has a large aperture and reconfigurable radiation pattern with relatively small numbers of array elements compared with a direct array antenna. We introduced a prototype array-fed IRA configuration. It consisted of 32 feed horn antennas and a main-reflector whose diameter is 1.8m. We showed calculated radiation patterns of the array-fed IRA with measured radiation patterns of the feed array [4].

However, grating-lobes appeared in the radiation pattern of the array-fed IRA due to the sparse array of the magnified arrangement. To reduce the grating-lobes, we proposed an array-fed shaped reflector antenna (array-fed SRA) that is an assembly of a feed-array and dual shaped reflectors [6]. In this paper, we evaluate the radiation pattern of a prototype antenna.

2. Array-fed Dual Shaped Reflector Antenna

(1) Antenna Configuration

Configuration of the array-fed SRA is illustrated in Fig.1. The divided RF signal passes through the phase shifter, TWT amplifier, and filter. The output signals of the filter are connected to each feed horn. The main reflector is shaped to configure a radiation pattern to cover the main area of Japan with uniform power (JP-beam) when it is configured as a single offset reflector (SOR). Then, the sub reflector is shaped to approximate the radiation pattern of a feed-horn antenna for a SOR when the phases and amplitudes of the feed elements are equal.

(2) A Prototype Antenna

A prototype array-fed SRA is depicted in Fig.2. The main reflector, whose aperture diameter is 1.9m, was originally fabricated for a SOR antenna [5]. We designed the surface of the 0.25m sub reflector. The difference between the parabolic and designed shaped surface is depicted in Fig. 3. The red and blue represent the convex and concave, respectively. We assembled the feed array, the sub reflector, and the main reflector. When the phases and amplitudes of 31 feed elements were equal, the array-fed SRA configured a JP-beam.

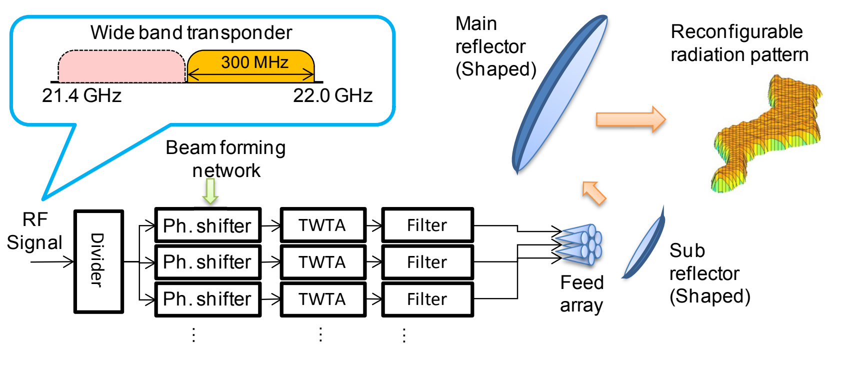


Fig.1. Block diagram for 21-GHz band BS

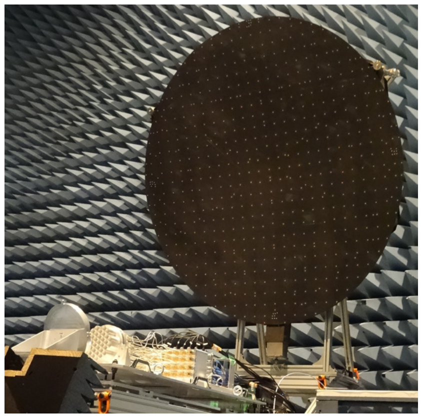


Fig.2. A prototype array-fed SRA

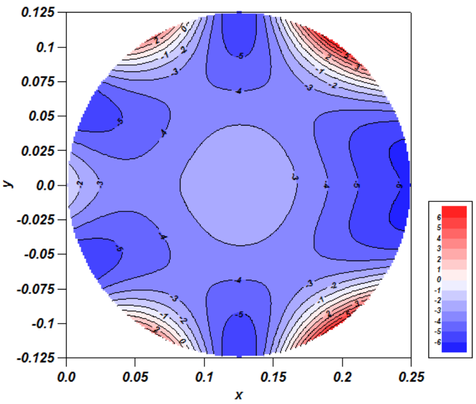
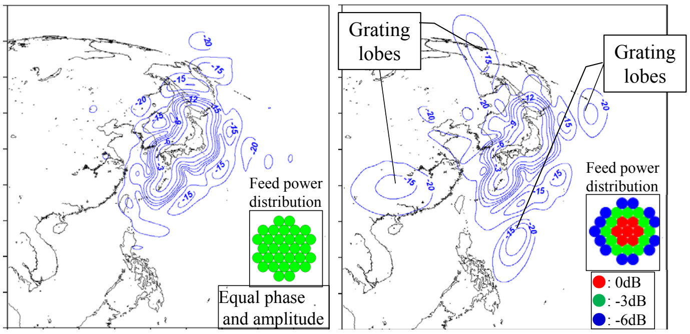


Fig.3. Designed surface of the sub-reflector

3. Radiation Pattern

(1) Calculated Radiation Pattern

Calculated radiation patterns of the array-fed SRA and IRA are depicted in Fig.4 (a) and (b), respectively. The feed power distribution of the array-fed SRA was uniform, while that of the array-fed IRA was tapered. The grating lobes in the radiation pattern of the array-fed SRA were reduced compared with those in that of the array-fed IRA. The antenna parameters of the array-fed SRA and IRA are described in Table 1.



(a) Array-fed SRA (b) Array-fed IRA

Fig.4. Radiation patterns of the array-fed SRA and IRA

Table 1 Antenna parameters of the array-fed SRA and IRA

	Array-fed SRA	Array-fed IRA
Diameter of main reflector (Type or surface)	1.9 m (shaped)	1.8 m (parabola)
Diameter of sub reflector (Type or surface)	0.25 m (shaped)	0.24 m (parabola)
Focal length (F/D)	1.767m (0.93)	1.8 m (1)
Offset angle	10 deg.	17.2 deg.
Num. of elements	31	32
Spacing of array elements	24.9 mm (1.8 w.l.)	
Frequency	21.7 GHz	

(2) Measured Radiation Pattern

Measured radiation patterns of the prototype array-fed SRA are depicted in Fig.5. The measured and calculated contours are shown by the solid and dotted lines, respectively. The measured and calculated results were in good agreement. The excitation coefficients of each array element were controlled to be equal phase and amplitude by the prototype beam forming network (BFN). The control accuracy of the phase and amplitude were less than 7 deg. RMS and 1dB RMS, respectively [4].

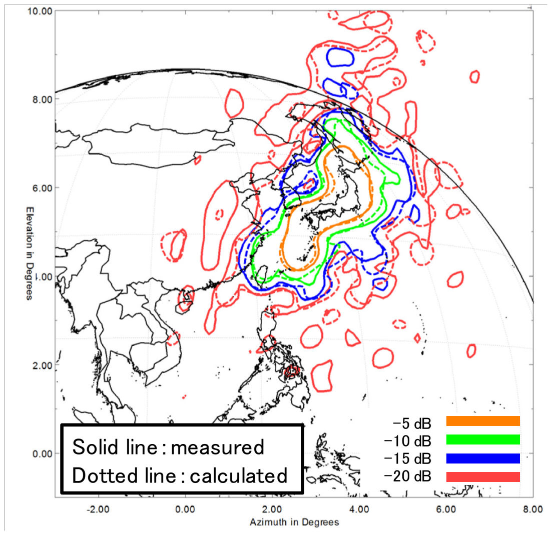


Fig. 5. Measured and calculated radiation pattern of the array-fed SRA

4. Conclusion

We proposed the array-fed shaped reflector antenna, which was an assembly of a feed array and dual shaped reflectors. The proposed antenna can reduce grating lobes due to the sparse array of the magnified arrangement. We fabricated a prototype and evaluated radiation patterns of the proposed antenna. The measured contour agrees well with the calculated one. The side lobes in the uniform radiation pattern covering Japan were reduced compared with those in that of the array-fed imaging reflector antenna.

Acknowledgments

This research and development is funded by the Ministry of Internal Affairs and Communications of Japan.

References

[1] Recommendation ITU-R BT.2020, “Parameter values for ultra-high definition television systems for production and international program exchange”, 2012.

[2] M. Kamei, M. Nagasaka, S. Nakazawa and S. Tanaka, “Engineering Model of a 300 MHz Class Wideband Transponder for the 21GHz-band Broadcasting Satellite”, Joint conference of 30th AIAA ICSSC & 18th Ka and Broadband Communications, Otawa, September 2012.

[3] S. Nakazawa, M. Nagasaka, M. Kamei, S. Tanaka and Y. Ito,” Configuration of Array-fed Imaging Reflector Antenna for 21-GHz Band Broadcasting Satellite”, Proc. of International Symposium on Phased Array Systems & Technology 2013, pp. 220–223, Boston, USA, Oct. 2013.

[4] S. Nakazawa, M. Nagasaka, M. Kamei and S. Tanaka, “Radiation Patterns of Imaging Reflector Antenna Calculated with Measured Patterns of Feed Array for 21-GHz Band Broadcasting Satellite,” Proc. of ISAP2015, Kaohsiung, Taiwan, Dec. 2015.

[5] S. Nakazawa, M. Nagasaka and S. Tanaka, “Engineering Model of a Shaped Reflector Antenna for 21-GHz Band Satellite Broadcasting,” Tech. report of ITE, Vol. 36, No. 30, BCT 2012-71, pp. 45–48.

[6] S. Nakazawa, M. Nagasaka and S. Tanaka, “Equalized Excitation Coefficient Distribution of Array-fed Shaped Reflector Antenna for 21-GHz Band Satellite Broadcasting,” Tech. report of ITE, Vol. 37, No. 6, BCT 2013-32, pp. 13–16.