PHASE RETRIEVAL MEASUREMENT ON A SINGLE SURFACE FOR PHASED ARRAY ANTENNAS

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1. Introduction:

The phase retrieval method[1],[2],[3] has been studied as sophisticated and efficient antenna performance measurement techniques without measuring the phase distribution. The future of this method is to estimate the phase distribution from the measured amplitude characteristics of near-field or far-field by using iteration algorithm.

This paper describes the consideration on the aperture field estimation method for phased array antennas in terms of phase retrieval method. There are many measurement techniques to obtain aperture distributions for phased array antennas such as near-field measurement, rotating element electric field vector (REV) method[4], and so on. The advantages of the proposed method are;

(1) No need to measure phase distributions (need only amplitude characteristics).
(2) Measure amplitude characteristics with two different aperture phase distributions.
(3) Measure the amplitude characteristics at the single surface of either near field or far field.

The validity of the proposed method is described in the following section.

2. Application to Phased Array Antennas:

We have studied to apply the phase retrieval method for phased array antennas. Prior to the calculation, it is necessary to measure the amplitude characteristics of the antenna with two different aperture phase distributions at the same measurement distance as shown in Figure 1. Then, the aperture field distribution (amp. and phase) can be estimated in terms of the iteration algorithm shown in Figure 2. The procedure of the proposed method including measurements and iteration calculations is;

(1) Measure the amplitude radiation pattern (a1) of the antenna under test (AUT) with the initial phase distribution (P1: unknown) of the AUT.
(2) Measure the amplitude radiation pattern (a2) of the AUT with the modified phase distribution (P2) of the AUT, where the delta phase (ΔP=P2-P1) should be known parameter.
(3) Assume the amplitude and phase distribution (A and P) at the aperture of the AUT.
(4) Transform the aperture distribution (A and P) to amplitude and phase distribution (a and p) at the measurement distance in terms of the field transformation.
(5) Replace the calculated amplitude (a) with the measured amplitude (a1) and transform the distribution (a1 and p) to aperture distribution (A' and P') in terms of the field transformation.
(6) Replace the calculated phase (P') with P'+ΔP and transform the aperture distribution (A' and P'+ΔP) to amplitude and phase distribution (a' and p') at the measured distance.

(7) Replace the calculated amplitude (a') with the measured amplitude (a2) and transform the distribution (a2 and p') to the aperture field (A" and P").
(8) Replace the calculated phase with P"-ΔP and transform the distribution (A" and P"-ΔP) to the field (a" and p") at the measured distance.
(9) Repeat the steps (4) through (7) until the amplitude and phase are converged.

3. Calculation Example:

To verify the validity of the proposed method, we have performed the following simulation as an example. We assumed a following system shown in Table 1.

Table 1 Simulation Model

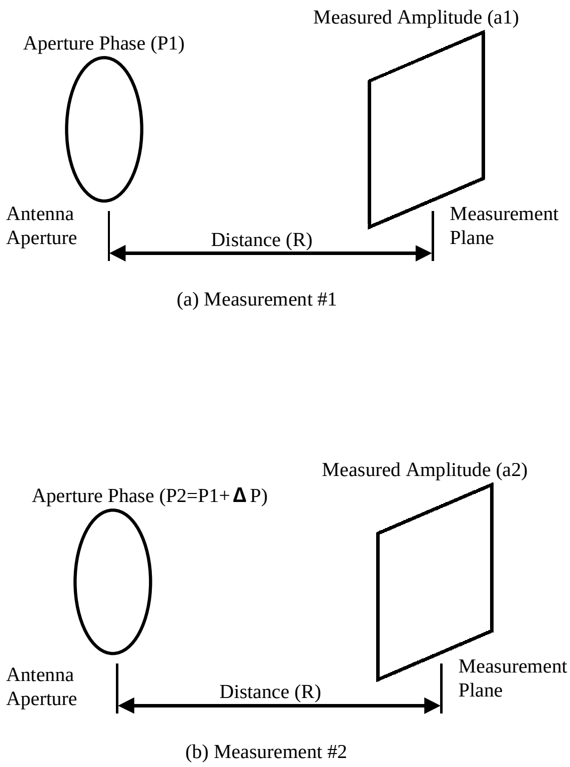
Frequency	15 GHz
Antenna Aperture Diameter	1000 mm
Element Spacing	20 mm
Number of Sampling Points	64 x 64
Amplitude Distribution at Aperture	Uniform
1^{st} Phase Distribution at Aperture	Uniform
2nd Phase Distribution at Aperture	180° Taper at the Edge

Figure 3 shows the assumed initial amplitude and phase of the phased array antenna, where A and P denote the assumed initial amplitude and phase, A1 and P1 denote unknown (to be estimated in terms of this iteration algorithm) amplitude and phase of the AUT, and P2 denotes the modified phase by the delta phase (known parameter), respectively. Figure 4 shows the transformed far-field amplitude and phase in terms of the field transformation, where a and p denote amplitude and phase transformed from the aperture field (A & P), ai and pi denote amplitude and phase transformed from the initial field (ai & pi), and i=1,2. In this simulation, we assume that the calculated amplitudes from the aperture distribution (A1, P1) and (A1, P2) are the measured fields (amplitude) a1 and a2. As shown in Figure 5, by repeating the field transformation with replacing the calculated data by the measured data, we can obtain the unknown aperture field of the phased array antenna. In this simulation, we obtained the converged result by approx. 60 times iteration.

As shown in the above simulation result, we can estimate the aperture field (amplitude and phase) of the phased array antenna correctly, and verified the validity of the proposed phase retrieval method.

4. Conclusion:

We proposed the aperture field estimation method for phased array antennas in terms of phase retrieval method. And we showed the validity of this method in terms of the software simulation.
To obtain the precise aperture field estimation, we need to investigate further the error analysis taking into account the mutual coupling effect of the array elements, S/N of the measurement system and so on.



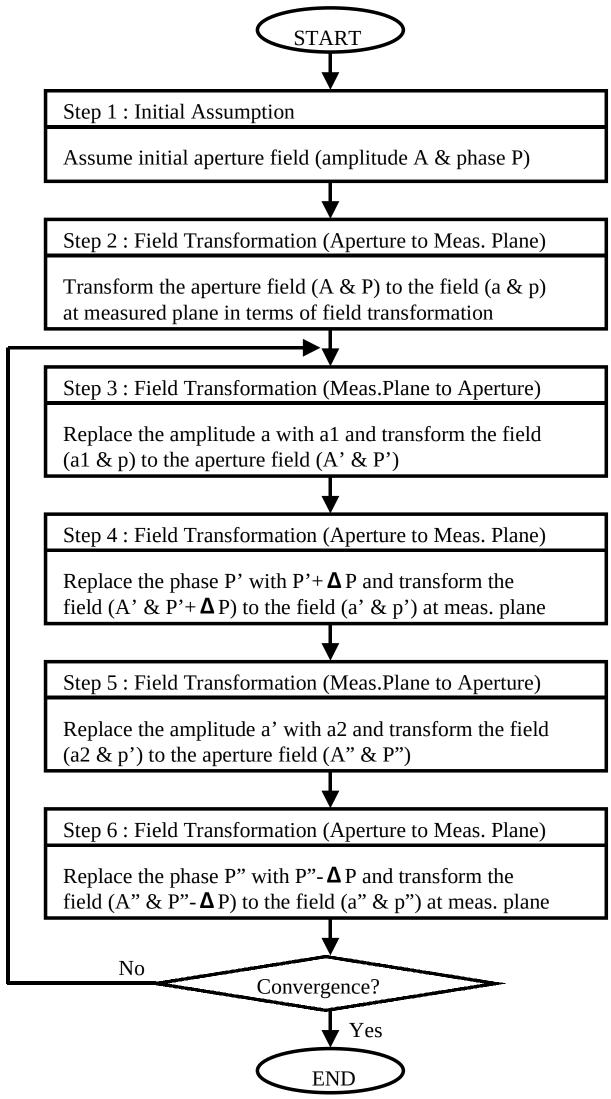


Figure 1 Measurement Conditions

Figure 2 Calculation Flow Chart

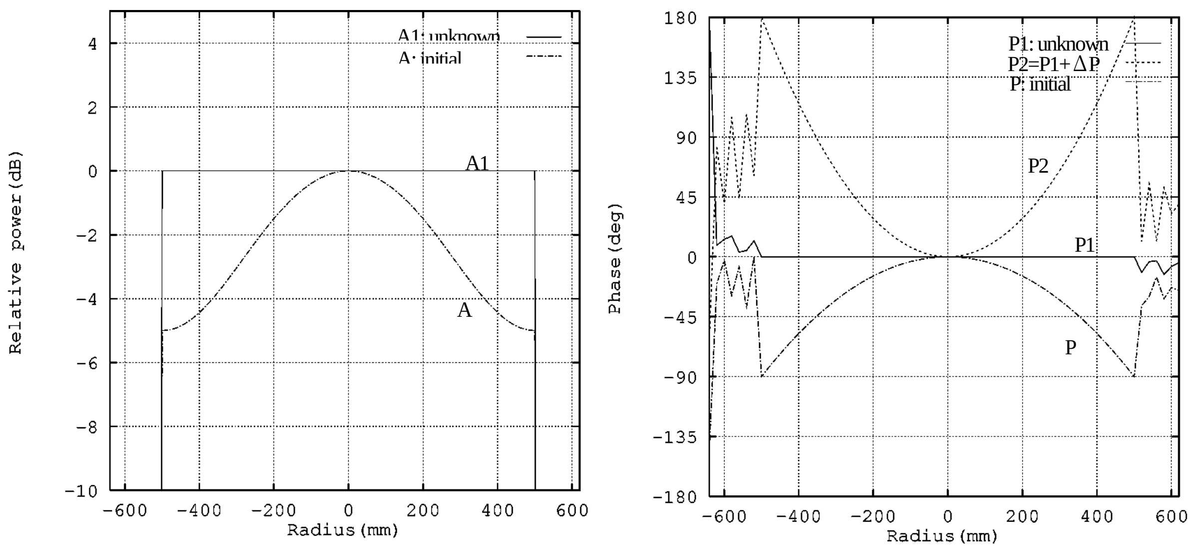


Figure 3 Assumed Initial Aperture Field (Amplitude and Phase)

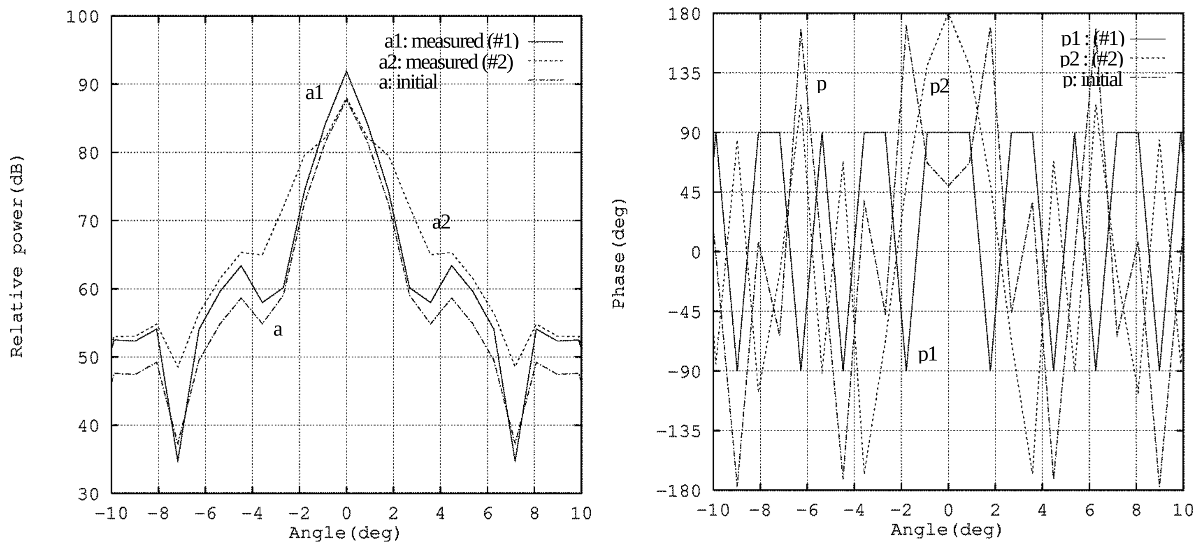


Figure 4　Transformed Far-Field Pattern (Amplitude and Phase)

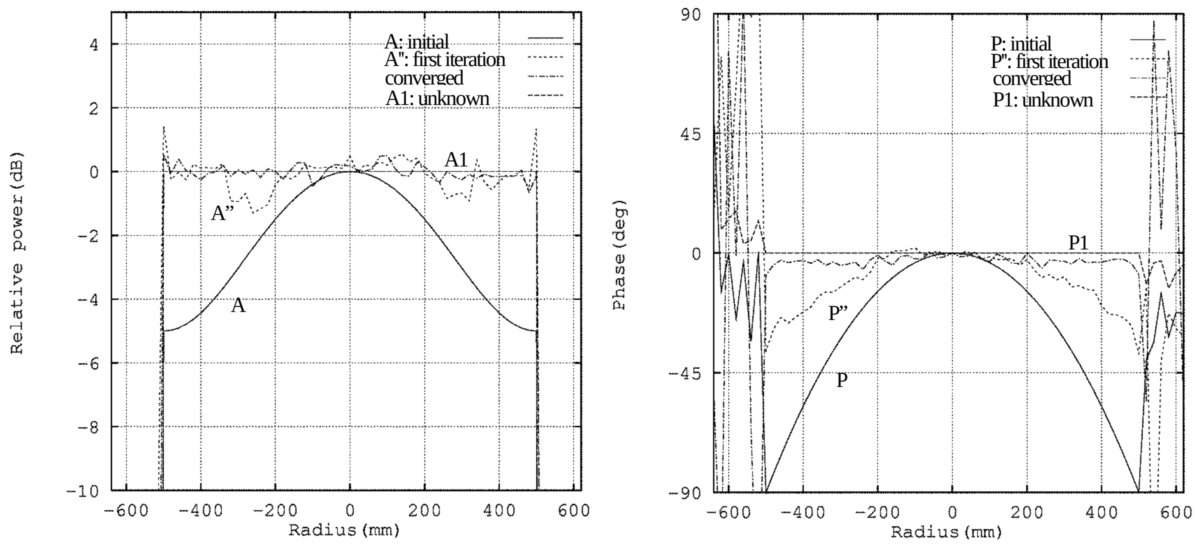


Figure 5　Estimation of Aperture Field (Amplitude and Phase)

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(4) S.Mano and T.Katagi, **"A Method for Measuring Amplitude and Phase of Each Radiating Element of A Phased Array Antenna", Trans.IECE Japan, J65-B, 5, pp555-560, 1982**