Probe-Positioning Error Estimation for Planar Near-Field Phaseless Measurements

Riho Suzuki and Hiroyuki Arai
Department of Physics, Electrical and Computer Engineering,
Graduate School of Engineering, Yokohama National University,
79-5, Tokiwadai, Hodogaya-ku, Yokohama, Kanagawa, 240-8501 Japan
suzuki-riho-hk@ynu.jp

Abstract – **In this paper, a probe-positioning error estimation of phase retrieval method in planar near-field measurements in millimeter frequency band is presented. Not only is the accuracy of the estimation but also the tolerance of probe-positioning error necessary in high frequency measurements because of its short wavelength. Using phase retrieval method, the accuracy of the estimation is shown in simulation with including the probe-positioning error.**

Index Terms — **near-field phaseless measurement, phase retrieval method, probe-positioning error.**

1. Introduction

In high frequency, the error of the near-field phase measurements of an electric field distribution becomes large because of its short wavelength. To avoid this problem, the phase retrieval (PR) methods are suggested [1] [2]. It requires decreasing the probe-positioning error on each measuring planes for precise measurement. The effects of the probe-positioning error have been discussed in [3] [4], however the detail estimation in antenna gain, side lobe level and main beam direction has not been discussed yet.

In this paper, we present a far-field estimation of a horn antenna by PR method with including probe-positioning error to find its accuracy in detail.

2. Model of Phase Retrieval Method

Fig. 1 shows the model of the phase-retrieval method proposed in this paper. W_{0x}, W_{0y}, W_x and W_y are the width of aperture and measurement planes, assuming that an aperture plane on $z = 0$ and two measuring plane on $z = d_1$, d_2 in near-field of an antenna under test (AUT). The electromagnetic fields on the aperture are estimated from the fields on planes 1 and 2, by the field transformation between the AUT aperture plane and measurement planes.

Fig. 2 shows the flowchart of the phase retrieval method applied in this paper. The number of iteration is denoted as superscript k and the maximum number is k_{max}. $\boldsymbol{M}_0$, $\boldsymbol{E}_1$ and $\boldsymbol{E}_2$ are magnetic field assumed on the AUT aperture and the electric fields on planes 1 and 2, respectively. The estimated and measured fields are expressed as subscript "est" and "mea". $\Delta\boldsymbol{E} = \iint(|\boldsymbol{E}_{2,\mathrm{mea}}| - |\boldsymbol{E}_{2,\mathrm{est}}|)\, dx_2 dy_2$ is the factor to judge the convergence of this method and $\Delta\boldsymbol{E}_{\min}$ is the minimum criterion of $\Delta\boldsymbol{E}$. This method needs the information of AUT aperture and measurement plane size, the position of two planes, and the amplitude distributions on both measurement planes. In each iteration, the estimated amplitude distributions on measurement planes are replaced with the measured ones.

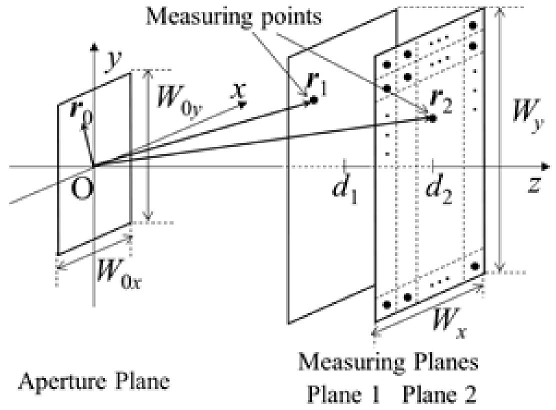


Fig. 1. Model of PR method.

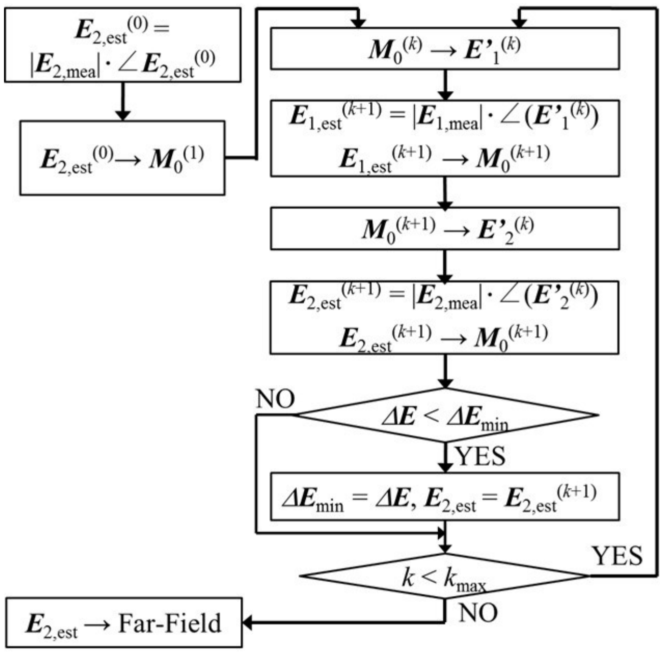


Fig. 2. Flow chart of PR method.

3. Simulation Results including Probe-Positioning Error

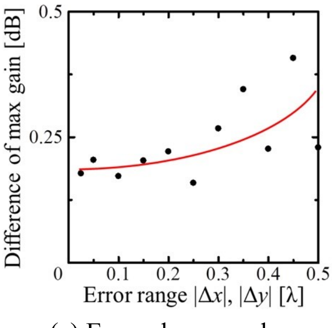
The examination is performed in the simulation. 23 dBi standard horn antenna is used as AUT and the frequency is f = 75 GHz, i.e. the wavelength is λ = 4 mm. The position and width of planes are d_1 =5λ, d_2 =10λ, W_{0x} = W_{0y} = 10λ and W_x = W_y = 30λ. The elevation angle from the origin to the edge of plane 2 is θ_v = 56 degree. The numbers of sampling points are 64×64 on all planes. Random probe-positioning error ($\Delta x, \Delta y, \Delta z$) occurred on each sampling points of planes 1 and 2, and two cases are considered: (1) $|\Delta x|, |\Delta y| \leq 0 \sim 0.5\lambda$ and $|\Delta z| = 0$, (2) $|\Delta x|$ and $|\Delta y|$ = 0 and $|\Delta z| \leq 0 \sim 0.5\lambda$, due to the error along *xy*-plane is different in character from that along *z*-axis. The result for far-field pattern without the probe-positioning error is when the number of iterations in the estimation is less than 250. The results show that the simulated far-field and the far-field which calculated from estimated near-field coincide when they are more than – 20 dB.

Fig. 3 and Fig. 4 show the results of the absolute difference of maximum gain of the far-field pattern and the angle difference of the main-lobe. The range of positioning-error along *xy*-plane or *z*-axis is changed from 0.25λ to 0.50λ. In Fig. 3, the maximum gain error is increased with the increase in error range. The gain error remains 0.5 dB with the increasing of $|\Delta x|$ and $|\Delta y|$, however the maximum error increases about 4.0 dB when $|\Delta z|$ is 0.50λ. This is because of the significant decreasing of the field strength caused by the random positioning-error. The attenuance depends more on *z*-axis error than *xy*-plane. The error angle of the main-lobe shown by Fig. 4 remains 0 ~ 1 degree regardless of the direction and range of the error.

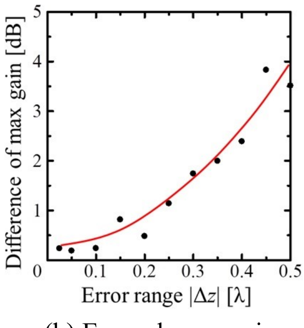
Fig. 5 shows the result of the far-field estimation when the error is $|\Delta x|, |\Delta y| \leq 0.5\lambda$ or $|\Delta z| \leq 0.5\lambda$. The result shows that the difference between the calculated far-field from simulated near-field and that from estimated near-field is less than ± 1 dB when they are more than –20 dB.

4. Conclusion

In this paper, we examined the effects of the probe-positioning error on far-field patterns estimated with phase retrieval method. The accuracy of phase retrieval method is shown in detail by the simulation with including the probe-positioning error.

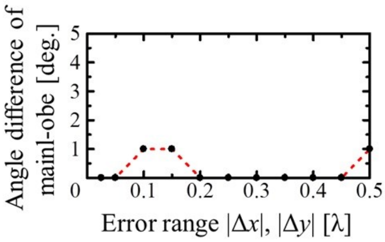


(a) Error along *xy*-plane.

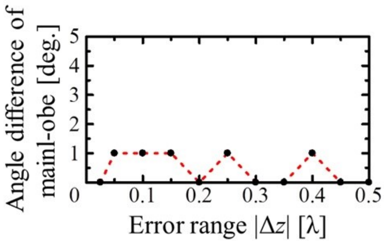


(b) Error along *z*-axis.

Fig. 3. Relation between error range and difference of max gain.



(a) Error along *xy*-plane.



(b) Error along *z*-axis.

Fig. 4. Relation between error range and angle difference of main-lobe.

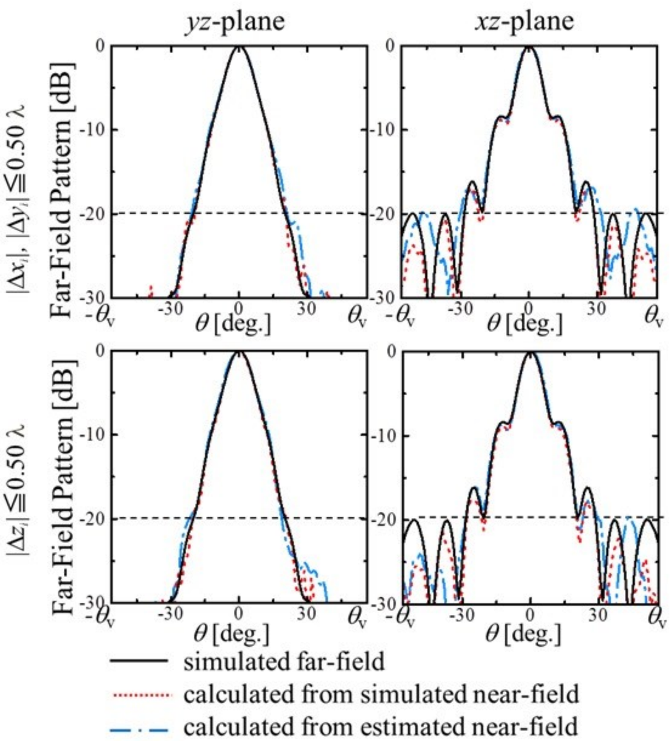


Fig. 5. Comparison of far-field patterns (w/ probe-positioning error).

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