EXPERIMENTS ON PHASE RETRIEVAL METHODS IN NEAR FIELD ANTENNA MEASUREMENT FOR Ku-BAND OFFSET REFLECTOR ANTENNA

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1 Introduction

Recently, increasing millimeter and submillimeter wave observation systems require sophisticated testing techniques in order to measure the electrical performance of the antennas. Such techniques are based largely on near field antenna measurement methods(NFAM). However, it is difficult to determine the phase distribution at such a high frequency, since accurate scanner systems are necessary to achieve enough accuracy.

In order to overcome this difficulties, phase retrieval method[1] has been proposed. This method has a future that the phase distribution is estimated from the amplitude data by iteration algorithm [2]. Especially, in near field measurement, Gerchberg-Saxton algorithm[3] is well suited to the problem and some papers describe the theoretical simulations.

In this paper, we examine experimental evaluation of the method by measurement of near field amplitude of Ku band antenna using Gerchberg-Saxton algorithm as the basic research for the study of millimeter or submillimeter antenna measurement.

2 Gerchberg-Saxton Algorithm in NFAM

Figure 1 shows flow chart of the Gerchberg-Saxton algorithm. The Gerchberg-Saxton algorithm was originally invented in connection with the problem of reconstructing phase from two intensity measurements. Before calculation, it is necessary to measure the intensity at two prescribed near field planes. The distances between the antenna aperture and the measured planes are defined as z1 and z2, respectively as shown in figure 2. The iteration continues until satisfying the constraints, for example, the squared error in measured and transformed amplitude.

It is well known that this algorithm may find local minima instead of the desired global minimum and it is due to its assumed initial phase function. Theoretically, the interval of two measured planes is only related to its convergence. Usually, the interval is selected to be so long that the phase can converge to the minimum rapidly. However, at high frequency, it is difficult to choose the enough range because of the test zone or required dynamic range. In this case, there may be little amplitude difference between the two planes, we should consider the effect of not only its convergent characteristics but also the ambiguity of the algorithm in practical applications . Therefore, we consider that it is necessary to evaluate the possibility by experiments.

3 Experimental Result

Figure 3 and Table 1 show the configuration of the measurement and the conditions of measurement and estimation, respectively. Antenna under test(AUT) is single offset reflector antenna fed by dual mode conical horn antenna and measurement frequency is 12.5GHz. There are two reasons to select such a frequency. First, it is relatively simple to measure the phase distribution to be compared with the estimated results. Further, it is required to reduce the other cause of estimation error, for example, S/N ratio and the alignment, since the purpose of the experiment is to examine the realization in the case where the distance of two measured plane is extremely small. In this measurement, S/N ratio is identified larger than 70dB.

We measured different five plane's amplitude and phase distributions. The nearest plane of z=500.5mm is used as one side plane(z1) in the estimation , another plane is changed to examine the convergence. Figure 4 shows the amplitude distributions at z=500.5mm and 600.5mm. This figure shows that the amplitude difference between two measured planes is extremely small.

Table 1: conditons of experiment

Frequency	12.5GHz
diameter of AUT	600mm
intervals Δx,Δ y	12mm
measured area(x $\times$ y)	1.8m$\times$1.9m
measured plane (z)	500.5mm,510.5,520.5
	530.5,600.5mm
iteration times	1000
initial phase distribution	uniform
	calculated

In this study, the algorithm was run for 1000 iterations. At this stage the rate of convergence had dropped to a very low value.

Figure 5 shows the phase distributions at z=500.5mm in the case of changing the initial phase distribution and the measured distance. From figure 5(a) and (b) ,in case of 10mm interval between two measured plane, it is apparent that the estimation results do not converge to the solution sufficiently. On the other hand, in the case of 100mm interval, the estimation results converge to the solution. Especially,using the initial phase as calculated distribution, the result agrees well with the solution as shown in Figure5(d).

Figure 6 shows a plot of phase r.m.s. error as a function of the interval between two measured planes. This figure shows that the effect of using calculated data as initial value on the phase error is valid for larger interval of two measured planes. However,there is remaining 15 degrees r.m.s. error in case of 100mm interval. The factors affecting it is the error at the edge of aperture, as shown in Figure5(d). The cause of the error at the edge may be associated with effect of S/N ratio, truncation error and so on.

Figure 7 shows the far field pattern transformed by the result in Figure5(d), using calculated phase as initial and Δz=100mm. This figure also shows the pattern transformed by measured result. The estimated result agrees well with the measured one.

4 Conclusion

We have performed experimental evaluation of phase retrieval by two near field amplitude data by Gerchberg-Saxton algorithm. The results have shown that the accuracy of estimation is not only related to the initial phase distribution but also the interval of measured distance. Further, we would like to investigate the possibility at millimeter or submillimeter wave antenna measurement.

References

[1] L.S.Taylor,"The Phase retrieval problem,"IEEE Trans. Antennas Propagat.Vol.AP-29,no.2,pp.386-391,March 1981.

[2] O.M.Bucci,G.D.G.Leone,R.Pierri:"Far-field pattern determination from the near-field amplitude on two surface,"IEEE Trans. Antennas Propagat.Vol.38,no.11,pp.1772-1779,Nov. 1990.

[3] R.W.Gerchberg,W.O.Saxton,"A practical algorithm for the determination of plane from image and diffraction pictures,"Optik,vol.35,no.2,pp.237-246,1972.

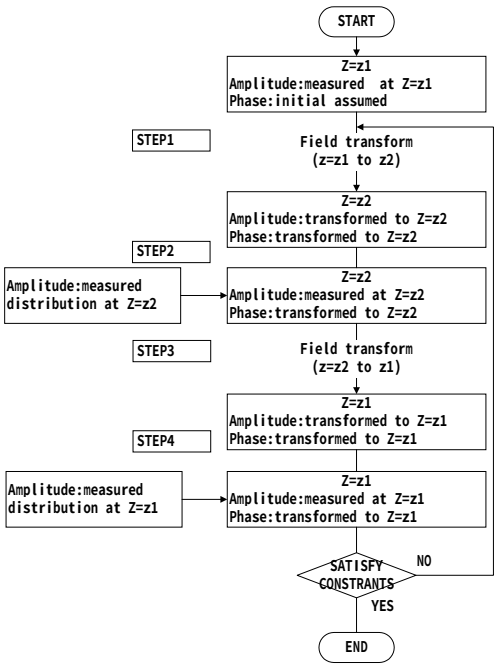


Fig. 1: Flow chart of Gerchberg-Saxton algorithm.

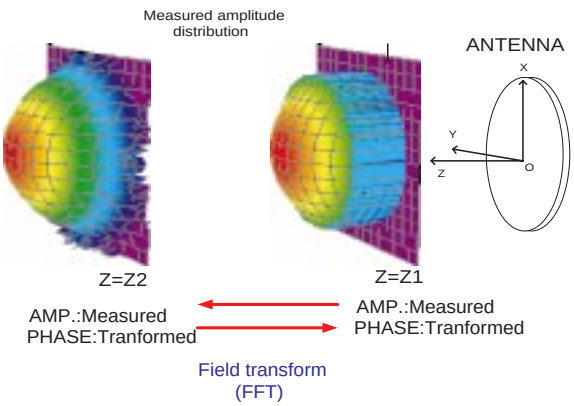


Fig. 2: Geometry of scanning surface.

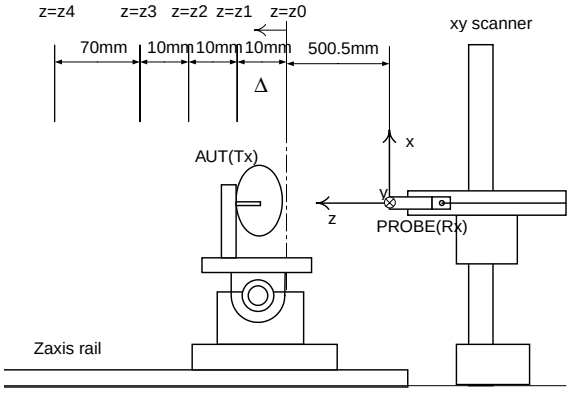


Fig. 3: Sideview of measurement configuration

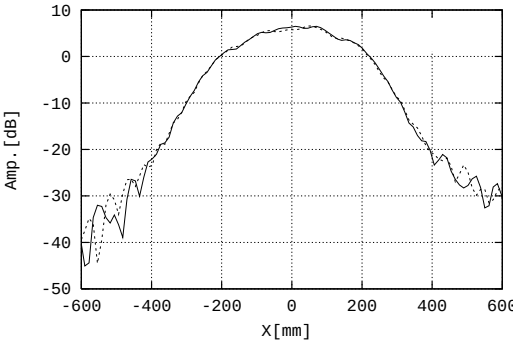
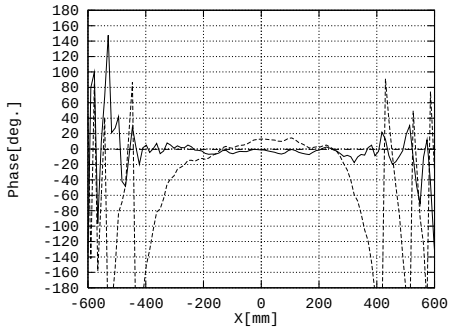
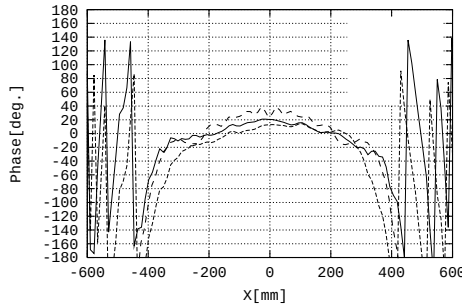


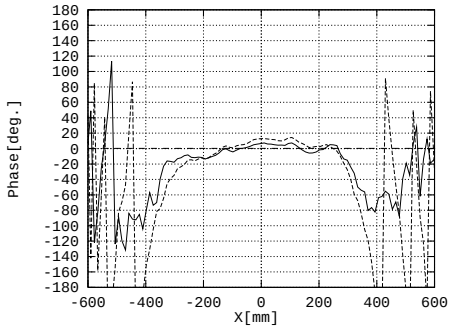
Fig. 4: Measured amplitude at z=500.5 and 600.5mm(xz plane).
——:z=500.5mm,- - -:z=600.5mm.



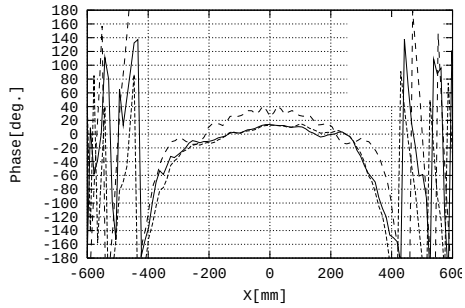
(a) Δz=10mm,uniform phase.



(b) Δz=10mm,calculated phase.



(c) Δz=100mm,uniform phase.



(d) Δz=100mm,calculated phase.

Fig. 5: Comparison of phase distribution at z=500.5mm(xz plane).
——:estimated result,- - -:measured result ,– – –:initial distribution.

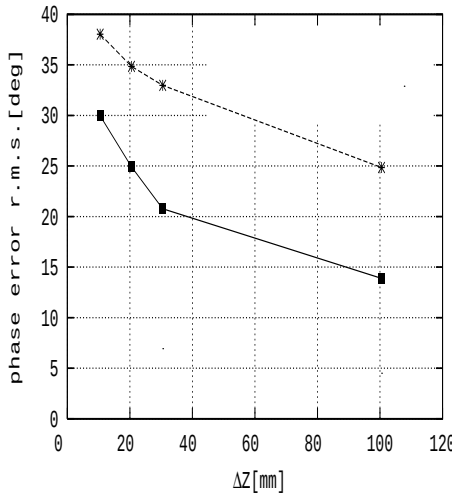
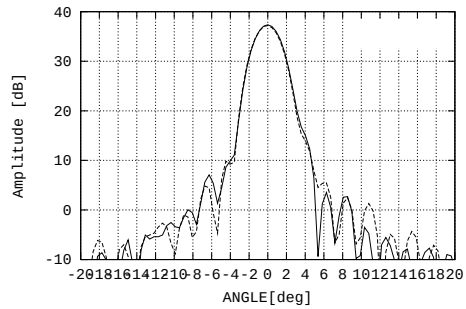
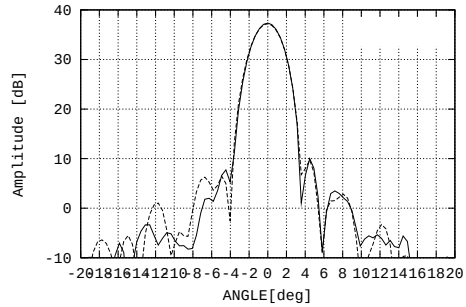


Fig. 6: Phase error at z=500.5mm.
Initial phase distributions are
- - × - -:uniform ,–■–:calculated.



(a)verical plane.



(b)horizontal plane.

Fig. 7: Far field radiation pattern.
Δz=100mm,calculated phase.
——:estimated ,- - -:measured.