AN IMPROVED METHOD FOR MEASURING AMPLITUDE AND PHASE OF EACH RADIATING ELEMENT OF A PHASED ARRAY ANTENNA

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Introduction - It is important to measure the amplitude and phase of each radiating element for obtaining desired array performance.

The rotating element field vector method (REV method)[1] is a measurement method of the amplitude and phase of each element of a phased array in operation. In this method, the amplitude variation of total field of the array by changing phase of a under test element is measured and numerically processed.

But in practice, the measured amplitude and phase of each element include errors caused by the phaseshifter connected to the element. So setting error of array excitation distribution are unavoidable and cause deterioration of the array performance.

In this paper, an improved REV method is presented, which give more accurate amplitude and phase of each element in operation by compensating the errors caused by phase shifter.

Influence of errors of phase shifter - As shown in Fig. 1, the phase of one element, for example, the ith element, is changed using the phase shifter connected to the element and total electric field variation is measured in a REV method. This measurement is performed under the condition in which all elements are excited. The total field amplitude (power) variation versus an element's phase changing is obeyed to a consinusoidal manner . The consinusoidal curve is obtained by means of the least square approximation (LSA), assuming the phase is equally changed and the loss of phase shifter is constant. In using practical digital phase shifters, however, measurement errors of amplitude and phase of each element are generated by the loss and phase fluctuation of the phase shifter itself.

Fig. 2 show examples of errors due to these fluctuations of phase shifter In this figure, it is assumed that 5-bit phase shifter is used and loss variation of phase shifter are simulated by random numbers of standard deviation 'ar' of loss variation. These errors are taken into account for obtaining more accurate electric field of each element.

Theory of compensating - We define phase shift as pi, ..., pi..., loss variation as a_1, ..., ai, ... and total field amplitude is A_1, ...Ai, ... The procedures of compensating errors are follows.

(1) Variation of Ai^2 versus pi is approximated by cosine function by LSA. Ordinarily, pi is uniform (ex. 11.25 DEG in case of 5-bit phase shifter). The error of phase setting of phase shifter is corrected.

(2) Cosinusoidal curve in Fig. 3 correspond to circular locus of element electric field vector PQ.OQ is vector of initial total electric field.

(3) PQ is rotated by angle of pi and extended. Point R on this line is obtained from that |OR| is Ai and R' is obtained from PR' = PR X(-ai).

(4) |OR'| is amplitude of new total electric field Ai' that is corrected. Then, we can obtain cosinusoidal curve by process (1), and new circular locus with a center of P' by process (2).

(5) As the element electric field vector is P'Q, we iterate (1) ∿ (4) processes over again.

(6) As the influence of errors of phase shifter is more excluded by repeating these procedures, movement of P to P' becomes smaller. If this movement is within some area, we stop correcting procedures.

Numerical Results and Discussion - The measurement errors of amplitude and phase versus number of iteration of compensating procedures is shown in Figs. 5(a) and 5(b). It is assumed that 5-bit phase shifters are used and loss ai and phase setting error pi are simulated by random numbers as in Fig. 2. In these figures, ar and pr are the standard deviations of loss variation and phase setting errors of phase shifters, respectively. And 'NO COMPENSATING' means ordinary method and 'ONLY PHASE' means that only phase setting error pi is taken into account.

From Figs. 5(a) and 5(b), only 4 or 5 times of iteration are needed in order that the convergence is attained. In this case, the measurement errors of amplitude and phase of each element are below -60 dB and 10^{-2} deg, respectively.

Conclusion - From numerical results, it is concluded as follows;

(1) If the performances of phase shifters are known, the amplitude and phase of each element measured by a REV method can be compensated by above correcting procedures.

(2) Number of iterlation which is needed for compensating is 4 or 5 times in case ordinary phase shifters are used.

Reference

(1) S. Mano and T. Katagi (IECE Trans (B), J65-B, P555, May 1982).

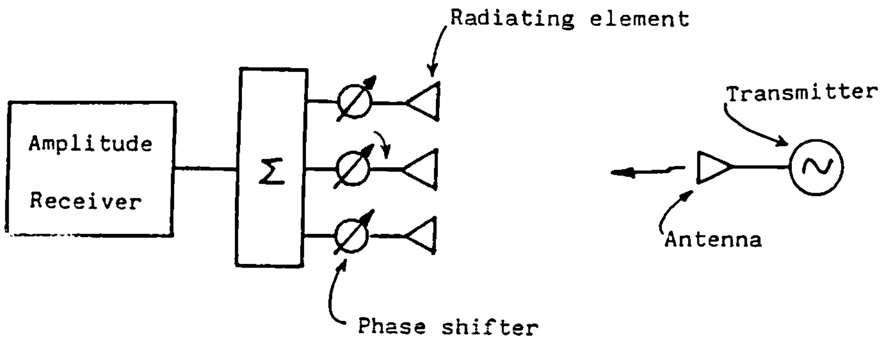

Fig. 1 Diagram of measurement

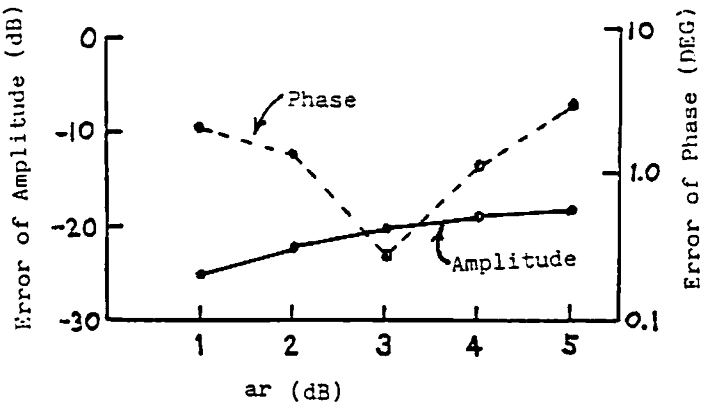

Fig. 2 Influence of error

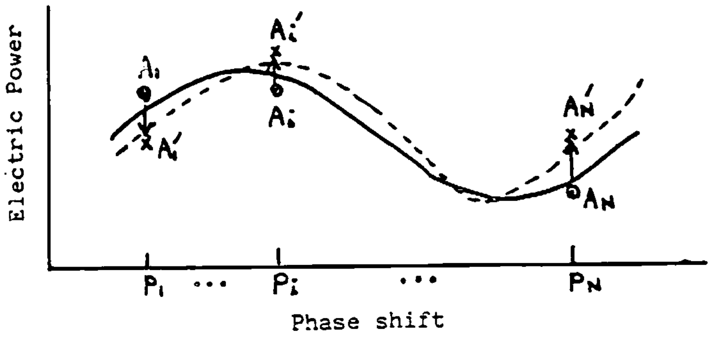

Fig. 3 Electric Power versus Phase shift

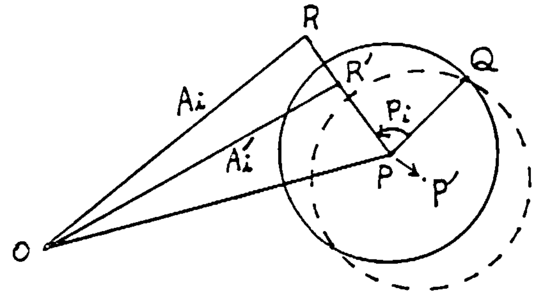

Fig. 4 Method of compensating

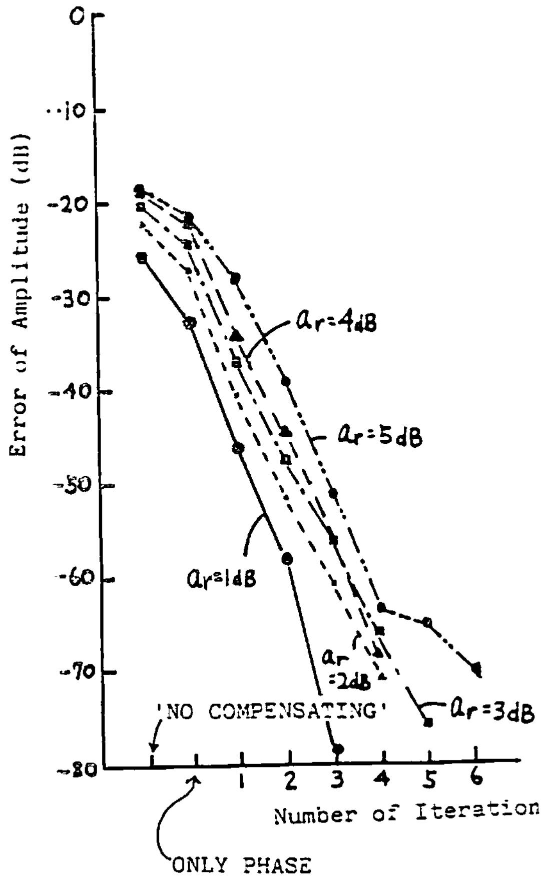

Fig. 5 (a) Error of Amplitude

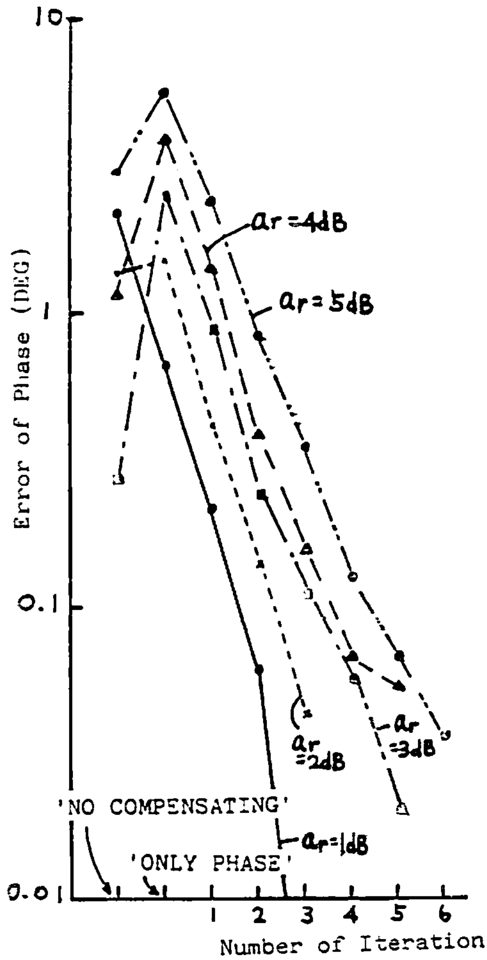

Fig. 5 (b) Error of Phase