MONITORING TECHNIQUES FOR PHASED-ARRAY ANTENNAS

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ABSTRACT

Various methods of monitoring phased-array antennas are suggested. One is based on changes in the far-field radiation pattern arising from defects in the array. Another method uses the near-field to far-field transformation, based on the concept of the plane-wave spectrum, for the detection of defects in the antenna. A third method is based on near-field measurements and uses the properties of the Fresnel integral.

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SUMMARY

The Microwave Landing System (MLS) which has been proposed to replace the present Instrument Landing System (ILS) has presented an interesting challange to phased array antenna monitoring. This is mainly to find a solution, on a noninterfering basis, to the problem of real-time monitoring where a decision is to be made within a fraction of a second, on the presence of defects in the array. The purpose of the present work is to look for monitoring methods based on the composite RF signal radiated from the array radiators.

Not much published work has been found that deals with this kind of composite signal monitoring. Blake, Schwartzman and Esposito [1] suggested a method for mainitenance system check, which can best be described as a "perturbation" or "coding" technique. The necessary time stated for performing the tests over a 2165-element array is 16 minutes. This method, although simple, is too lengthy.

Ransom and Mittra [2] suggested a method of locating defective elements in large arrays based on near field (Fresnel region) recording of phase and amplitude over a plane parallel to, and of the same size as, the aperture. The solution is based on the reconstruction of the aperture field by inversion of the recorded field, using the diffraction formula. This method which can be used in a near field antenna measurement is impractical in field-operated systems, such as the MLS, where such obstructions are not permitted. This is quite apart from the requirement of two Fourier transformations which might be found too lengthy, although probably shorter than the previous method [1].

A method for pattern measurement of phased-array antennas is suggested by Scharfman and August [3], by focusing the transmitting antenna into the near zone. It is also not desirable as it changes the original patterns and, in addition, interrupts the normal operation of the system.

An experimental investigation by a team from the Bendix Company [4] checked the degradation in the performance of MLS antenna patterns due to array elements failure, using two methods. The first was as in [3]. The second method used a waveguide line integral monitor. Both tests results showed good agreement with patterns measured previously on an antenna test range. It was found that about 10% of array components can fail before the side-lobe increases to 17db and the beam pointing error exceeds .02 degrees. However as in the previous paper [3], no specific proposal has been made for the inverse problem of identifying defective elements based on monitoring.

No other methods for the monitoring and detection of defects in operational phased array antennas are known to the authors. Therefore alternative methods, or modification of present methods, will be sought in the present study.

The work reported here, emphasizes the proposed "subtraction method", based on changes in the far-field radiation pattern arising from defects in the array. The "substitute element" technique based on familiar formulas for ideal antenna arrays is first presented and the subtraction method for the detection of single defective elements in the array is described. A more realistic antenna model is then described by the inclusion of random phase errors and interelement mutual coupling effects to the ideal antenna model. The performance of the proposed technique in the presence of these effects is discussed. Two other methods briefly mentioned are the "angular spectrum method" which uses the near-field to far-field transformation based on the concept of the plane-wave spectrum for the detection of defects in the antenna, and the "Near field focusing" method which uses properties of the Fresnel integral. The last method proposes an alternative technique for checking the far-field beam scanning from near-field monitoring. This is different from methods described earlier, for example in [3] and [4]. The benefit of all three methods stems from the fact that no modification of normal operation of the array is needed, and uses modes of the ordinary transmission (or reception) of the array.

The proposed methods were simulated on the computer and, where possible, were tested by experiment.

REFERENCES

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