A Method of Measuring the Scattering Patterns of Materials by Means of UHF TV Broadcasting Waves

K.SAEGUSA, S.SUZUKI, K.SUZUKI and N.HASEBE
Department of Electronic Engineering,
Nihon University, 7-24-1 Narashinodai
Funabashi-shi, Chiba, Japan, 274.

Introduction

In a previous paper, a method of measuring the scattering patterns of materials with low reflectivity was presented[1]. The method is based on the principle of planar near-field measurement in antenna technology. In this paper, the experimental results for a metal plate and an absorber with reflectivity of about -20dB are presented and discussed.

Principle

The method utilizes the concept of determining the far-field scattering pattern of a material from a knowledge of the fields over a surface in near-field by using Huygens's principle.

Fig.1 shows the coordinate system and the measurement setup for the method. The UHF TV broadcasting wave(video carrier frequency:669.25MHz) is used as a main incident wave.

In order to distinguish the scattered field of a material from the main incident field, a two element endfire array consisting of half wavelength dipoles is used as a spatial directional coupler.

In practical field measurements, it is difficult to keep a sufficient scanning width for a material with wide spread scattering because of the limitation of measuring environment.

The error caused by the limited scan width and by the effect of the radiation pattern of a probe antenna is suppressed by developing the field on the surface of a material. The synthetic aperture technique in antenna thchnology is utilized for developing the field on a sample surface.

Results

For practical measurements, the scattering pattern in the Y-Z plane only(in the case of TM incidence) is considered, and one-dimensional scanning of six wavelength on the Y-axis is employed to reduce measuring time.

Fig. 2 shows the near-field scattering amplitude and phase normalized by the main incident field for a metal plate of 1.34λ square(λ:wavelength) at $d=z=3\lambda$. The solid line shows the calculated result using the moment method[2], and the broken line shows the experimental result. A good agreement between the experimented and the calculated results is obtained for the amplitude range above -35dB. From the result, it is noted that the dynamic range of the measuring system used here is about 35dB. It is mainly decided by the residual field amplitude of the main and multi-path incident waves in a suppression process.

An experimental result of the normalized near-field scattering amplitude and phase for a zigzag-shaped absorber of height 1.34λ and width 2λ at d=λ is shown in Fig.3, and the normalized field distribution on the surface of the absorber calculated by using the synthetic aperture technique is shown in Fig.4. It is noted that both field distributions are asymmetrical with respect to the X-axis. In order to examine the asymmetry caused by the inherent characteristics of the absorber, the near-field distribution of the absorber was measured again by exchanging the right and left sides. Fig.5 shows the field distribution on the surface of absorber after it was turned round - the same as shown in Fig.4. From the results, it seems that the asymmetry is caused by the inherent characteristics of the absorber itself.

Fig.6 shows the resultant far-field scattering pattern of a zigzag-shaped absorber. The absorber has a reflectivity of -20dB for normal incidence. The method presented of measuring the scattering pattern can be employed with materals with a reflectivity of above -30dB. The error caused by the residual field amplitude of incident waves and by the effect of the limited scan width is less than ±1dB at the main-lobe level and ±2dB at the side-lobe level in a range above -30dB from a main-lobe level. This error on the field distributions has been examined by computer simulation and by actual measurements.

Conclusions

It has been confirmed from simulated and experimental results that the method of measuring scattering patterns can be employed with materials with a reflectivity above -30dB.

Further investigations to establish a precise measuring method are being conducted.

References

[1]K.Saegusa,M.Takeda and N.Hasebe:"A method for the scattering pattern measurements of materials by means of UHF TV broadcasting waves -For the case of normal incidence- ",IEICE technical report, AP88-38(1988).

[2]N.Hasebe and T.Zama:"Radar cross section of a metal plate reflector with loaded dipoles",IECE Trans.,Vol.62-B,No.6, 1979,pp.557-564.

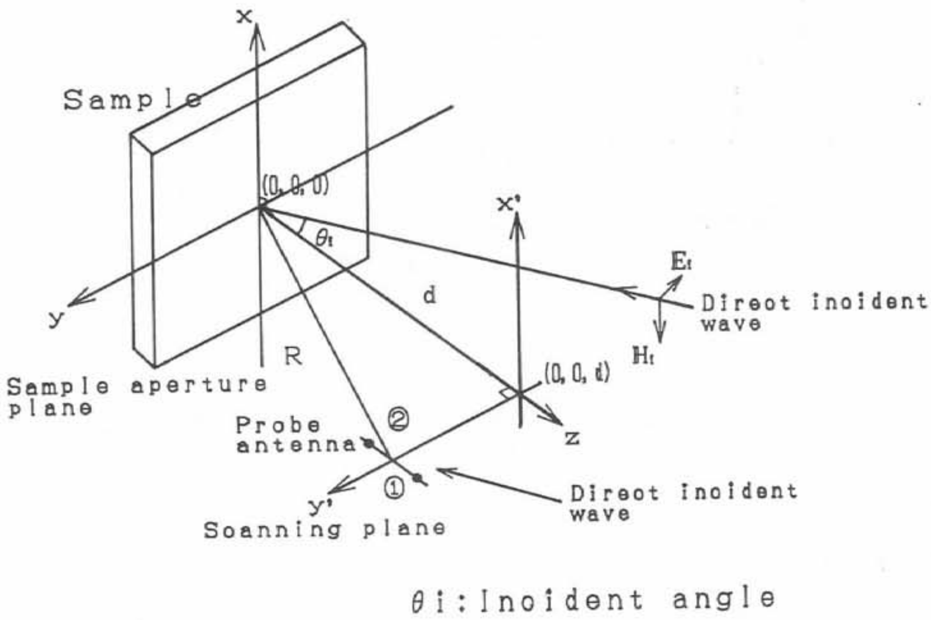

Fig.1 Coordinate system and measuring setup.

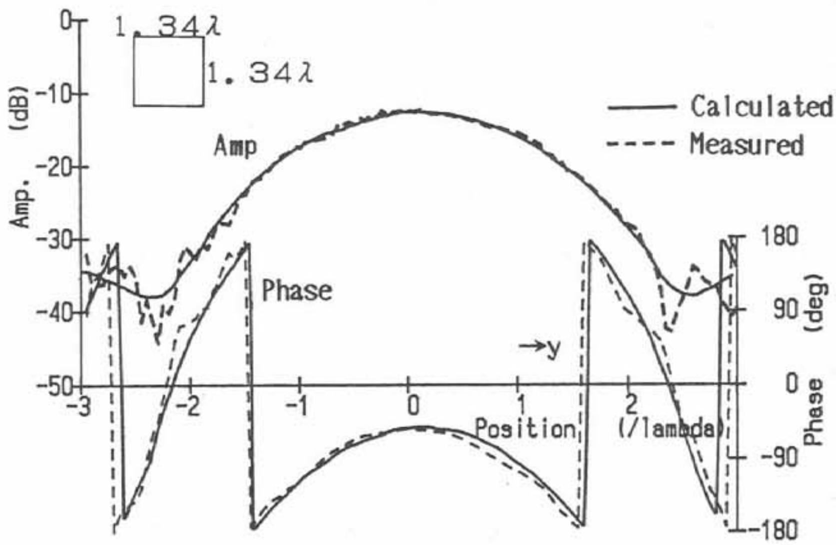

Fig.2 Near-field scattering distribution for a metal plate at d=3λ

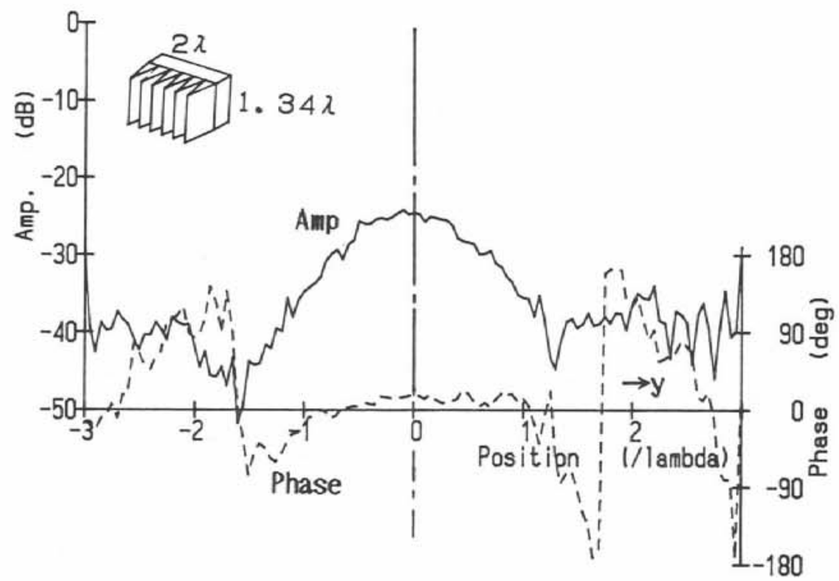

Fig.3 Near-field scattering distribution for an absorber at d=λ

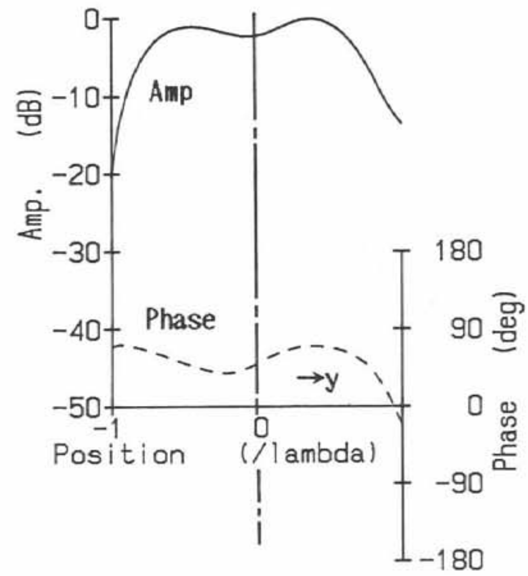

Fig.4 Field distribution on the surface(absorber)

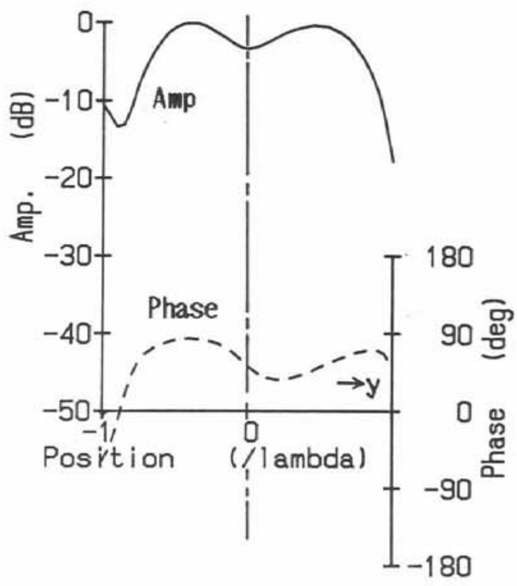

Fig.5 Field distribution on the surface (exchanged right and left sides)

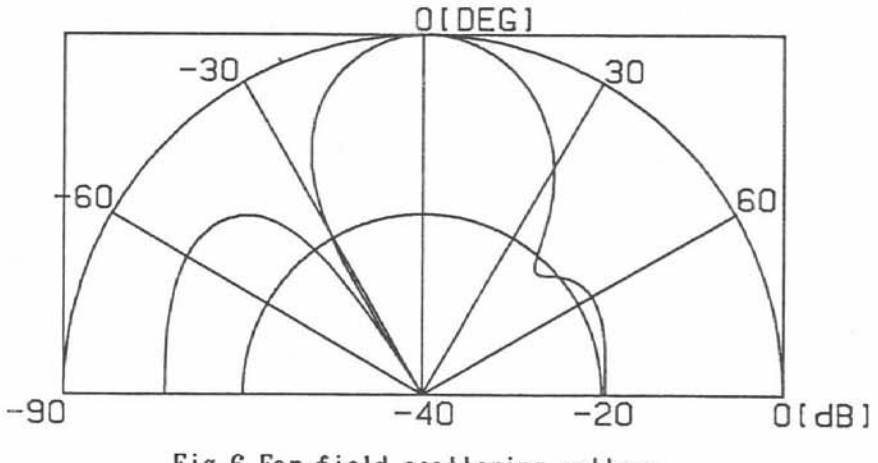

Fig.6 Far-field scattering pattern