A MEASUREMENT SYSTEM FOR THE RADIATION EFFICIENCY OF SMALL ANTENNAS USING RADIO WAVE SCATTERERS

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1. Introduction

Radiation efficiency is the most important figure of merit for evaluating a small antenna. So several measurement methods have been proposed in order to measure the radiation efficiency of electrically small antennas so far [1][2][3][4]. Among these methods, the RFM (random field measurement) method [3][4] is suitable for the fabrication test during production, because no additional coaxial cable nor balun are required for measuring the input impedance. In addition, it can measure the radiation efficiency of a built-in antenna including the human body effects. In a previous paper, some experimental investigations on the indoor RFM method and the evaluation technique for the measurement site using a new evaluation index (DDD value) was presented[5]. The authors have already proposed a basic idea for an indoor RFM method using radio wave scatterers to increase the accuracy of this method. In this paper, an automated measurement system for the indoor RFM method will be presented in order to stabilize the mechanical structure and electrical characteristics of the radio wave scatterers and to increase the measurement efficiency of this method. Finally, some measurement data on the absorption loss of a phantom head will be shown briefly.

2. PRINCIPLE FOR INDOOR RANDOM FIELD MEASUREMENT

The principle for indoor RFM measurement is shown in Fig. 1. The antenna under test (AUT) and the standard efficiency antenna (SEA) are measured as transmitting antennas. The field strength is measured while rotating a receiving antenna, and the data from the receiver's output are processed by a data processor composed of a microcomputer. The relative radiation efficiency of an AUT can be determined from the difference between the receiving power of the AUT and that of the SEA, corresponding to the same cumulative probability of reception, such as 50 %, as shown in Fig. 2. In this measurement method, it is required that the cumulative probabilities of reception of both the SEA and AUT should have the same distribution, such as a Rayleigh distribution.

Experimental results[5] showed that the measured radiation efficiency of the test antenna varies when the set up direction of the test antenna is changed. This variation in the measured radiation efficiency causes a measurement error. An idea for radio wave scatterers was newly introduced in order to decrease the error corresponding to this variation [5][6]. However, the mechanical stability of the scatterers used in the previous papers and the efficiency of the measurement operation were not so good, since the scatterers were a first step trial.

3. MEASUREMENT EQUIPMENT

Figure 3 shows the structure of the scattering

equipment and rotating arm with the receiving antenna. The scatterer frame is divided into two halves. Each half contains five rows of scatterers. These five rows are controlled by one expansion/compression motor. The motor is activated in order to expand one set of scatterers, and then pulls a horizontal bar along the frame, and a sensor stops the expansion motor when the scatterers are fully expanded.
Moreover, the motor is reversed to compress the scatterers, and constant torque springs pull the horizontal bar back to the compressed position. The scatterers are arranged in a cylindrical shape of 2 m height and there is an empty space at the center (1 m in diameter) for the transmitting antenna.
The frame itself measures 3.7 * 2.4 * 3.1 m (height). Each leaf is individually curved so that the scatterers perform effectively. The curvature for each leaf was calculated using a table of random numbers, and having determined the curvature for each leaf, it was possible to set this value using a certain length of wire to tension the leaves. Each leaf is made from a plastic coated aluminum foil, and so is easily curved or shaped. These leaves measure 20 * 30 cm.

4 MEASUREMENT RESULTS OF DDD VALUE

The DDD value of this equipment was measured in the range 400 MHz - 2600 MHz since the DDD value is almost equal to the accuracy of the RFM method [6]. The measured data is summarized in Fig. 4, where #1 - #5 correspond to 5 different positions of the transmitting antenna in an empty space at the center of the scattering equipment shown in this figure. It has been confirmed that the mean level of the DDD value was almost 1 dB, and the maximum DDD value was 2 dB.

Measurements were also carried out to determine the reflection loss of the standard efficiency dipole antennas.
The results showed that the effects of the scatterers on the reflection loss was negligible (less than 0.3 dB) in comparison with the DDD value.

5 MEASUREMENT RESULTS FOR A PHANTOM HEAD

Although the ultimate aim of this measurement system is to measure the effect of the human body on the radiation characteristics, the measurement results for a phantom head will be shown in this section as the first step to check this system. Two sizes of spherical phantom heads were used in order to produce a set of experiments. Figure 5 shows the spherical phantom and the standard half wave length dipole antenna. The antenna used was placed at certain distances from the head,namely 1,2,3,4 and 5 centimeters, and the losses due to the phantom head were measured. Theoretical results for the absorption loss associated with saline filled spheres have already been calculated using the Spatial Network Matrix (S.N.M.) method in order to compare them with the measured results. The parameter for the 3-dimensional lattice network was 80 * 70 * 90 (delta d), where the unit length of the lattice, (delta d), was 0.02 wavelength. As can be seen in Fig. 5, the experimental results almost matched the theoretical ones,the difference between these data being less than the DDD value.

6.CONCLUSIONS

An automated measurement system for the indoor random field measurement method has been developed and was investigated experimentally. It has been found that the mean DDD value is less than 1 dB for all measured frequencies (430 MHz - 2600 MHz). The absorption losses associated with two sizes of phantom heads were measured and compared with theoretical calculations to check the accuracy of this system. T h e experimental results closely matched the calculated loss. This new equipment has produced huge gains in measurement efficiency while maintaining a high accuracy of results.

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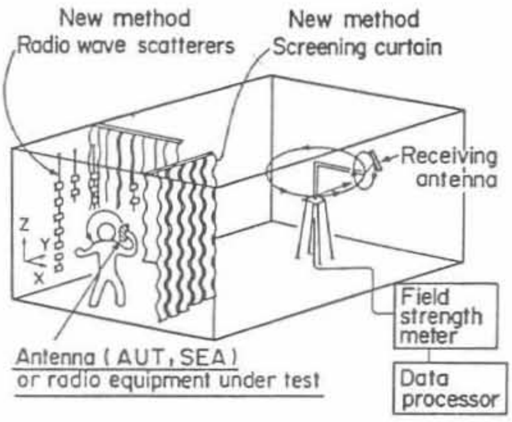

Fig.1 Principle for indoor RFM

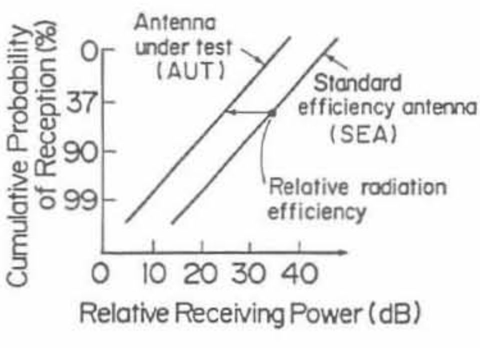

Fig.2 Measured data for RFM

Fig.3 Scattering equipment

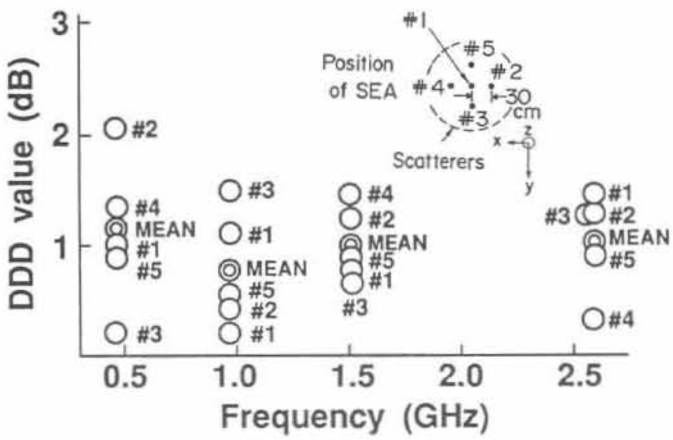

Fig.4 Measured DDD value

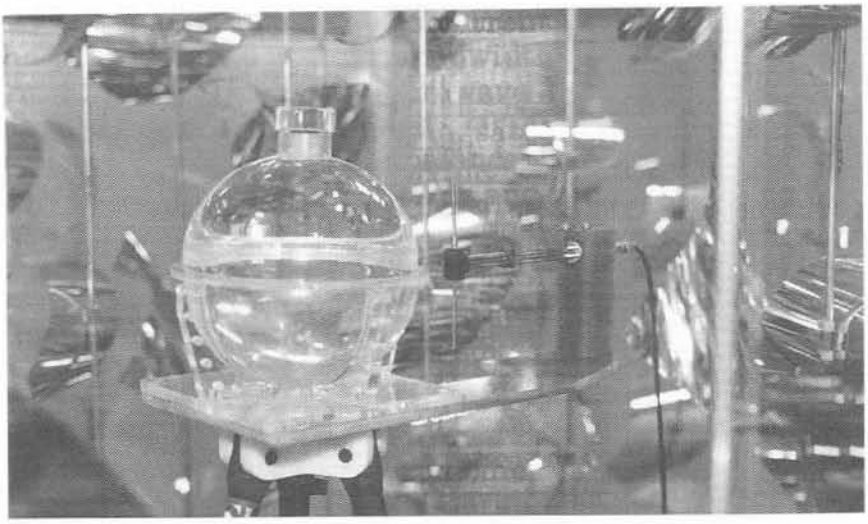

Fig.5 Phantom head

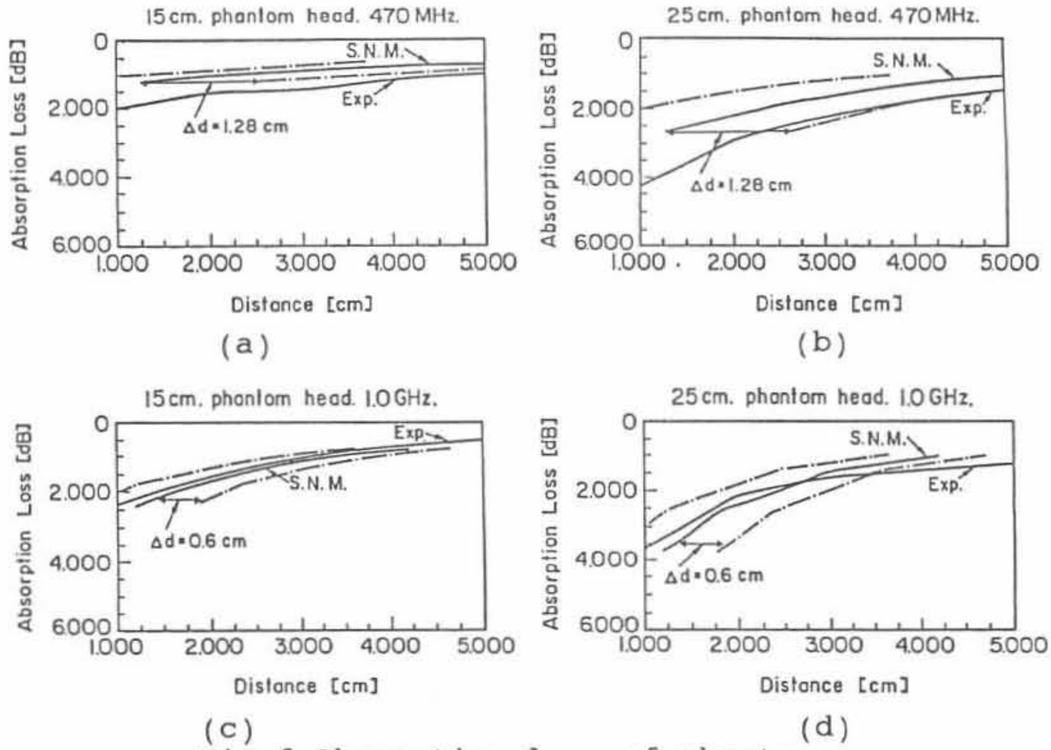

Fig.6 Absorption loss of phantom