RADIATION EFFICIENCY MEASUREMENT FOR SMALL ANTENNAS USING A NEW RADIATION CHARACTERISTIC MEASUREMENT EQUIPMENT

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Introduction

New techniques, such as antenna diversity, will be introduced for portable radio equipment in future mobile communication systems, and it will become essential to know the antenna's radiation characteristics quickly and accurately including the effects of the portable radio equipment. The radiation efficiency of an antenna, in principle, can be obtained by integrating the radiation field over the solid angle of a sphere surrounding the antenna (or test object). However, it has been difficult to measure the radiation field over the solid angle of a sphere in the VHF or UHF band in which most of the portable antennas are used. As far as the authors know, no experimental results on such measurement have been reported so far. So, several other measurement methods for the radiation efficiency of an antenna have been proposed.[1][2][3]

This paper describes some experimental results by using a new radiation characteristic measurement equipment and clarifies some inherent problems in this measurement.

Measurement equipment

Figure 1 shows a schematic structure of the measuring equipment which is composed of the antenna rotating mechanism, control equipment and control software. The directivity of the test object at the VHF band, which is used for mobile radio communication, is relatively wide. Accordingly, radio wave absorbers, with a height of 1 m or more, must be used to cover the whole rotating mechanism to restrain the reflection of radio waves , if the rotating mechanism is made of metal, as in the case of conventional measuring equipment. Moreover, the measurement on the radiation field must be made over a sphere, so that the radio wave absorber, covering the metallic rotating mechanism , should not be arranged so as to intercept the radio waves from the test object. Therefore, the rotating mechanism , which is used to support and rotate the test object in all directions, should not be radioacoustically visible. In the present trial manufacture, the whole rotating mechanism, including bearings and screws, was formed with nonmetallic materials. Teflon and Delrin were used to form the bearings. Motors and other metallic parts are located at the lowermost portion of the measuring equipment, which is sufficiently distant from the rotating mechanism , and are covered by radio wave absorbers.

Table 1 shows the mechanical requirements for this equipment. The ripple of the H plane for the half-wavelength dipole antenna was intended to be within 1 dB as the electrical target value including the effects of scattering from the rotating mechanism. The theoretical directivity for the half-wavelength dipole antenna was calculated over the solid angle of a sphere in order to compare it with the measured directivity. Figure 2(a) and (b) show the half-wavelength dipole antenna on a turntable and the coordinate system which was used to deduce the theoretical values. Figure 3 shows the results of these calculations. A standard half-wavelength dipole antenna was used for the measurement, and was mounted on a turntable in the manner shown in Fig.2(a). Measurements were carried out in a preparatory experiment using a 250 MHz frequency band. Figure 4 shows the result of the

measurements. The measurement result were substantially different from the theoretical one. It was found from some investigations on this difference that radio wave scattering from a dielectric arm,which was used as a part of the rotating mechanism, had influenced on the directivity.
It is difficult to analyze the radiation characteristics theoretically,including the effects of the dielectric arm. In this test,the dielectric arm was improved experimentally by hollowing out the arm to minimize radio wave scattering. Figure 5 shows a photograph of the rotating mechanism including the arm portion.

Experimental results

The absolute and relative level accuracy of a receiver were calibrated by means of a power meter and standard attenuator, respectively. The operating precision of the receiving system as a whole was maintained at 0.3 dB or less.
At first,two log-periodic antennas of the same model were opposed to each other. The distance between the antennas was varied, and the polarization was changed to determine the actual gain of the log-periodic antennas. Since the absorption characteristic of a radio wave anechoic chamber is not perfect,a maximum level-difference of 1 dB was observed, between the horizontal polarized waves and the vertical polarized waves,even when the distance between the antennas was kept constant. Therefore,actual gain values for the receiving antenna, calculated in accordance with Friis transmission formula, were not the same for various distances and polarizations. Here,the average of the gain,i.e.,4.9 dBi,was regarded as the actual gain of these antennas. One of these antennas was used as the receiving antenna for measurement.
A half-wavelength dipole antenna, having a known radiation efficiency fed by a miniature oscillator,was set horizontally on the turntable as the test antenna,and the radiation field characteristics for this antenna were measured. As shown in Figs.3 and 6, the experimental value agreed well with the theoretical one as low as -30 dB. Even if a conventional single-axis positioner is used, it is very difficult to measure the H-plane pattern for a half-wavelength dipole antenna within the accuracy of 1 dB,since the absorption characteristic of the radio-wave anechoic chamber and balun of the standard antenna are not perfect. In view of this, the directivity measured by the above method was considered to be satisfactory. The radiation efficiency can be obtained by integrating the measured values of the horizontal and vertical polarized waves. Table 2 shows the results of measurements. The reflection loss (0.3 dB) and internal cable loss (0.2 dB) of the test antenna were measured in advance using a network analyzer. Therefore,the radiation efficiency for the half-wavelength dipole antenna was determined to be -0.7 dB. This measurement is an absolute measurement of the radiation efficiency ensuring a high accuracy that cannot be attained by the conventional measurement method.

Conclusion

A new equipment which can measure the radiation characteristics for a small built-in antenna has been developed on the basis of experimental investigations. It was found, from the measured results of radiation efficiency of a half-wavelength dipole antenna, that a measurement accuracy within 1 dB can be obtained. Furthermore, the measurement equipment displays the radiation characteristics over a sphere surrounding the test antenna for a short time of 1 minute including the measuring time. Antenna researchers can research and develop small built-in antennas effectively and visually using this measurement equipment.

Acknowledgement

The authors would like to thank Mr Seiji Ohura of Yanagi works of Toshiba Corp. for his kind help during the experiment.

References

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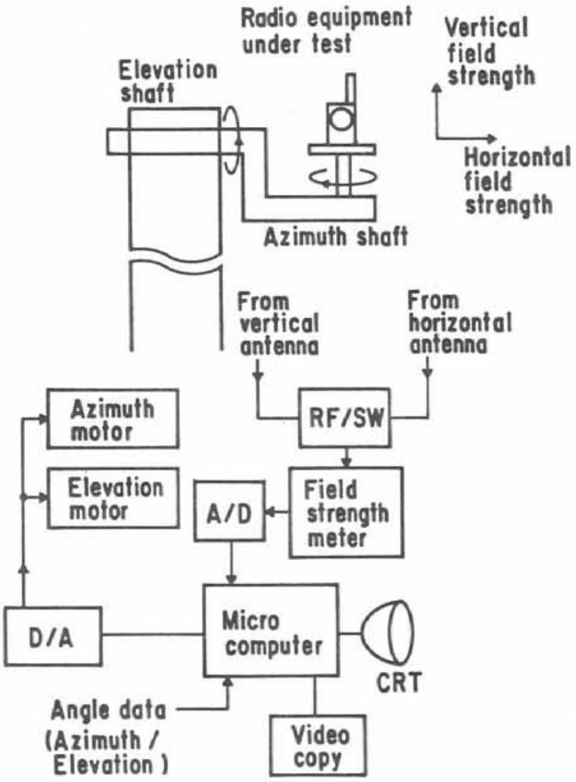

Fig.1 Measuring equipment

Table 1 Mechanical requirements

Item	Target value
Measuring time	1 minute or less
Azimuth rotational frequency	120 rpm or less
Diameter of test object	60 cm or less
Weight of test object	2 Kg or less
Allowance for test object variation	5 mm or less

Table 2 Radiation efficiency of standard dipole antenna

Item	Power
Integral value of received power	0.8 dBm
Actual gain of receiving antenna	4.9 dBi
Transmitted power	-2.9 dBm
Test antenna	
Internal cable loss	0.2 dB
Reflection loss	0.3 dB
Radiation efficiency of test antenna	-0.7 dB

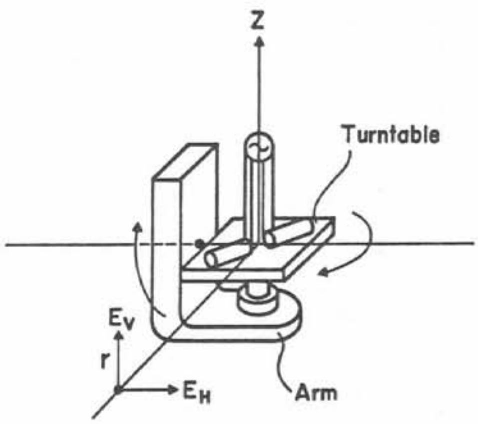

Fig.2(a) Test antenna and arm portion

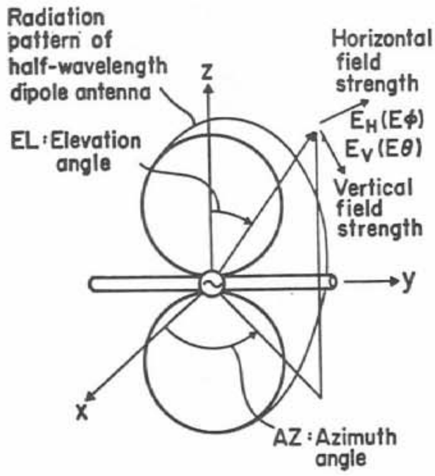

Fig.2(b) Coordinate system

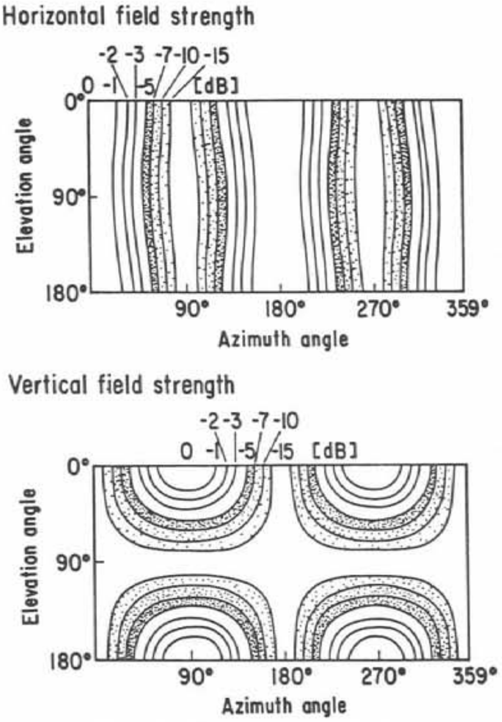

Fig.3 Theoretical directivity for half-wavelength dipole antenna

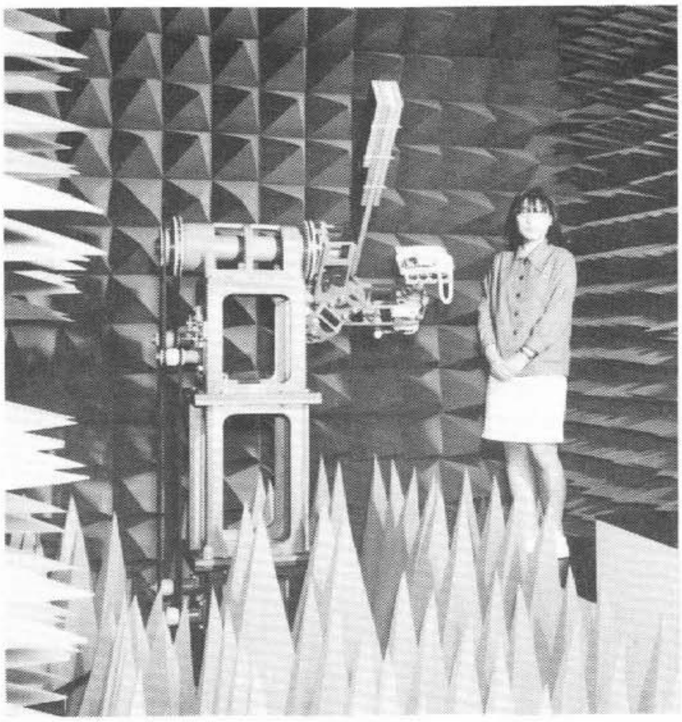

Fig.6 Rotating mechanism

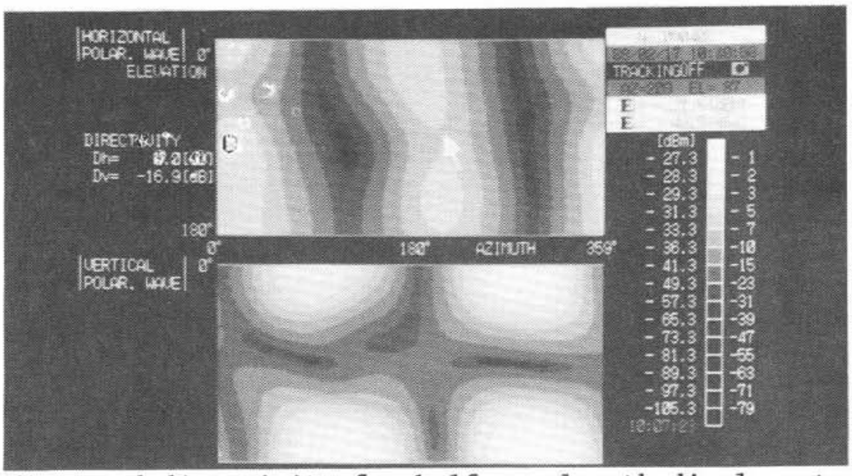

Fig.4 Measured directivity for half-wavelength dipole antenna (Original rotating mechanism: Level is relative value)

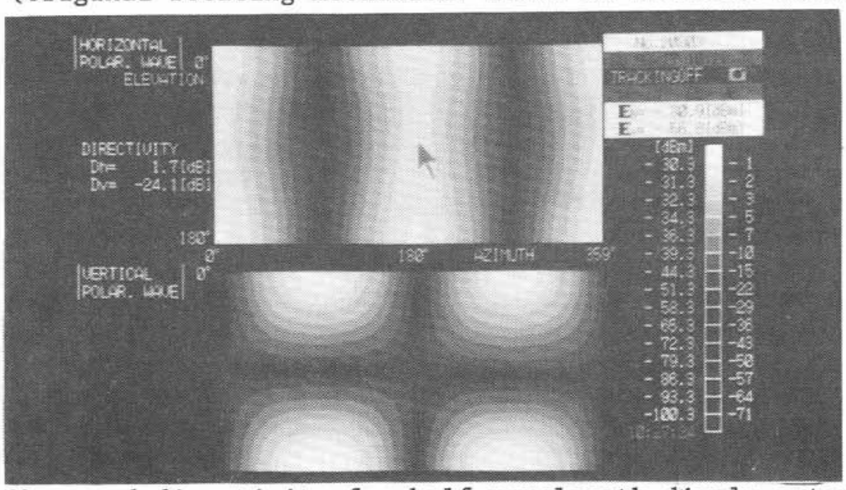

Fig.5 Measured directivity for half-wavelength dipole antenna (Improved rotating mechanism: Level is absolute value)