A–6–4 A PHANTOM TO SIMULATE SCATTERING FROM A HUMAN BODY

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INTRODUCTION

Many discussions have been reported including the consideration of the human body effect on an electromagnetic field.(1)(2)

In these reports, the characteristics of the human body are represented by data measured on a few members. It seems no consideration is made for differences between bodies.

However, it has been pointed out by manufacturers of portable wireless equipment that the sensitivities of equipment measured on several bodies are not of the same value. Accurate measurements on some bodies, that will be shown later, showed clear electrical difference between individual bodies.

To estimate sensitivity or other characteristics of the wireless equipment, it is very inconvenient for receiving levels to vary with each body on which the equipment is measured.

This paper describes a trial to remove this inconvenience by using a "Phantom", a simulation of a human body, on electromagnetic field scattering.

Establishment of a standard method of test and evaluation for portable wireless equipment, especially for paging equipment, has been desired.

The phantom described here can contribute to this standard establishment.

I. Measurement of Scattering from a Human Body

Scattered fields from several bodies, strictly, scattered fields superimposed on direct fields, were measured.

To avoid field disturbance from cables, a small battery operating oscillator (3 cm x 3 cm x 1 cm for 250 MHz) is used. Both the oscillator and the battery are parts of a loop antenna. (Fig. 1) The antenna is operating in a small loop antenna mode. This is verified by experimental data where the radiation level in the direction of loop axis is lower than -20 dB, compared with that on the loop plane. Therefore, this antenna operates as a magnetic source.

Measuring setup is shown in Fig. 2. In the figure, both scattered and direct waves can be regarded as plane waves at the receiving point.

The measured scattering patterns from the loop antenna on stomachs are obtained as shown in Fig. 3. Obviously, characteristics for individual bodies are not the same. The level difference reaches 4 dB, in the forward direction.

II. Human Body Equivalent Dielectric Constant Estimation

This paragraph shows a dielectric constant value for an infinitely long dielectric cylinder that shows theoretical scattering characteristics like the average human body.

Scattering theory from a long cylinder is expressed in references(3). In Fig. 4, theoretical scattered fields are shown for three constants ε_r = 10 - j10, 20 - j20, 120 - j80. Radius of all the cylinders is 15 cm and the E field to be received is parallel to the cylinder axis. From the results, it may be noted that the field deviation of the three cylinders is no larger than that of the human bodies.

When ε_r is 10 - j10, patterns are nearer the average for a human body. Therefore, the phantom may be formed of a material that has a 10 - j10 dielectric constant. This value cannot be insured directly for the pantom because of the assumption regarding the body as being infinitely long. The dielectric constant for the phantom should be decided after measurement of scattered fields.

III. Material Choice and Result

The phantom may be used anywhere. The dielectric constant should not vary with time and should be light in weight. Therefore, water, a salt solution, or ceramics are not appropriate for the phantom.

After several investigations on various materials, a carbon immersed urethan sponge was determined as most appropriate for the phantom.

Weight is 0.07 g/cc and the dielectric constant is measured as ε_r = 10 - j13 when stuffed into a coaxial line.

A phantom, shown in Fig. 5, is formed with this sponge and scattering characteristics measured in the same way as in Fig. 2. The obtained results are shown in Fig. 6 with means and standard deviations in the data in Fig. 3.

The scattered fields from the phantom are almost included in the spread of those for human bodies. Asymmetry is found in the figure at 90° $\sim$ 270°. This is considered removable by homogenizing the carbon density in the sponge.

Therefore, it can be said that the phantom can represent human bodies and it can be used in standard tests for men carrying radio equipment.

IV. Conclusions

Measurements of scattering from seven bodies at 250 MHz are described. It was confirmed that there is some spread of human characteristics as electromagnetic wave scatterer.

A phantom was formed with a urethan sponge containing carbon that simulates scattering from a typical human body.

This is very useful for avoiding effects of men's individual characteristics in estimating the performances of portable wireless equipment.

References

(1) Z. KRUPKA: IEEE Trans. Vol.AP-16, No.2.

(2) H. E. KING: IEEE Trans. Vol.AP-23, No.2.

(3) J. R. WAIT: "Electromagnetic Radiation from Cylindrical Structures", Pergamon Press.

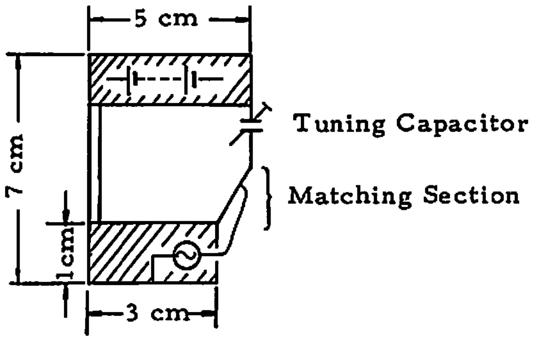

Fig 1 Small loop antenna with an oscillator in it

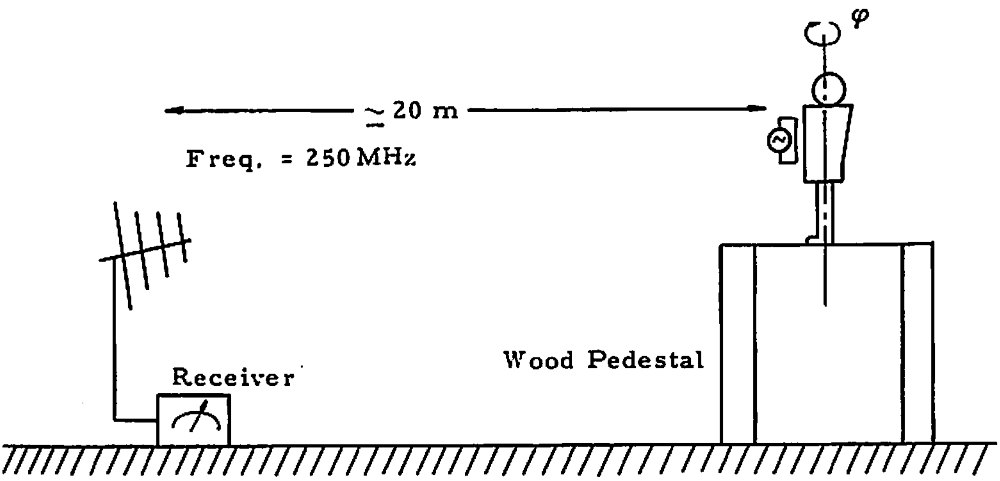

Fig 2 Measurement setup

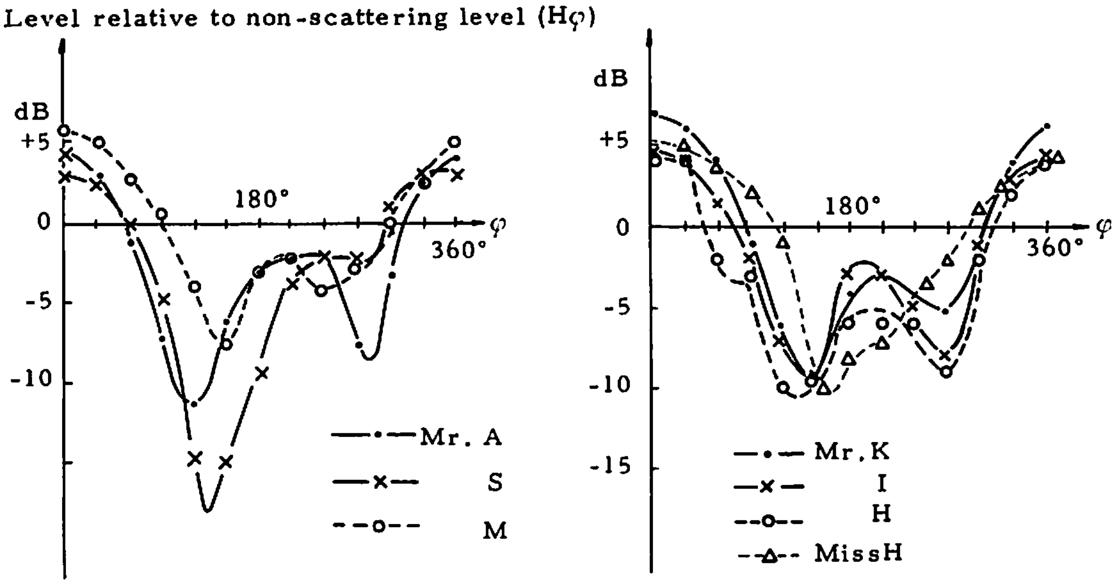

Fig 3 Scattering patterns for seven persons. (Measured)

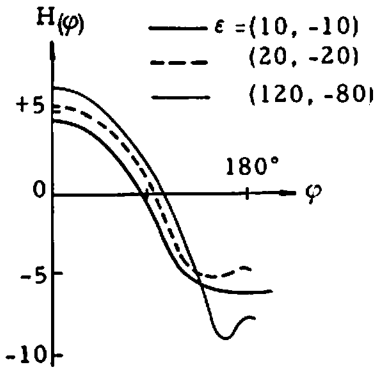

Fig 4 Scattering patterns for dielectric cylinders (calculated)

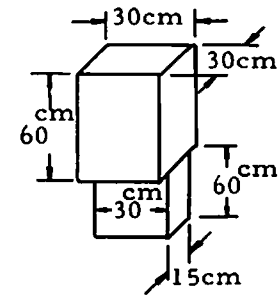

Fig 5 Sketch of a Phantom

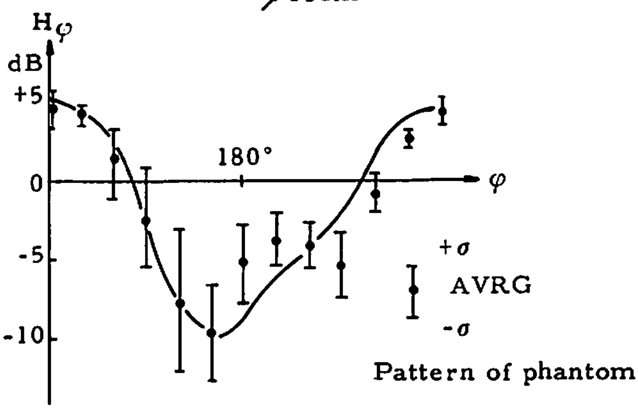

Fig 6 Scattering patterns for the Phantom over the average, standard deviation of Fig 3