A BUILT-IN ANTENNA FOR 800MHz BAND PORTABLE RADIO UNITS

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1. Introduction

Several reports have appeared recently dealing with 800MHz band portable radio units [1],[2]. External linear antennas are usually used with this kind of equipment. However, when portability is taken into account, it is desirable that the antenna be the built-in type. Built-in inverted F antennas are currently used in NTT's Detachable mobile radio units [3]. In addition to portability, inverted F antennas exhibit sensitivity to both horizontally and vertically polarized radio waves and therefore are suitable for use with portable radio equipment in which antenna orientation is not fixed.

The characteristics of inverted F antennas depend on the position and location of the antenna in the case. Some of these characteristics have been described statistically [4]. However, the effect of antenna configuration under actual usage conditions, especially when the radio is held to the side of the user's head, has not been investigated. This paper (1) compares the gain characteristics of built-in inverted F antennas to those of external linear antennas, and (2) describes the optimum position of an inverted F antenna under actual usage conditions.

2. Inclination angle of radio units

This paper describes radio units for full duplex systems. Designers must assume that handheld units will be inclined at the side of user's head, and that antenna gain will change as a function of this angle.

In order to design an antenna configuration and maximize antenna gain during operation, it is necessary to estimate the inclination angle. Fig.1 shows the inclination angle distribution from the vertical for handheld units. Almost 80 percent of the distribution occurs between 55 to 70 degrees with an average angle of about 60 degrees. Therefore, the appropriate design angle for an antenna under actual usage conditions is taken to be 60 degrees.

3. Pattern Averaging Gain

Antenna effective gain in a multipath fading environment can be measured by random field measurement (RFM) [5]. In RFM, the effective gain is obtained by processing a large number of data measured throughout the field. Consequently, the RFM technique requires a lot of time and manpower, and a simpler estimation technique is needed to design antennas.

Antenna gain in the multipath fading environment is discussed theoretically by Jakes [6], and can be calculated by integrating the product function of the antenna power gain patterns and the angular density functions of incoming radio waves over the entire field surrounding the antenna. Jakes' formula can be simplified to Eq.(1) by using the following assumptions.

(1) The elevation angle of incoming radio waves is assumed to be distributed mainly in the horizontal direction [7], and
(2) The direction of waves arriving at the receiving antenna as it moves throughout some area is assumed to be random, so that incoming radio waves can be considered to arrive uniformly from all directions in the horizontal plane. The simplified equation can be given as :

$$Gp = 1/2\pi \int_0^{2\pi} \{ Gv(\Phi) + Gh(\Phi)/Cvh \} d\Phi \qquad (1)$$

where $Gv(\Phi)$ is the vertically polarized power gain pattern in the horizontal plane, $Gh(\Phi)$ is the horizontally polarized power gain pattern in the horizontal plane, and Cvh is the XPD in the multipath fading environment.

The effective gain can therefore be estimated using Eq.(1). Based upon previous search, the Cvh value used in this paper is assumed to be 9 dB [8] and the Gp is referred to as "Pattern Averaging Gain" (PAG).

4. Antenna configuration and characteristics

Some typical antenna configurations are shown in Fig.2. Inverted F antennas are mounted on the top side of the radio case (type A), on the back opposite the dials (type B), and on the side of the case (type C). A sleeve dipole antenna configuration is also shown (type D). The radiation patterns for the inverted F antenna for types B and C and for the sleeve dipole are shown in Fig.3 and 4, respectively. When the inclination angle of the portable radio unit increases, the vertically polarized radiation pattern approximates the E_Φ component pattern on the XZ-plane for types B and D, or that on the YZ-plane for type C, respectively. Under actual usage conditions, the antenna effective gain for types B and D is considered to be lower than that for type C.

The effective gain for each configuration is shown in Fig.5, where the solid lines are the PAG calculated by measuring the radiation patterns. The plotted points show the gain measured at 920 MHz using RFM. 0 dBd is used as the effective gain of a reference half-wavelength dipole antenna. The PAG is in good agreement with the effective gain determined by RFM. The best antenna configuration for actual usage conditions was found to be type C. This was especially true when the antenna element was mounted on the upper side of the case. The effective gain of type C is 2 dB greater than that of type D. Even when the antenna element is mounted on the lower lateral side, type C has approximately the same gain as type D.

The effective gain depends on antenna radiation performance, which is affected by the human body. For example, in Fig.5, the gain degradation for types B and D is mainly the result of pattern degradation. In contrast, the gain degradation for type A is caused by the antenna's proximity to the human body. Unfortunately, the effect of the human body on built-in antenna configuration has not yet been analyzed. More research is needed to understand exactly how the human body affects radiation patterns.

Fig.6 shows the gain characteristics of an 800MHz band type C inverted F antenna. The relative bandwidth for a VSWR≦2 is 6 percent. This built-in antenna configuration is therefore suitable for 800MHz band portable radio units.

5. Conclusion

The inclination angle of portable radio units was investigated under actual usage conditions. The optimum configuration of inverted F antennas for portable radio units and the gain characteristics of the 800MHz band inverted F antenna were also investigated. It was found that an inverted F antenna mounted on the upper side of a portable radio unit's case provided better performance under multipath fading conditions than either inverted F antennas mounted on other positions in the case or a sleeve dipole antenna. The effect of the human body on radiation patterns was also discussed.

References

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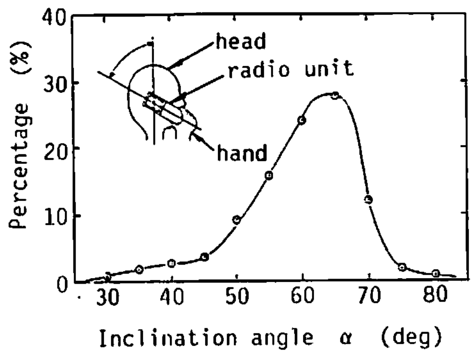

Fig.1 The inclination angle of radio units

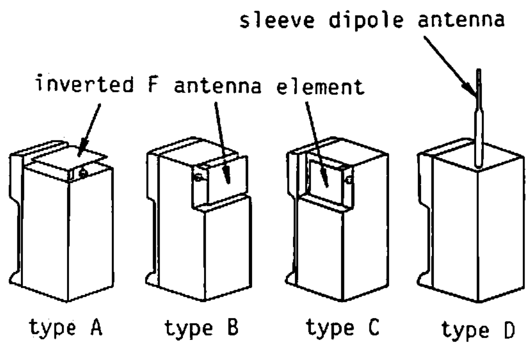

Fig.2 Antenna configurations for portable radio units

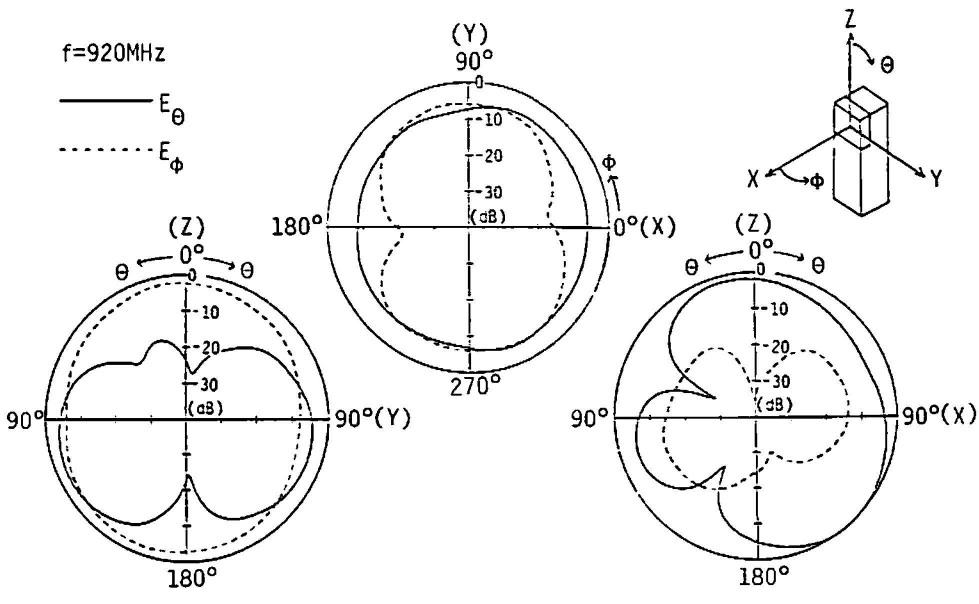

Fig.3 Radiation patterns of inverted F antennas (types B and C)

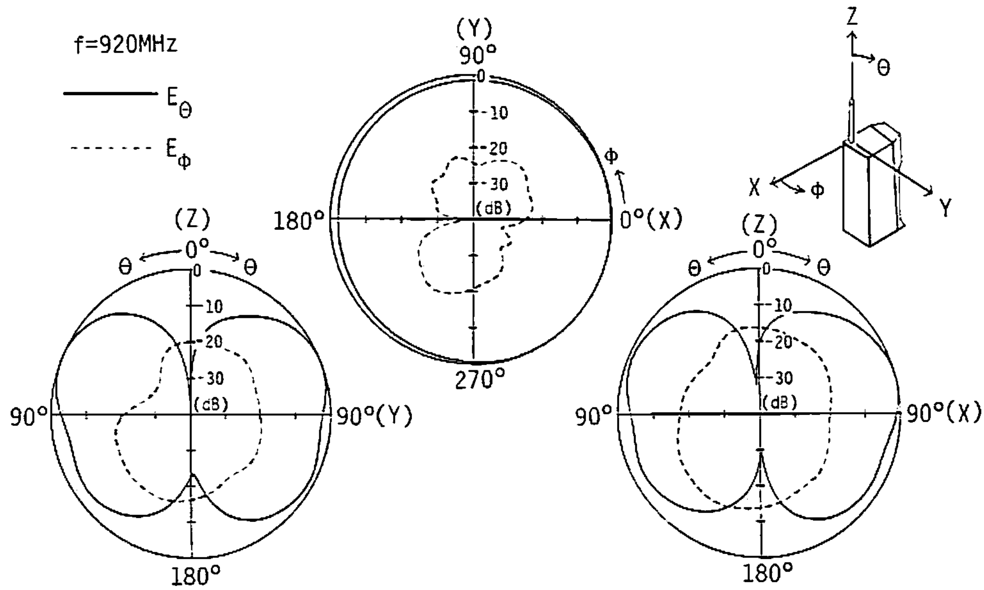

Fig.4 Radiation patterns of sleeve dipole antenna (type D)

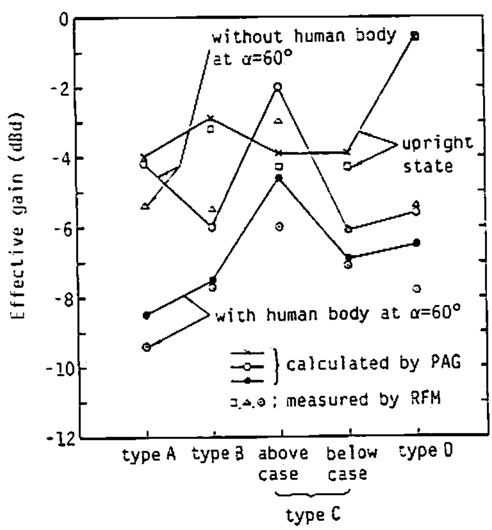

Fig.5 Effective gain vs antenna configuration (Inclination angle is 60°. f=920MHz)

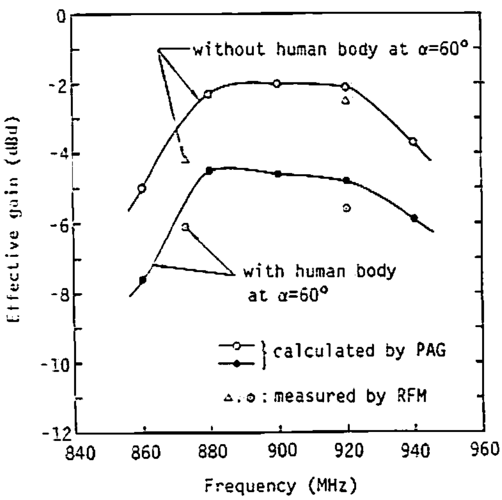

Fig.6 Gain characteristics in the 800MHz band for an inverted F antenna with type C configuration (upper lateral side element)