

A NEW GPS ANTENNA CONFIGURATION

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Abstract

A new quasi-planar GPS antenna is described. The antenna is realized on the basis of a pair of isotropic complementary antenna elements and noise match- power mismatch active antenna concept. Good isotropic directivity and circular polarization characteristics are verified experimentally.

Introduction

"Isotropy" and "circular polarization" are essential characteristics required for GPS antennas. Difficulty of simultaneous realization of both characteristics forces us very often to compromise with degradation of the antenna characteristics, especially in the case of planar antennas. Planar antennas are, however, of interest from the practical viewpoint, because they have the advantages of space saving and good productivity. The proposed antenna in this paper has a quasi-planar configuration, nevertheless it is basically isotropic and possesses good circular polarization characteristics in any direction.

Basic Concept

The conceptual design procedure of this antenna consists of two stages. On the first stage we determine a pair of complementary antenna elements which have basically isotropic characteristic regardless of their polarization. For the quasi-planar configuration, an appropriate pair of dipole- and patch antenna is suitable. On the second stage we superpose each radiation characteristic appropriately to obtain a circular polarization characteristic. Avoidance of coupling of each element is important to achieve this. To minimize the coupling, mismatching the power between each antenna element and the following preamplifiers is effective.

Complementary Antenna Element

We first determine a pair of complementary antenna elements which have basically isotropic radiation characteristic. As the complementary pair we take an electric- and a magnetic current source antenna which are embodied in the form of a line- and a patch antenna

respectively. The existence of the complementary pair attributes to existence of the same current distribution both for electric- and magnetic current, and such dual current distribution is allowed only on relatively simple shape antenna elements. Within this restriction we find cosine current distribution on a hemicycle contour has the best performance for this purpose.

An example of radiation diagram is illustrated in Fig.1. The ratio of the maximum radiation on the z-axis to the minimum radiation on the y-axis is about 8 dB. Such deviation from isotropy is still acceptable in practice because we rarely have occasion to receive signals from very low elevation angles.

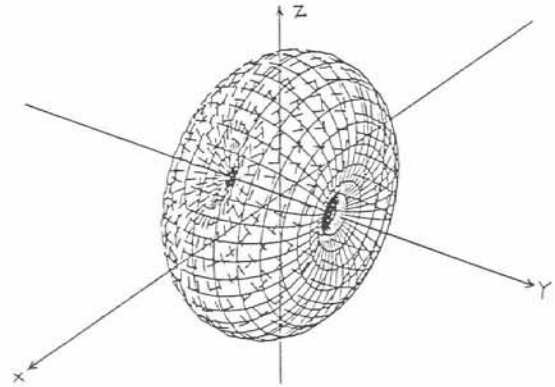


Fig.1 Radiation Pattern of a hemicycle source

The electric current antenna is realized in such a manner that one wave length loop antenna is divided into two portions odd symmetrically in terms of electric current, and that a portion having a feeding point is taken while the rest is removed(Fig.2). We should note that the electric current distribution remains unchanged through this division. The electric current antenna is thus determined and we call it hereafter "a bow dipole antenna". Complementally, the magnetic current antenna is then realized in such a manner that an E_{110} mode patch resonator is divided into two parts by an infinitely wide conducting plane odd symmetrically in terms of electric charge distribution. In the same way as the bow dipole antenna, a portion having a feeding point is taken while the rest is removed. The dividing conducting plane is then removed leaving the shunting portion to the ground(Fig.3). We should note that the electric charge distribution remains unchanged through this division. The electric charge distribution on the contour, and hence the derived equivalent magnetic current, has the same form as the electric current distribution on the bow dipole antenna. The complementary magnetic current antenna is thus determined and we call it hereafter "a hemicycle patch antenna". A slight difference of the effective wavelength between these two current sources produces no significant deviation in radiation characteristics. A pair of complementary antenna elements is thus determined.

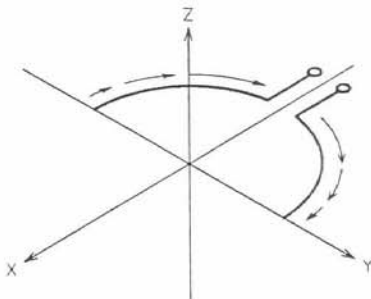


Fig.2 bow dipole antenna

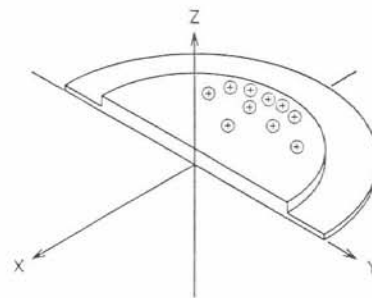


Fig.3 hemicycle patch antenna

Circular Polarization

The basic concept to produce circularly polarized waves is to superpose two waves having spatially orthogonal components with phase difference of $\pi/2$. The complementary antenna element pair in the previous paragraph produce a pair of such spatially orthogonal waves. Strict application of this principle to realization of actual antenna systems is not possible in practice because of strong coupling of each antenna element which would degrade the desired characteristics. We therefore leave such strict superposition and allow acceptable tolerance to achieve practical superposition of the complementary antennas. Such practical superposition is done by setting two antenna elements a small distance apart compared with the specified wavelength. The distance is determined so that the degradation of circular polarization and directivity characteristics does not exceed the predetermined tolerance. The degradation due to the coupling also depends on the termination of each antenna element. Power mismatch between each antenna element and each following preamplifier reduces influence of the coupling. Noise match is a reasonable and effective alternative to achieve this power mismatch, because noise match gives the minimum system noise temperature. The output of each preamplifier is summed together with phase difference of $\pi/2$ to produce a circular polarization reception characteristic. The conceptual block diagram is shown in Fig.4.

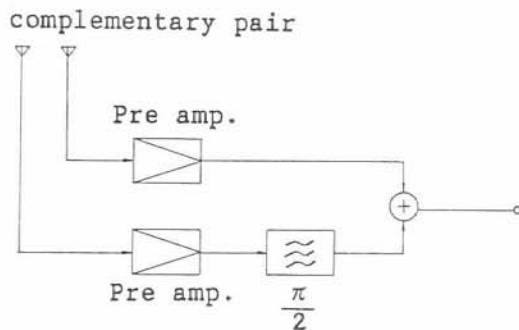


Fig.4 circular polarization antenna array

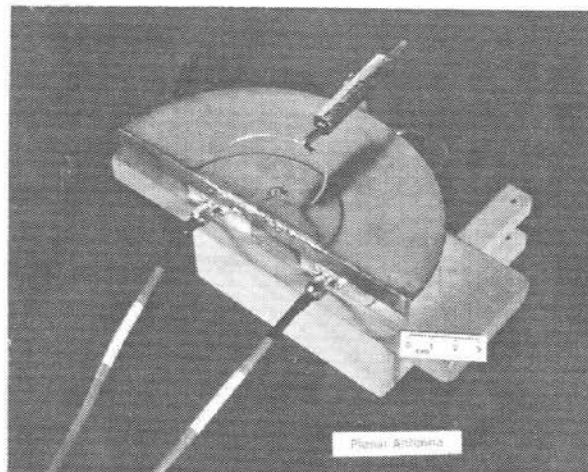


Fig.5 an experimental model

Experimental Result

Fig.5 is a photograph of an experimental model of the GPS antenna on this basis. The distance between the bow dipole antenna and the hemicycle patch antenna is ca. 2.5cm. The hemicycle patch antenna is made of a metalized Teflon substrate having thickness of 0.8mm. Some measured parameters are shown in Fig.6. Reception experiments from the NAVSTAR have been carried out successfully and the validity of this antenna concept has been verified.

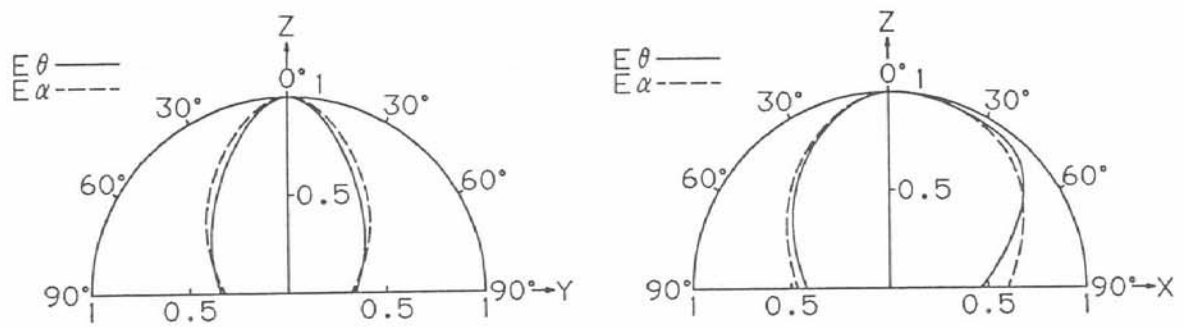


Fig.6 measured radiation patterns

Conclusion

A GPS antenna is composed of a bow dipole antenna, its complementary hemicycle patch antenna and some auxiliary active circuitries. By virtue of noise match and power mismatch concept the complementary antennas are to be arrayed to realize isotropy and circular polarization characteristics.

Reference

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- 3) Fujimoto, K., et al., "Small Antennas," Hertfordshire : RESEARCH STUDIES PRESS LTD., 1987.