Investigation of a Short Conical Helix Antenna

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IV. Conclusion

The main results of our study are summarized below

1) The electromagnetic field over the scattering object showed a significant variation with depth only when the object was near a depth of $(2n + 1)\lambda_w/4$ where λ_w is the wavelength in the dissipative medium and n is a positive integer. This suggests the possibility of utilizing a swept source to estimate the depth of the submerged object.

2) In terms of the distribution of the electric field over the scattering objects, best results were obtained by analyzing the variation of $|E_x|$ along the y-axis over the scattering objects. Both the size and the shape of the objects could be related to the measured distributions.

Though the results presented in this communication were derived on the basis of rudimentary signal processing, they clearly indicate the potential of the technique.

Acknowledgment

The author would like to thank the reviewers for suggesting several improvements.

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Investigation of a Short Conical Helix Antenna

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Abstract—**The input impedance, radiation pattern, axial ratio, and power gain of a conical helix antenna with a short arm are calculated as a function of frequency, using theoretically determined current distributions. It is shown that the antenna radiates a circularly polarized wave over a frequency range ratio of about 1:1.2, having a power gain of about 7.7 dB. The experimental results are also presented.**

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I. Introduction

An earlier paper [1] has described that the current distribution of a monofilar conical helix antenna [2], [3] with low pitch angle has two distinct regions, and that a decaying current region from the feed point to the first minimum point, called a region D (see an inset of Fig. 2(a)), is responsible for the radiation pattern. It has also been found that a monofilar conical helix antenna for wide-band usage should have an enough arm length for the current distribution which includes the second minimum point at the lowest frequency.

When the extreme wide-band characteristics are not required, the conical helix antenna may be constructed by a short antenna arm that supports only the region D in the current distribution. This type of the antenna is designated as a short conical helix antenna (SCHA). The purpose of this communication is to present the radiation characteristics of the SCHA, which are evaluated on the basis of the current distributions determined by solving an integral equation [4]. It is found that the SCHA has an axial ratio of less than 3 dB over a frequency range ratio of about 1:1.2.

II. Theoretical and Experimental Results

The configuration and the coordinate system are shown in Fig. 1. The helix mounted on an infinite ground plane, allowing the use of image theory in the analysis, has the same configuration as used in [1] except for the total arm length. The helical arm is defined as an equiangular spiral function $r = r_0 \exp(a\phi)$. The parameters are as follows; $r_0 = 0.707$ [cm] and $a = 0.074$; the pitch angle $\tau = 6°$; the

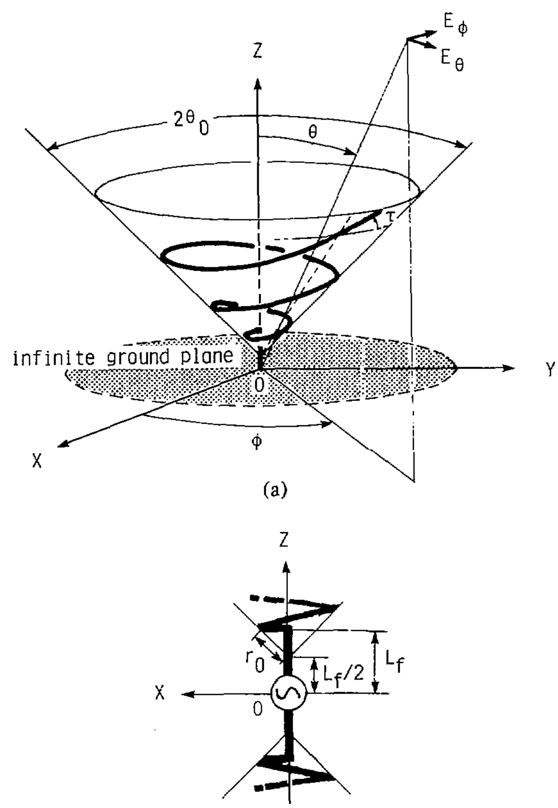

Fig. 1. Configuration and coordinate system.

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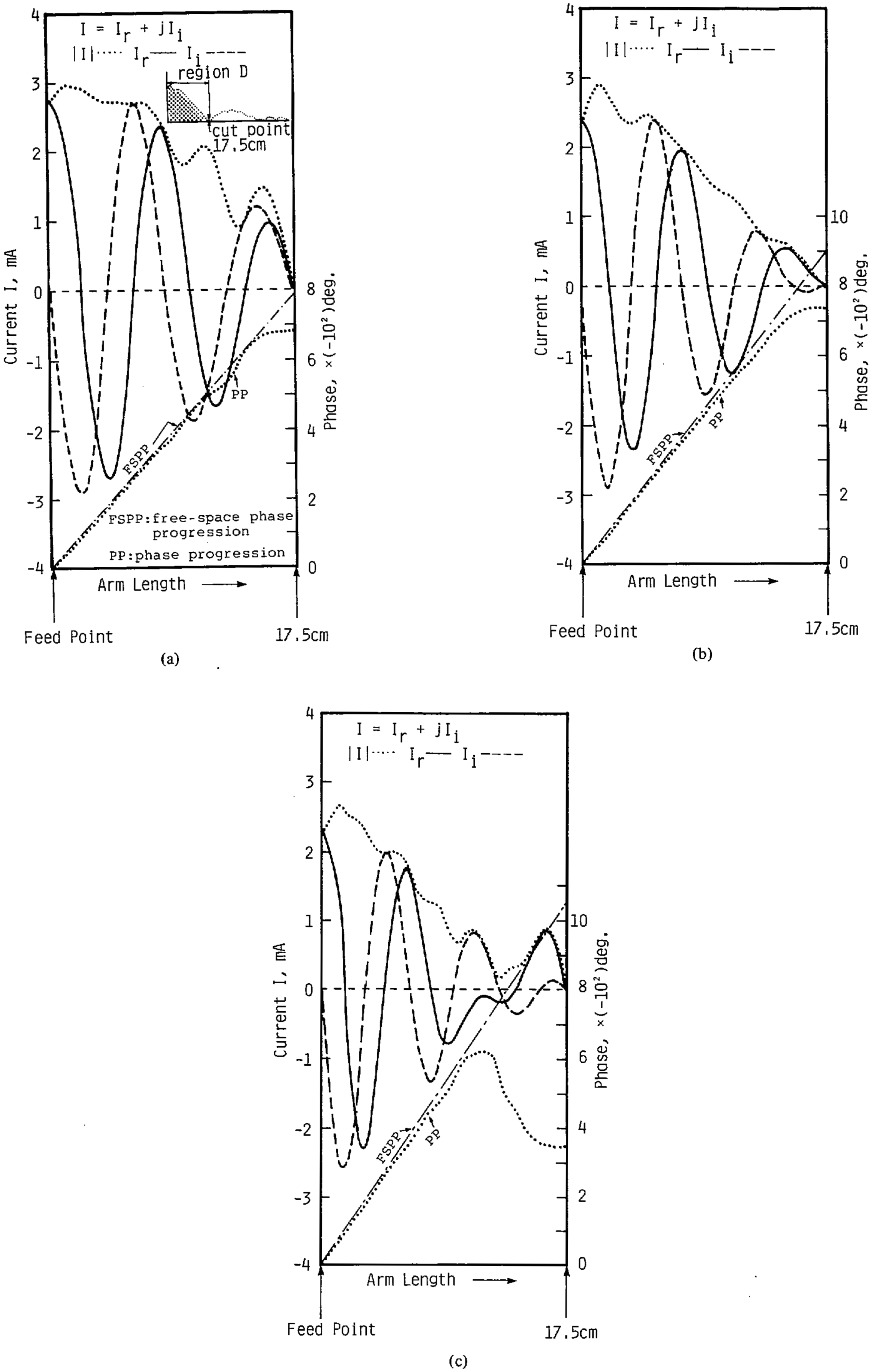

Fig. 2. Theoretical current distributions at (a) 3.75 GHz, (b) 4.25 GHz, and (c) 5.00 GHz.

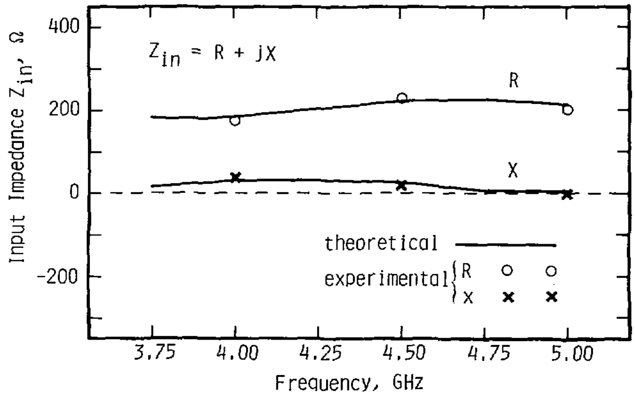

Fig. 3. Input impedance.

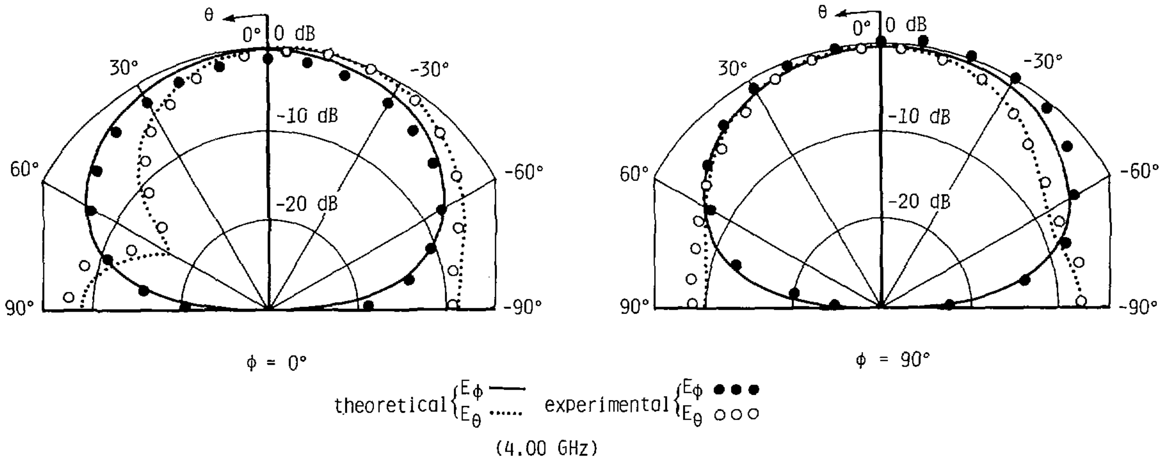

Fig. 4. Radiation pattern at 4.00 GHz.

apex angle of the cone $2\theta_0 = 90°$; the wire radius $\rho = 0.3$ [mm]; the feed wire length $L_f = 1.0$ [cm]; and the total arm length $L = 17.5$ [cm], corresponding to 2.33 λ at 4.00 GHz, where λ is the wavelength of operating frequency.

It should be noted that the present antenna is made by cutting a long conical helix antenna [1] at the first minimum point in the current distribution at 4.00 GHz (see [1, Fig. 3(c) or an inset of Fig. 2(a)]). The appearance of the minimum point is attributed to the presence of a ground plane reflector, i.e., the reflected electromagnetic fields from the ground plane reflector affect the outgoing current on the long conical helix and cause the minimum point in current distribution. By cutting the conical helix at the minimum point, the present antenna becomes a low silhouette of about 0.3 wavelengths at 4.00 GHz.

The theoretical analysis is made at frequencies in the vicinity of 4.00 GHz. The current distribution is determined by solving an integral equation [4] by a point matching method. The fact that the integral equation has the closed kernel containing neither derivatives nor integrals leads to the advantage of less computational time. Once the radiation field is calculated using the determined current distribution, the axial ratio, which is defined as the ratio of the major to minor axes of the polarization ellipse, is easily evaluated. In this communication the theoretical antenna characteristics, including the input impedance, radiation pattern, axial ratio, and power gain, are verified by experimental work.

Fig. 2 shows the theoretically determined current distributions and their phase progressions at 3.75 GHz, 4.25 GHz, and 5.00 GHz. At 4.25 GHz the current smoothly decays from the feed point with phase progression close to that in free space, whereas a standing wave appreciably appears near the arm end, as shown in Figs. 2(a) and 2(c), as the frequency deviates from 4.25 GHz. The value of current at the input, however, is nearly constant regardless of the change in frequency. This fact leads to the wide-band characteristics of the input impedance. Fig. 3 illustrates the input impedance versus frequency. The theoretical input impedance indicates almost a pure resistance of the order of 200 Ω over a frequency range from 3.75 GHz to 5.00 GHz, showing agreement with experimental results. It is noted that the experimental work is made by using the balanced type helix as shown in Fig. 1(b) instead of using an infinite ground plane, and that the balanced type helix is fed by a bazooka balun designed for each frequency. The input impedance is measured on the basis of the conventional standing wave method, and the half values of the measured input impedance are plotted because of the conversion of the balanced type of Fig. 1(b) to the real type of Fig. 1(a).

A typical radiation pattern at 4.00 GHz is shown in Fig. 4. Although the configuration is not symmetrical with respect to the Z-axis, the radiation pattern shows fairly good symmetry with respect to the Z-axis, with an average half-power beamwidth of about $\pm 40°$. Excellent agreement is seen to exist between the theoretical and experimental results.

The frequency characteristics of the axial ratio and the power gain on the Z-axis are shown in Fig. 5. It is found that, as the frequency is increased or decreased from 4.25 GHz, the axial ratio gradually deteriorates. The deterioration is due to the appearance of the

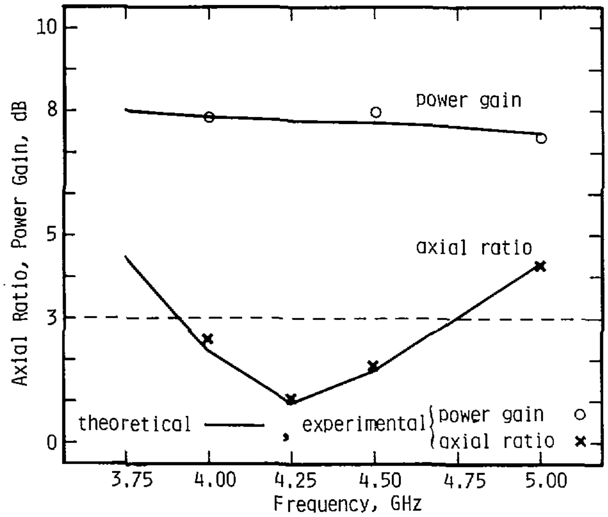

Fig. 5. Axial ratio and power gain.

standing wave in the current distribution, as shown in Figs. 2(a) and 2(c). The axial ratio of less than 3.0 dB is obtained over a frequency range from 3.90 GHz to 4.75 GHz (1:1.2), where the power gain indicates about 7.7 dB. The experimental data are also presented in Fig. 5.

III. Conclusion

A short conical helix antenna which has only a decaying current distribution has been theoretically and experimentally investigated over a frequency range from 3.75 GHz to 5.00 GHz. The present antenna has a low silhouette of about 0.3 wavelengths at 4.00 GHz. It is revealed that the short conical helix antenna radiates a circularly polarized wave with an axial ratio of less than 3 dB over a frequency range ratio of about 1:1.2, with a power gain of about 7.7 dB.

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Correction to "Renormalization of EM Fields in Application to Large-Angle Scattering from Randomly Continuous Media and Sparse Particle Distributions"

DAVID A. DE WOLF, SENIOR MEMBER, IEEE

The third of equations (5) in the above paper[1] should read $G_f = G_0 + G_0 V_f G_f$. The exponent of the last factor in the second of equations (29) should be $-ik\vec{\Omega}\cdot\Delta\vec{r}$.

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[1] D. A. de Wolf, *IEEE Trans. Antennas Propagat.*, vol. AP-33, no. 6, pp. 608–615, June 1985.

Correction to "Current Induced on a Conducting Cylinder Located Near the Planar Interface Between Two Semi-Infinite Half-Spaces"

CHALMERS M. BUTLER, FELLOW, IEEE, XIAO-BANG XU, STUDENT MEMBER, IEEE, AND ALLEN W. GLISSON, MEMBER, IEEE

In the above paper,[1] π of the denominator of the factor multiplying the integral of (33b) should be deleted, and, in (33b′), the denominator of the factor multiplying the brackets containing the Hankel functions should be 4 rather than 4π.

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[1] C. M. Butler, X.-B. Xu, and A. W. Glisson, *IEEE Trans. Antennas Propagat.*, vol. AP-33, no. 6, 616–624, June 1985.

Correction to "High Frequency Diffraction by Wedges"

GEORGES A. DESCHAMPS, LIFE FELLOW, IEEE

In Appendix I of the above paper[1] the letter F designating the Fresnel integral was omitted at several places. Equation (73) should read:

$$V(\tau) = \operatorname{sgn}\ \tau e^{-i\tau^2} F(|\tau|) = e^{-i\tau^2}[F(\tau) - \theta(-\tau)]$$

and (74) defines F by

$$F(\tau) = \frac{1}{\sqrt{\tau}} \int_\tau^\infty \exp\ i \left[\left(\tau^2 - \frac{\pi}{4}\right)\right]\ d\tau.$$

In Section III-F, on page 360, the same letter F is used to designate an electromagnetic field. It had been intended to use different characters (italic or script) for the two meanings of F. The context, however, is sufficient to distinguish between these two meanings.

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