A TWO-WIRE SPIRAL ANTENNA WITH UNBALANCED FEED

K. Hirose, M. Miyamoto*, and H. Nakano†

College of Science and Engineering, Tokyo Denki University,
Hiki-gun, Saitama, 350-0394 Japan
†College of Engineering, Hosei University, Koganei, Tokyo, 184-8584 Japan

INTRODUCTION

A two-wire spiral antenna has been numerically analyzed in the presence of a conducting plane reflector [1]. The analysis shows that, when the outer circumference is appropriately chosen, the antenna radiates a circularly polarized (CP) wave in the direction normal to the antenna plane. In practice, a balun circuit is required to achieve anti-phase excitation for the CP radiation in the normal direction [2].

The purpose of this paper is to propose a novel unbalanced feed system, which achieves quasi-anti-phase excitation without a balun circuit. The antenna is fed from a single coaxial line. The radiation characteristics are numerically investigated and compared with those for a conventional spiral antenna with a balanced feed system.

CONFIGURATION

Fig. 1 shows the antenna configuration and coordinate system. An Archimedean two-wire spiral antenna of outer circumference C is located at height h above an infinite ground plane. The inner spiral-wire ends a and b are connected to vertical wires aa' and bb', respectively, as shown in Fig. 1(c). The antenna is fed by a coaxial line from point a'. The other point b' is in contact with the ground plane. The distance between the vertical wires is designated as d.

The distance d and antenna height h are taken to be $d = 0.015\lambda_0$ and $h = \lambda_0/4$, where λ_0 is the free-space wavelength at a test frequency of f_0. Other configuration parameters are taken to be the same as those in [1] except for outer circumference C.

NUMERICAL ANALYSIS AND RESULTS

An electric-field integral equation is solved using the method of moments [3] to obtain the current distribution along a spiral antenna with an unbalanced feed system. The radiation characteristics are evaluated on the basis of the obtained current distribution.

0-7803-7070-8/01/$10.00 ©2001 IEEE

A spiral antenna having $C = 1.40\lambda_0$ with a *balanced* feed system [1] is used as a reference antenna throughout this paper.

Preliminary calculations reveal that the antenna with an unbalanced feed system radiates a CP wave over the same frequency bandwidth as that of the reference antenna, when the outer circumference is $C = 1.40\lambda_0$. Within this CP bandwidth, however, an abrupt drop in the gain is observed. The outer circumference C, therefore, must be modified so that the gain remains unchanged within the CP bandwidth.

The solid lines in Fig. 2 show the frequency responses of the gain and axial ratio for a modified value of $C = 1.51\lambda_0$. The gain is almost constant (8 dB) in a frequency bandwidth where the axial ratio is less than 3 dB (18%). A minimum axial ratio of 0.3 dB is obtained at a frequency of $0.96f_0$. (The dotted lines show the frequency responses for the reference antenna, where the bandwidth for a 3-dB axial-ratio criterion is 21% with a minimum axial ratio of 0.9 dB at $1.04f_0$.)

Fig. 3(a) shows the radiation pattern when the minimum axial ratio is obtained at $0.96f_0$. E_R and E_L in the figure are the right- and left-hand circularly polarized wave components, respectively. The radiation pattern is comparable to that of the reference antenna shown in Fig. 3(b). The half-power beamwidth is 85° (86° for the reference antenna) and the axial ratio is less than 3 dB over an angle θ coverage of 99° (92° for the reference antenna).

Fig. 4 shows the current distribution. The left side of the figure shows the current along spiral (*ap*) and vertical (*aa*') wires, where *a*' is the feed point. The right side shows the current along parasitic spiral (*bq*) and vertical (*bb*') wires. The induced current on the right side is similar to the current on the left side. The current travels toward the outer spiral-wire end *q* with decay.

The solid lines in Fig. 5 show the frequency response of the input impedance $Z_{in} = R_{in} + j X_{in}$. For reference, the input impedance for the reference antenna is also shown by the dotted lines. An input resistance of approximately R_{in} = 400 Ω for the reference antenna decreases to approximately R_{in} = 200 Ω for the spiral antenna with an unbalanced feed system.

CONCLUSIONS

A way to obtain quasi-anti-phase excitation without a balun circuit is proposed for a two-wire spiral antenna, where an inner spiral-wire end is fed from a coaxial line and the other inner spiral-wire end is in contact with a ground plane. The radiation characteristics are found to be comparable to those of a conventional spiral antenna with anti-phase excitation. The frequency bandwidth for a 3-dB axial-ratio criterion is 18%, with a gain of approximately 8 dB.

REFERENCES

[1] H. Nakano, et al., "A spiral antenna backed by a conducting plane reflector", *IEEE Trans. Antennas and Propagat.* vol. AP-34, no. 6, pp. 791 - 796, 1986.

[2] R. C. Johnson, *Antenna Engineering Handbook*, 3rd ed., New York: McGraw-Hill, 1993, ch. 14.

[3] H. Nakano in E. Yamashita (Ed.), *Analysis Methods for Electromagnetic Wave Problems,* Norwood, MA: Artec House, 1996, vol. 2, ch. 3.

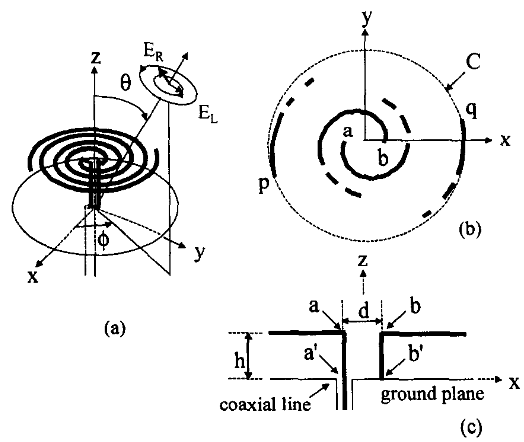


Fig. 1 Antenna configuration

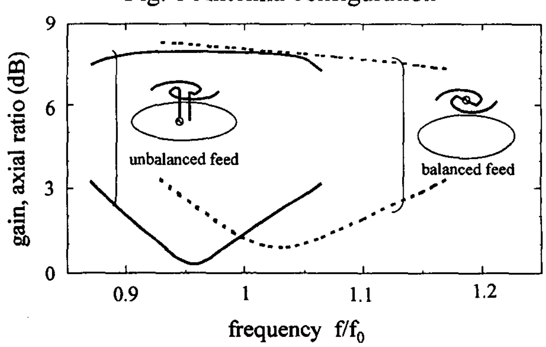
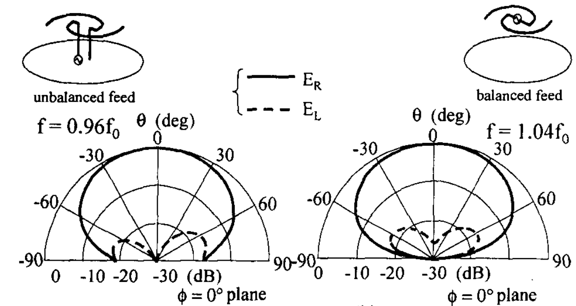


Fig. 2 Frequency responses of axial ratio and gain



(a) unbalanced feed (b) balanced feed

Fig. 3 Radiation patterns

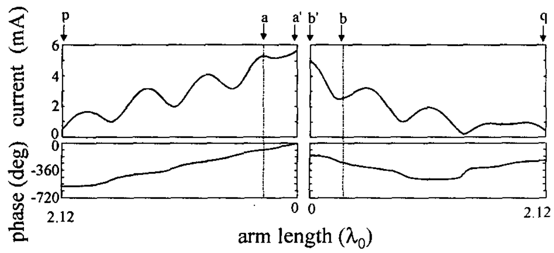


Fig. 4 Current distribution

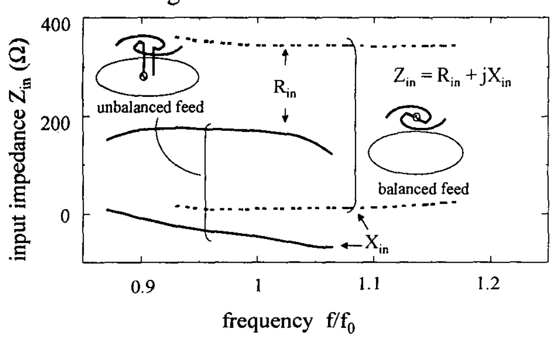


Fig. 5 Frequency responses of input impedance