A Broad Band Dual Polarized Azimuth Beamwidth Adjustable Antenna for Wireless Communications

Gangyi Deng[1], *Member, IEEE* and Bill Vassilakis[1], *Senior Member, IEEE*

[1]Powerwave Technologies, Inc., R&D
1801 St. Andrew Pl., Santa Ana, CA 92705, US
gdeng@pwav.com
bvassilakis@pwav.com

Introduction

Dual polarized remote controlled elevation beam down-tilt base station antennas (BSA) have been widely deployed in mobile communication systems. Their use allows mobile network operators to optimize system performance, and improve the network efficiency to some degree. The elevation beam tilt angle of the BSA can also be remotely adjusted without shutting down the network, which is very costly, and avoid tedious and expensive tower climbing work. Recently, some operators have requested more functionality in the BSA, in order to further improve the performance and the efficiency of their networks. Not only is it a requirement to control the elevation beam tilt angle, but they also want to adjust the azimuth beam (AZB) direction and change the AZB width so as to further improve the coverage and capacity of the network dynamically. This is referred to 3-way (pan-fan-scan) control antennas. The adjustable AZB width antenna is discussed in this paper, while the azimuth beam direction adjusted function can be quite obviously achieved by mechanically rotating the antenna.

The proposed new concept of adjusting AZB width for BSA is by staggering the radiating element in the horizontal direction mechanically to achieve the AZB width controllability. This proposed design has adjustable AZB width range from 60° to 90° since the most popular wireless systems at present have either 6 sector antenna with 65° AZB width, or 4 sector antenna with 90° AZB width. The authors believe that the AZB width variation from 60° to 90° is adequate for network optimization with minimum antenna cost and size increase. The radiating element used in this particular concept, is a traditional crossed dipole with fish-hook type of balun feed. A prototype of the crossed dipole element is shown in Fig. 1. This element provides excellent port-to-port isolation (>30 dB) across the frequency band of the interest (1710 to 2170 MHz). A measured isolation plot is shown in Fig. 2. The concept of staggering the elements has the advantage of providing lower cost and smaller overall profile versus other types of phased array antennas, such as multi-column arrays that employ passive or active phase and amplitude control, and that changes the reflector angle with various schemes. The multi-column phased array is very expensive, while the changing reflector angle concept has large aperture size. The element staggering function can also be achieved remotely.

The aim of this work is to investigate the feasibility and performance of staggering the crossed dipole elements in order to achieve the required AZB width. Experimental results for the array in both non-staggered and staggered configurations are presented.

Theory and Design

The single crossed dipole element, as shown in Fig.1, consists of two traditional dipole elements with fish-hook type of balun feed on printed circuit board (PCB). It has excellent broadband performance; the measured S parameters are shown in Fig. 3 and Fig. 4. The length of the dipole is about half wavelength (~77mm) at the center frequency of the band which is 1940 MHz, and the height of the dipole is about quarter wavelength (~38.5mm). The two dipoles have the same height, but the feed of the dipoles have a slightly different height so as to get the two dipoles crossed to create the dual cross-polarization antenna for polarization diversity. The crossed dipole is designed using HFSS software from ANSOFT Corporation. The analysis results show the input impedance of the dipole at the bottom of the feed to be about 50 Ω. Each crossed dipole is mounted on a movable sheet metal structure, which can be remotely controlled by a linkage system. The 15 elements are arranged in a single column configuration with 90 mm element spacing, the total length of the antenna being 1.4 meters, as shown in Fig. 5. For the staggered configuration, 7 elements stagger to each side by 35 mm while the center element stays in place, as shown in Fig. 7.

The radiation patterns of the array were simulated using the commercially available software package EZNEC. Both the model and simulation results for the 15 non-staggered element array are shown in Fig. 5 and Fig. 6, respectively. The simulation results show the desired ~ 90° Half Power Beam Width (HPBW) in the horizontal plane. The model and simulation results for the staggered 15 element array are shown in Fig. 7 and Fig. 8, respectively. The simulation results show the desired ~ 60° HPBW in the horizontal plane.

Experimental Results

In order to verify the simulation results, a 15 element array was fabricated and tested. Fig. 9 shows the prototype of the non-staggered 15 element array while Fig. 10 shows the measured radiation pattern of the azimuth beam of this configuration. Fig. 11 shows the prototype of the staggered 15 element array while Fig. 12 shows the measured radiation pattern of the azimuth beam of this configuration. Patterns were measured in a 11.5 m (L) x 9 m (W) x 8 m (H) shielded Spherical Near-Field (SNF) range currently in use at Powerwave Technologies, Inc. in Santa Ana, California, US.

Conclusion

A 15 crossed dipole element array antenna with excellent AZB width adjustability was presented. A prototype of the antenna has been designed, simulated, built and tested. Excellent port to port isolation of the crossed dipole has been achieved. The measured radiation patterns on both non-staggered and staggered configurations are in good agreement with simulated results. Therefore, a simple low cost AZB width adjustable antenna for base station systems can be constructed that effectively provides a means for operators to further optimize mobile cellular network performance.

Acknowledgments

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References

[1] R. C. Johnson, “Antenna Engineering Handbook”, Third Edition, 1993, Chapter 4-4.
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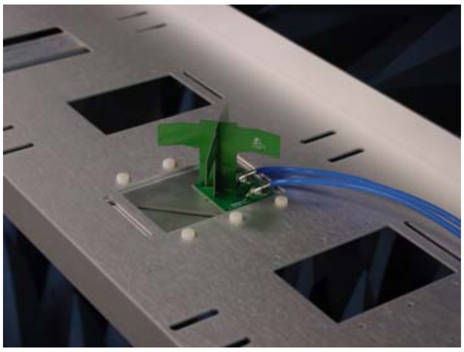

Fig.1 Prototype of a crossed dipole element

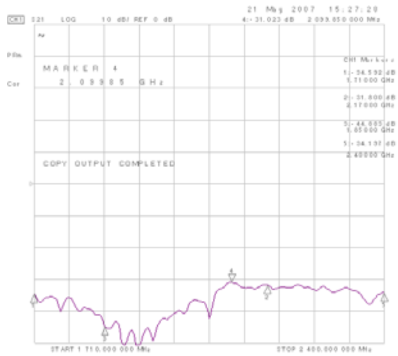

Fig. 2 Measured port to port isolation

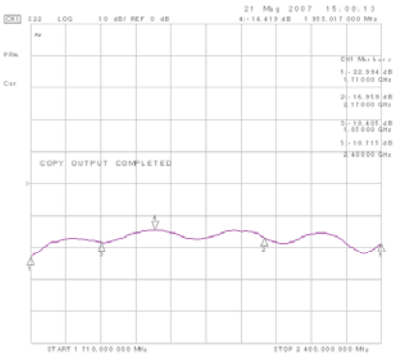

Fig.3 Measured return loss of one port of the crossed dipole element

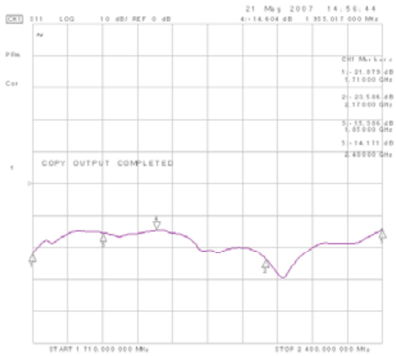

Fig.4 Measured return loss of the second port of the crossed dipole element

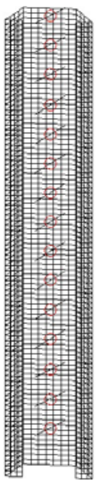

Fig.5 15 non-staggered element model in EZNEC

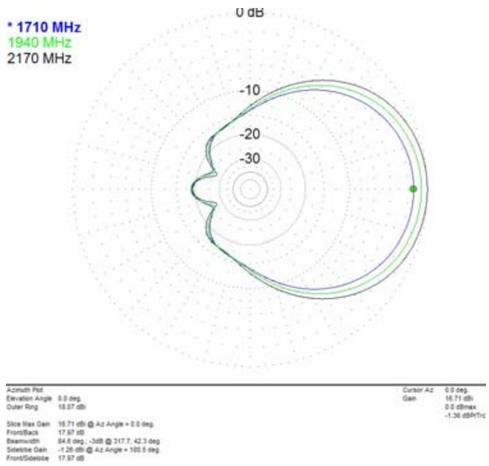

Fig.6 Predicted pattern of the 15 non-stagger element array

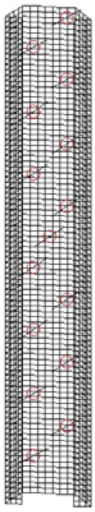

Fig.7 15 staggered elements model in EZNEC

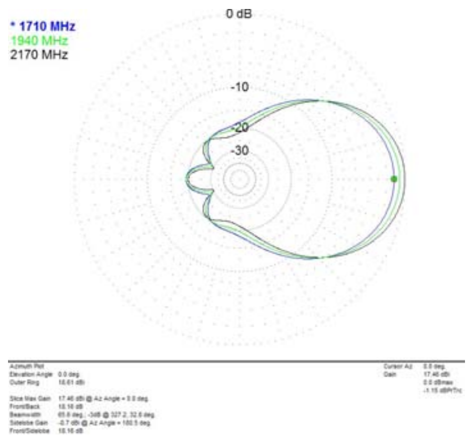

Fig.8 Predicted pattern of the 15 staggered element array

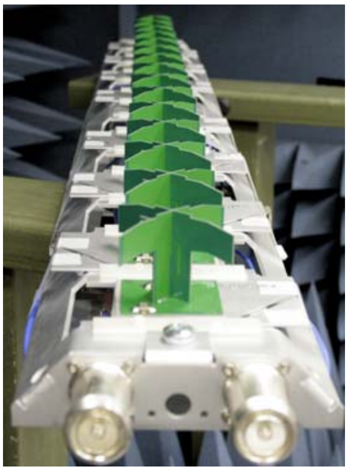

Fig.9 A prototype of non-stagger array

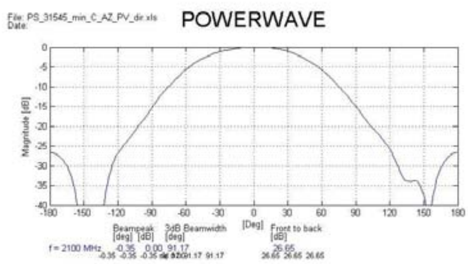

Fig.10 Radiation Pattern on Azimuth plane

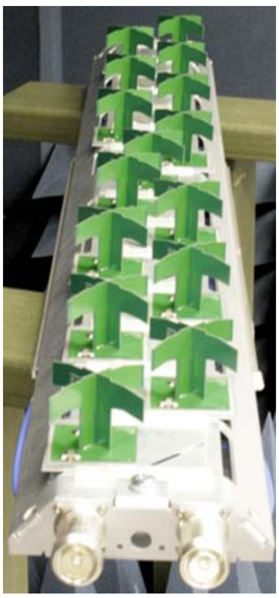

Fig. 11 A prototype of staggered array

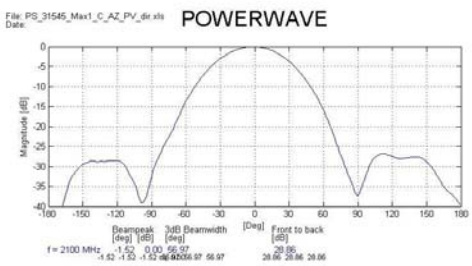

Fig. 12 Radiation Pattern on Azimuth plane