A Broadband Dual Polarized Antenna Element for Wireless Communications

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Abstract

A folded metal boxed dipole is of considerable interest as a broadband antenna element, and has good potential for use in low cost base station antenna design for wireless communications. In this paper, experimental and simulation results are presented which include both a folded metal single dipole, and a dual polarized boxed dipole. The results show that this new dipole element has excellent gain performance and radiation pattern profile, and results are closely correlated to simulated values. The use of this type of dipole eliminates the need for cable assemblies and costly circuit boards.

Introduction

The ideal base station antenna for use in wireless communications would have broadband performance, small aperture, high gain, low sidelobe levels, and the required appropriate beamwidth for cell sector design. In addition, power handling (500 Watts for Cellular band) must be adequate, intermodulation levels must be low, and assembly and manufacturing must be easy and geared for high volume. Increasingly, cost is a major factor, especially for applications in the emerging markets. In existing designs, the use of parabolic reflectors and elements composed of aperture-coupled stacked patches, lead to good performance, but it is difficult to achieve the required cost targets due to the use of extensive cabling and high cost printed circuit boards.

The proposed new folded metal microstrip feed dipole provides broadband performance of 15% (824 – 960 MHz for CDMA/GSM). As it is composed of bent sheet metal, it provides the high power handling required, and provides for ease of assembly and volume production. Fig.1 illustrates the single dipole. The antenna element is composed of two conductors formed from a sheet of conductive material, in this case aluminum. One is attached to ground with the dipole arm towards one side, while another one is spaced to the ground with the dipole arm towards the opposite side. The input section connects one part of the radiating section to the feed line, and the conductor section connects another part

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of the radiating section to the ground plane. The radiator input has an intrinsic impedance that is adjusted by varying the width of the conductor sections and the gap. The two legs of the dipole form a balanced broadside coupled stripline transmission line. The transmission line is balanced, so it is unnecessary to provide a balun. This provides an antenna with very wide impedance bandwidth. Fig.2 shows the boxed dipole in a square reflector with sidewalls on all sides. Because of the boxed dipole arrangement, the isolation between the two polarization channels is improved dramatically.

The aim of this work is to investigate the feasibility and performance of the boxed dipole arrangement. Experimental results for single dipole and boxed dipole are presented.

Theory and Design

The single dipole element, as shown in Fig.1, consists of a broadside coupled stripline, dipole element, and a quarter wavelength transformer. The broadside coupled stripline is balanced, and it provides the feed to the dipole. Moreover, the bandwidth of the broadside coupled stripline is ultrawide. The length of the dipole is half wavelength (~168mm) at the center frequency of the band which is 892 MHz, and the height of the dipole is about quarter wavelength (~84mm). The energy transfer between the broadside coupled stripline and the dipole is designed by the Moment of Method (MoM) code software IE3D of Zeland™ software Inc. The analysis results show the input impedance of the dipole at the bottom of the feed is about 135 Ω, and by using one stage of quarter wavelength transformer, the input impedance is transformed to 50 Ω.

Fig.2 shows the simulation of the return loss of the single dipole with one stage quarter wavelength transformer. Fig.3 shows the two pair of dipole arranged in a square configuration. The radiation element for use in a dual polarized antenna with isolation between polarization channels composed of four radiating elements arranged in a general square configuration to provide a boxed arrangement. The four elements are configured on a squared ground plate with equal height of sidewall. The dipole couples strongly with the neighboring orthogonal dipoles if the two parallel dipoles are fed with equal phase and amplitude and if arranged symmetrically with respect to the orthogonal dipoles, then the coupled energy from one neighboring dipole will be of equal magnitude and opposite phase as energy from the other neighboring dipole. The two coupled fields therefore cancel out. The isolation between two polarization channels will be improved dramatically because of the boxed dipole arrangement. The antenna elements are preferably paired dipoles with a mirrored feed pattern. The boxed dipole is contained in a square of 257 x 257 mm^2 with 40 mm sidewall ground plate. The input impedance is designed for 50 Ω on both polarizations. Fig.4 shows that the simulated result of return loss for both polarizations is greater than 15 dB across the band of 824 – 960 MHz, and the insertion loss between these two polarization ports is better than 35 dB across the band of the interest.

Experimental results

In order to verify the simulation results, a single boxed dipole element was fabricated and tested. Fig. 5 and Fig. 6 show the measured results of the return loss on both polarizations of the two ports, while Fig.7 shows the measured insertion loss between the two polarization ports. Fig. 8 shows the measured gain of the two ports of the boxed dipole across the band of 800 – 960 MHz, while the Fig. 9 and Fig. 10 show the azimuth co- and cross-pol and elevation co- and cross-pol patterns of the boxed dipole element. Patterns are taken in the 21 m (L) x 12 m (W) x 10.5 m (H) with 3 m (L) x 3m (W) x 3 m (H) quiet zone compact range with attenuation of 50 dB.

Conclusion

A folded metal boxed dipole element on a square box of ground plate is presented. A prototype of the boxed dipole element has been designed, built and tested. Excellent port to port isolation has been achieved from the symmetrical arrangement. Good antenna patterns and gain indicate that a simple low cost antenna for base station systems can be constructed that will have excellent performance and cost benefits.

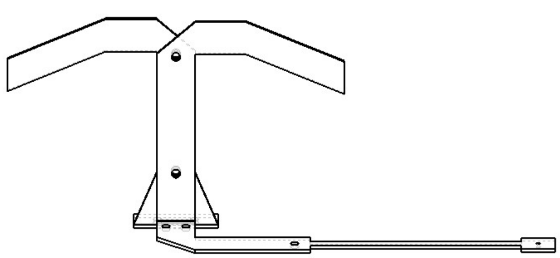

Fig.1 Dipole feed by paired microstrip line

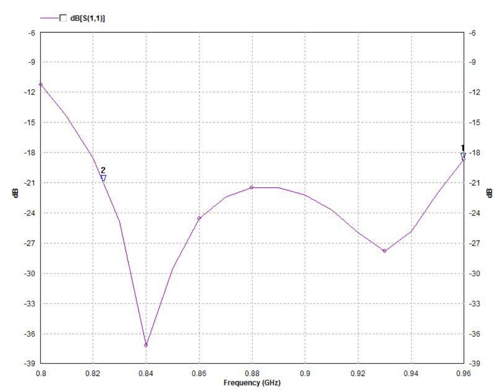

Fig. 2 Simulation Result on single dipole

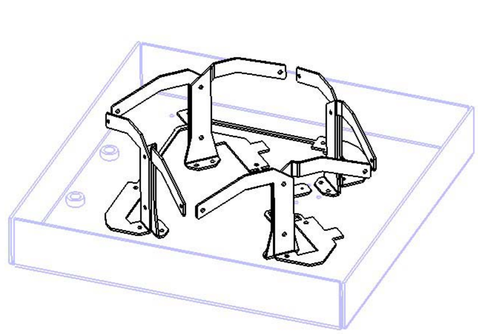

Fig.3 Boxed dipole for dual polarized antenna

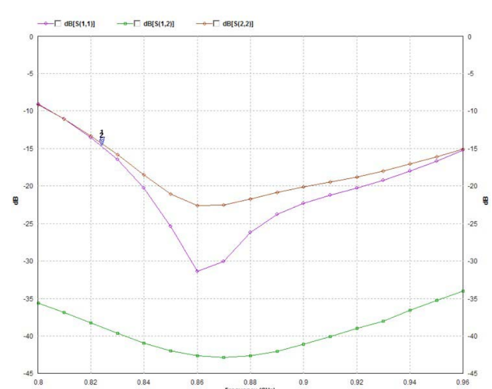

Fig. 4 Simulation Results on boxed dipole

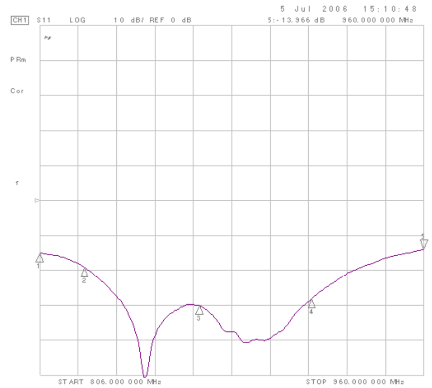

Fig.5 Measured return loss of one port of the boxed dipole element

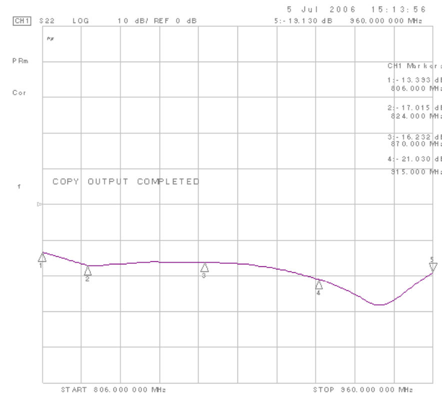

Fig.6 Measured return loss of the second port of the boxed dipole element

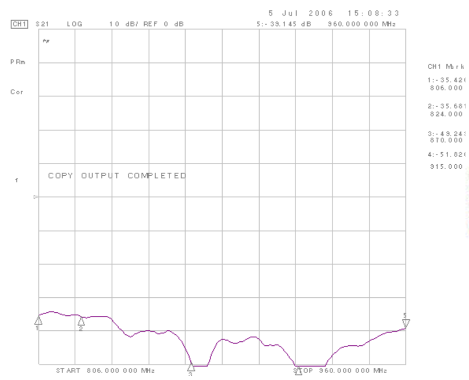

Fig.7 Measured port to port isolation port of the boxed dipole

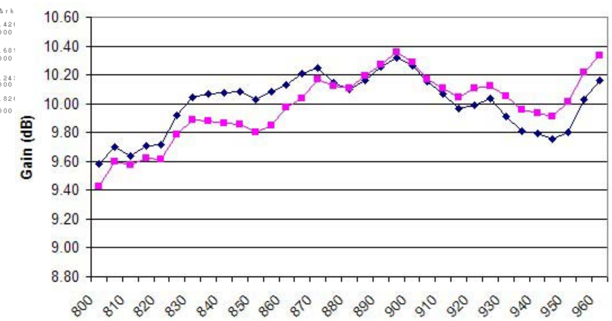

Fig.8 Measured Gain on two polarizations

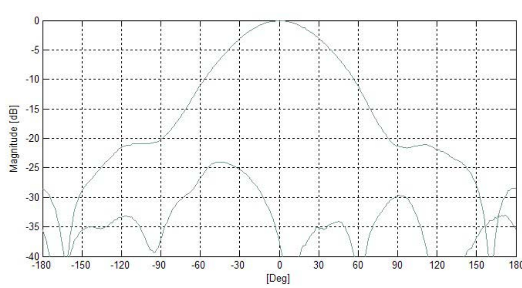

Fig.9 Radiation Pattern on Azimuth Co- and cross-pol

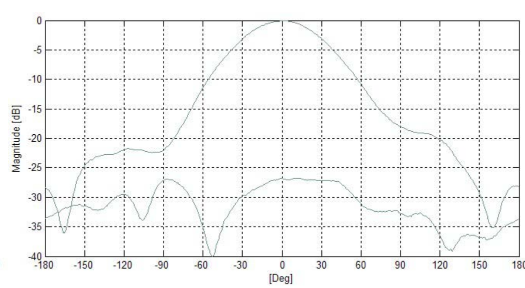

Fig.10 Radiation Pattern on Elevation Co- and cross-pol

References

[1] R. C. Johnson, "Antenna Engineering Handbook", Third Edition, 1993, chapter 4-4.

[2] B. C. Wadell, "Transmission Line Design Handbook", 1991, pp 226.