White Paper

"The Compact Quadrifilar Antenna (CQA) for Handheld GPS and Satellite Radio Reception"

Stanislav Licul, Jeremy Marks, and Warren Stutzman

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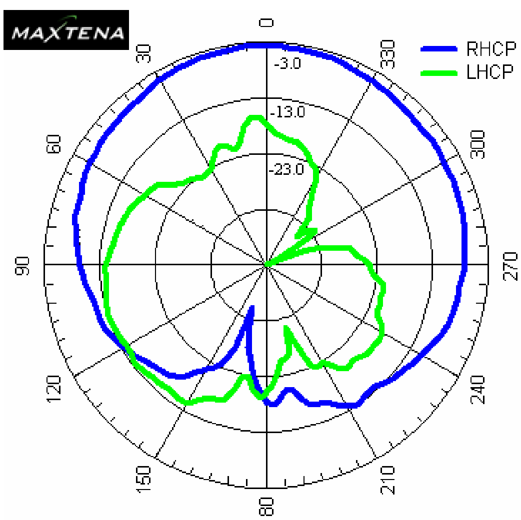
Summary:
The cell phone industry has been able to shrink both the size and cost of handsets by reducing part count and by increasing the use of integrated circuits. Only 10 years ago, pagers and cell phones included many discrete parts and RF front-end circuits used single-ended designs interfaced to a 50 Ω single-ended antenna. In recent years, RF integrated circuits have replaced discrete component transmitters and receivers in most wireless devices. The single-ended design remains a problem in applications where space is limited because currents are driven onto the metallic parts in the device, causing performance reduction and human exposure increase. Differential feed designs are needed to replace single-ended antenna interfaces.

A quadrifilar antenna has four antenna elements that differ in phase by 90 degrees, creating circular polarization (CP). But a CP antenna is also useful in handsets to receive linear polarization (LP) because it is insensitive to LP polarization orientation. A quadrifilar antenna requires four excitations (0º, 90º, 180º, 270º), which can be accomplished with a set of differential signals (0º, 180º). This feed arrangement avoids a matching network and balun, reducing insertion loss and noise figure.

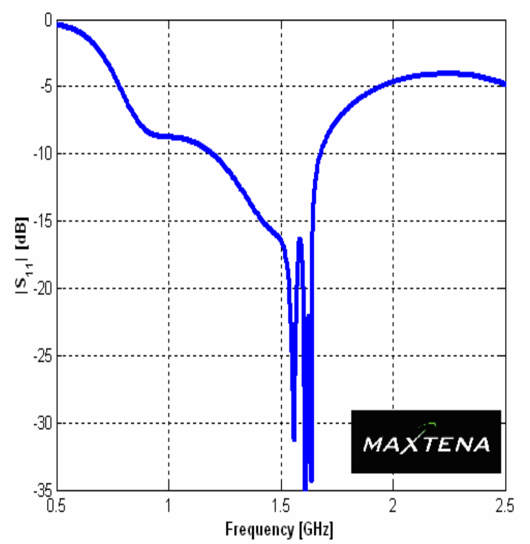
The new compact quadrifilar antenna (CQA) design is a low profile (1 cm x 2 cm) helical antenna for CP applications. The CQA is an improvement over previous quadrifilar antennas because the balun is eliminated from the antenna assembly, leading to significant size reduction. Some designs employ very high dielectric constant materials for antenna size reduction, but this leads to low efficiency and reduced bandwidth. Also, the use of discrete passive devices on a printed circuit board to generate the quadrature phases lowers the manufacturing cost and makes tuning of the antenna much easier.

This design has performance superior to other miniature passive CP antennas for GPS and satellite radio applications. Measured results include: more than 30% efficiency, a wide (140º half-power beamwidth) and symmetric zenith-directed mainbeam, axial ratio of 0.2 dB, front-to-back ratio of 12 dB, and input VSWR of about 1.3:1. Shown below are some measured radiation patterns and return loss for a GPS version of the antenna.

Furthermore, this design presents, not only a novel differential feeding approach, but also a single platform for **a modular quadrifilar antenna design**. The **phase shifter** for generating the quadrature phase is completely separated from the **antenna element** (helical arms on a dielectric core). This approach contributes to greater amplitude and phase balance, and isolation among the antenna feeding ports. This is reflected in an excellent axial ratio of 0.2 dB. The modular approach allows multiple size variations of an antenna element as well as various phase shifter approaches (diameters of 5 to 10 mm). Thus, the modular approach allows a single platform for having different radiation characteristics (e.g. efficiencies in the range of 10-90% and optimized pattern shapes) which results in a reduced manufacturing cost.



Elevation Plot vs θ, x-z plane, ϕ = 0



Performance data from experiments and simulations will be presented for various models. Also, a new approach to adding filtering capability using this design will be presented along with measured data. This new approach to filtering, combined with increased efficiency from the differential feed, will show that improved performance can be achieved with next generation miniature CP antennas for handset applications.