Dual-Band Quadrifilar Helix Antenna

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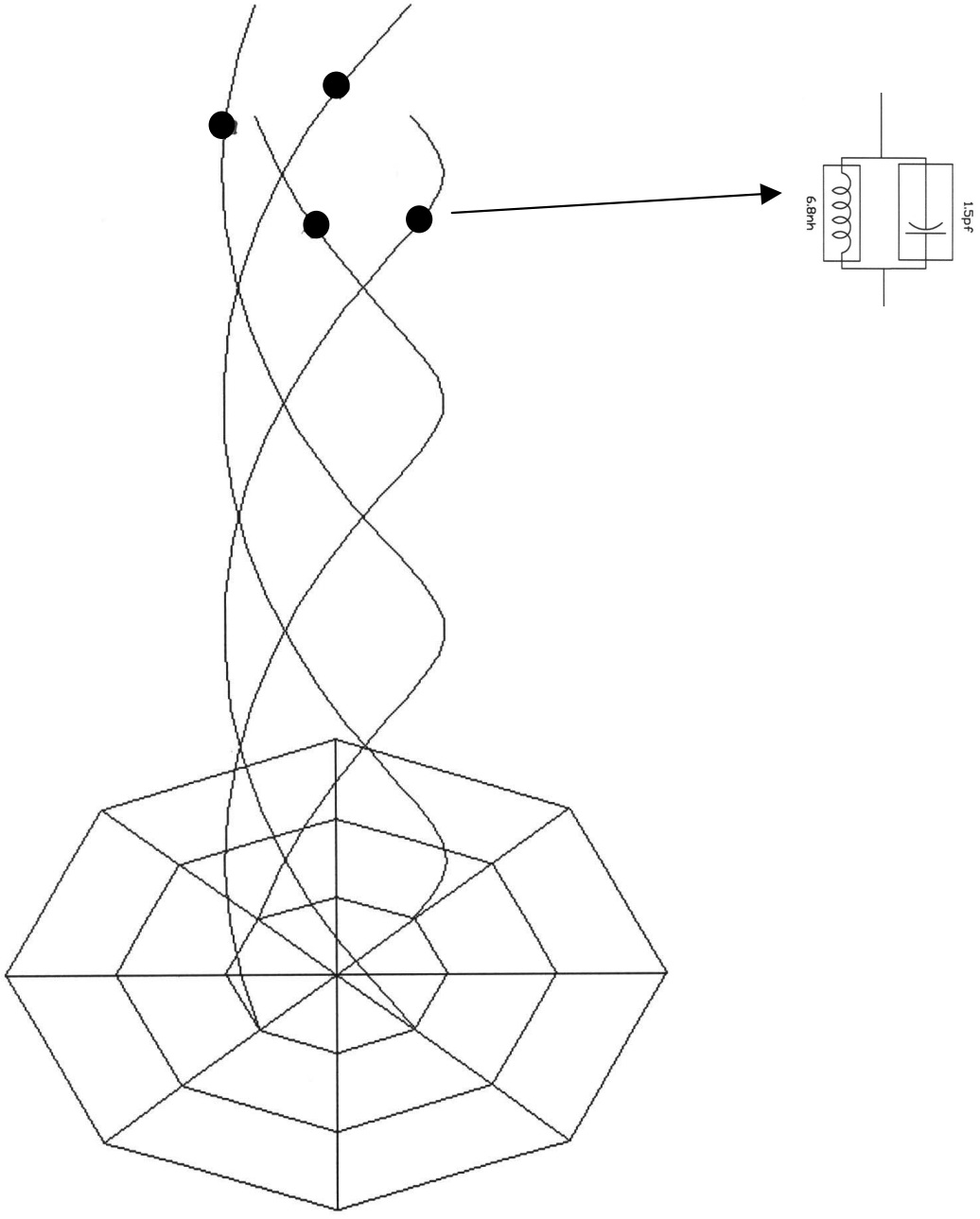
Resonant quadrifilar helix antennas are widely used on hand-held receivers for GPS (Global Positioning System) and for some mobile communication systems. (1) The significant advantages of this type of antenna include its relatively compact size and its cartioid shaped pattern with excellent right-hand circular polarization coverage and high axial ratio over most of the field of view. Since it is a resonant antenna, its dimensions are chosen to provide optimal performance for one frequency band. Several techniques have been described in publications that would extend this antenna's capability to two frequency bands (L1 and L2 for GPS applications). Each of these techniques has some limitations with respect to size and/or performance. A technique is described here that provides the same performance in two separate frequency bands and has no impact upon the overall size of the helix antenna.

Each of the 4 arms of the quadrifilar helix used here has one turn, with an open at one end and the feed point at the other end. The length is chosen for resonant operation at the lower frequency band. To provide resonant operation at the higher frequency band, a trap circuit is placed at an appropriate location in each arm. A trap is a passive circuit that acts as a switch. It consists of a parallel LC circuit (lumped components) that has infinite impedance (e.g., open circuit) at its resonant frequency. At the lower frequency, the trap circuit has low reactive impedance that can be compensated by a slight change in the overall length of the helix. The four arms of the helix are excited with sequential phase variation, 0°, 90°, 180°, 270° to obtain circular polarization.

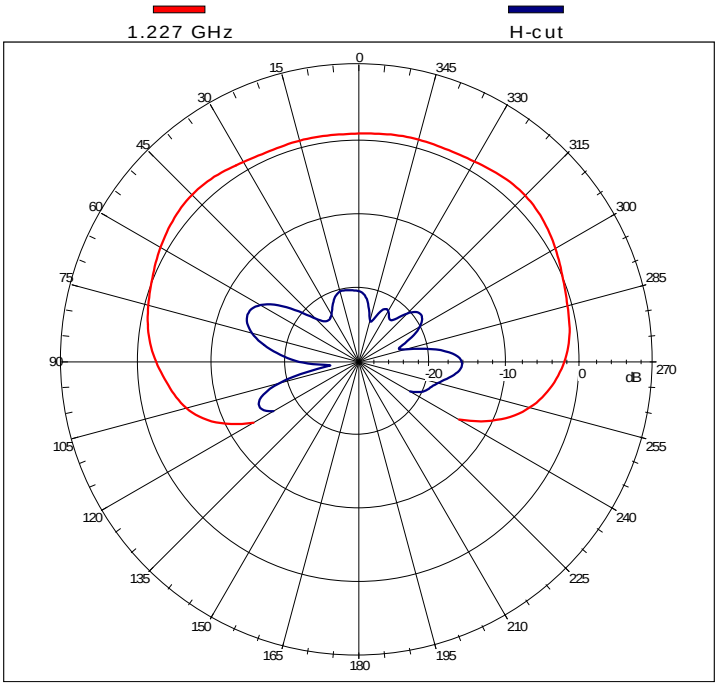
The peak of the radiation pattern for this antenna can be designed for either the forward axial direction (toward the open end of the arms) or the backfire axial direction. The former requires the placing of a small circular ground plane (diameter < 1/3 wavelength) perpendicular to the axis at the feed points. The latter has no ground plane. The initial experimental demonstration of this antenna was done for the forward direction along the axis. Since the helix inherently a backfire antenna, the ground plane is a reflector to redirect the energy. Because reflection of a circularly polarized electromagnetic signal from a planar conductor changes its sense of polarization, radiation of a right-hand circularly polarized signal requires the helix to have a left-hand twist. An example of a quadrifilar helix antenna over a ground plane and with trap loading is shown in the first figure.

A model of this antenna was built to operate at two frequency bands, 1227 MHz and 1575 MHz, with more than 2% bandwidth in each band. The four wires of the helix were created using narrow copper strips on a flexible mylar sheet that is then rolled into a

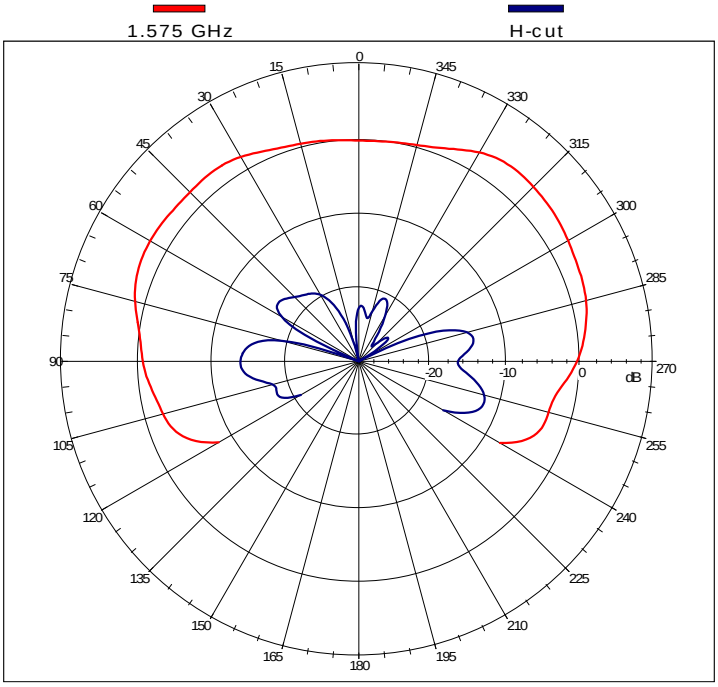
cylinder to form the helix. The trap circuit is placed across the gap in each strip. To obtain anti-resonance at the higher frequency, the trap circuit values are L = 6.8 nh and C = 1.5 pf. The four arms of the helix were then attached to a base plate whose diameter was chosen to reflect the energy from the helix while still maintaining coverage for angles just below the horizon, a cardioid pattern. Examples of the right-hand circular polarization elevation plane patterns measured at those two frequencies are shown below.



The inner patterns in each case are left-hand circular polarization or cross polarization residuals.

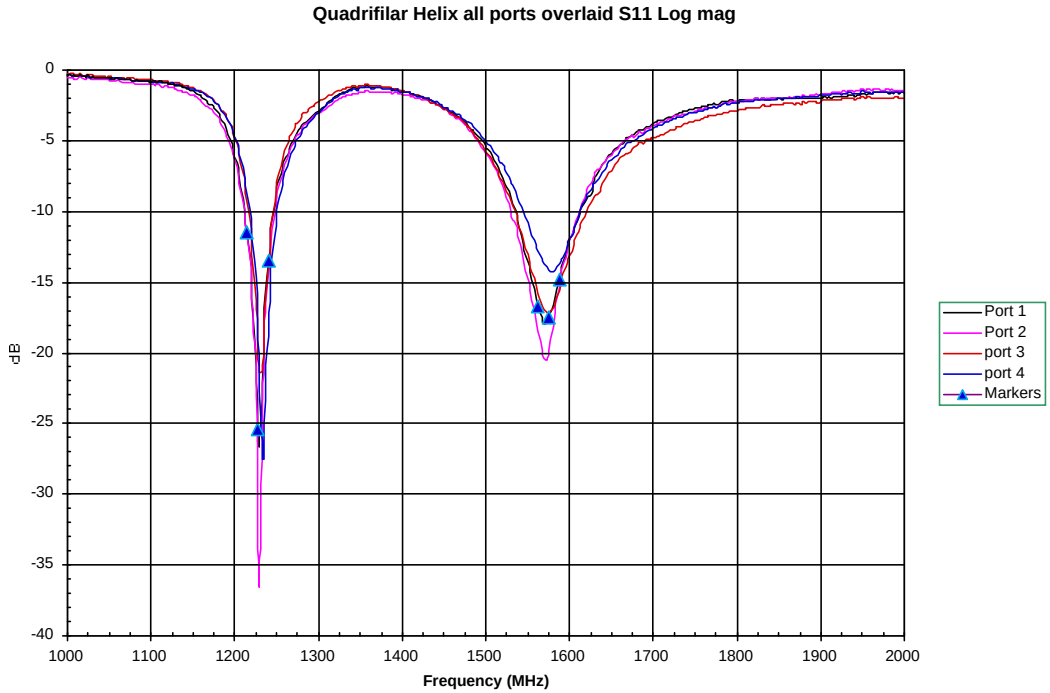


Elevation H-Cut 1.227 GHz



Elevation H-Cut 1.575 GHz

The input match for the antenna is illustrated by an overlay of the reflection coeficients at the input to each of the four arms of the helix.



1. O. Neill, Gregory A., Jr., Patent 5,920,292, 6 June 1999.
2. Tranquilla, James M. and Steven R. Best, “A Study of the Quadrifilar Helix Antenna for Global Positioning System (GPS) Applications,” *IEEE Transactions on Antennas and Propagation*, Vol. 38, No. 10, October 1990, p.1545.