The Quadri-Filar Helix Antenna as shown in Figure 1 has already been described in detail and discussed in references [1], [2], [3], [4]. That discussion will not be repeated here. Unfortunately, very little has been written on how to build a Quadri-Filar Helix Antenna to radiate with RHCP (Right Hand Circular Polarization) or with LHCP (Left Hand Circular Polarization).

To test the radiation characteristics of a Quadri-Filar Helix antenna, four prototypes were built for 2400 MHz. As can be seen from Figure 1, RHCP or LHCP is achieved if both loops are wound in the reverse direction of the desired field rotation so that LHCP is achieved by winding both loops right hand and RHCP by winding both loops left hand, which is exactly the opposite of a W8JK type helix antenna.

Figure 2 contains the design details. Half of the small bifilar loop was made of semi-rigid coaxial cable, UT-047. Silver plated copper wire with a diameter of 1.2 mm was used for the other half of the small bifilar loop and for the entire larger, second bifilar loop.

In Figure 2 the ends of the loops are connected to a so-called infinite balun having a phase relationship that here reinforces the field in the upward direction to generate endfire radiation. That cancels the field toward the SMA connector and feed point.

In Figure 3 it can be seen how the small and the large bifilar loops of a RHCP Quadri-Filar Helix are wound in the left-hand direction and are connected to the infinite balun having a phase relationship that reinforces the field in the downward direction to generate a backfire radiation that reinforces the right-hand circular field toward the feedpoint and creates a null in the upward direction of the picture in Figure 3.

Because the phase relationship in Figures 2 and 3 produces currents that reinforce the field in one direction and a field cancellation in the opposite direction, then both the above RHCP Quadri-Filar Helix antennas become a directional antenna, which does not need a reflector.

Figure 4 shows an enlarged view of the infinite balun, which is connected for endfire RHCP, as is shown in Polar Plot 1. In Figure 4 the RHCP radiation pattern points in the direction of the viewer. The interconnection for RHCP backfire radiation is shown in Figure 5 with the pattern shown in Polar Plot 2. In Figure 5 the RHCP radiation takes place in the opposite direction of the viewer and so is toward the feedpoint.

Figure 6 shows an enlarged view of the infinite balun, which is connected for LHCP endfire radiation, which is shown in Polar Plot 3. In Figure 6 the LHCP radiation pattern points at the viewer. In Figure 7 the interconnection for LHCP backfire radiation is shown in accordance with Polar Plot 4. In Figure 7 the LHCP radiation takes place in the opposite direction of the viewer and so toward the feedpoint.

The radiation pattern in Polar Plot 1 shows the result of these experiments for a RHCP Quadri-Filar Helix Antenna with endfire radiation. Polar Plot 2 shows the same for a RHCP Quadri-Filar Helix Antenna with backfire radiation.

As a further explanation, endfire radiation by definition takes place opposite to the feed point while backfire radiation points toward the feed point of the antenna. See Polar Plots 1 to 4.

During experimentation with connections of the loops to the infinite balun has been found that a connection producing endfire radiation in a RHCP Quadri-Filar generates backfire radiation in a LHCP Quadri-Filar as shown comparing Figure 4 to Figure 6. Likewise connections producing endfire radiation in a LHCP Quadri-Filar generates backfire radiation in a RHCP Quadri-Filar as shown comparing Figure 6 to Figure 5.

Another point, which has not been discussed in great detail in the references, is the feeding and phasing method with help of the infinite balun. This make it possible the self matching of the loop elements to a 50 ohm line as well to feed the loop element in such a way that either circular endfire radiation or circular backfire radiation can be achieved depending on loop connections to the infinite balun as schematically illustrated in each of the radiation patterns.

The gain of a Quadri-Filar Helix Antenna amounts to about 5 dBi and radiation patterns from Polar Plots 1-4 show that the major lobe of this type of antenna is very well suited to be used as a feed to illuminate dishes with a f/D ratio of 0.3. Because the illumination angle for feed at the edge of the dish is approximately 159 degrees, the space attenuation is 4.6 dB and the desired taper is 5.4 dB for –10 dB edge illumination.

A further advantage of the Quadri-Filar Helix antenna compared to a helix or to a patch used as a feed in a parabolic dish is its small size because the Quadri-Filar Helix Antenna is a directional antenna which does not need a reflector, so that the shadow, which a
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Figure 2 (above)
Construction of the RCHP-Endfire Type

Figure 3 (above)
Construction of the RCHP-Backfire Type

Figure 4 (above)
Detail photograph of the RHCP-Endfire

Figure 5 (above)
Detail photograph of the RHCP-Backfire
reflector can produce with a small diameter dish, can be neglected and thus increase the overall efficiency of the dish.

In addition to the above advantage, a dish with f/D=0.3 or less has only a small spillover since its focal length is short and the feed is close to the bottom of the dish. These conditions improve the G/T ratio of the system in comparison to other receiving systems, which use the same receiver to a dish with the same diameter but larger f/D ratios.

Since a parabolic dish reverses by reflection the direction of polarization of a circularly polarized wave, then a LHCP Quadrifilar Helix Antenna is needed as a parabolic feed to receive a RHCP signal transmitted by AO40. For this reason two LHCP prototypes for 2400 MHz were built. The first one was connected for LHCP endfire radiation as shown in Figure 6 and Polar Plot 3 and the second one was connected for LHCP backfire radiation as shown in Figure 7 and Polar Plot 4.

In the case of a feed with a LHCP endfire radiation pattern as in Polar Plot 3 mounted in a dish, the Quadrifilar Helix must point toward the dish and the SMA connector for the downconverter must point outward to the outer space. This is the best method for mounting the feed. On the other hand, in the case of a feed with a LHCP backfire radiation pattern as in Polar Plot 4 the helix must point to the outer space and the SMA connector for the downconverter must point toward the dish.

During the above experimental investigation it was found that another desirable characteristic of a Quadrifilar Helix Antenna used as a feed in a parabolic dish is its circularity, as shown in Polar Plot 5.

To measure the circularity a RHCP endfire Quadrifilar Helix Antenna was installed in front of a half wave slowly spinning dipole, which was fed by a signal generator through a rotating coaxial joint. As shown in Polar Plot 5, the Quadrifilar Helix was directed first toward the spinning dipole, which was at an angle of 0 degrees. The signal received from a spectrum analyzer was measured and resulted in the curve marked “circularity at 0”, which had a maximum axial ratio of only 1 dB between the 0-degree and 90-degree points of the polar plots.

And finally the Quadrifilar Helix antenna was turned by 90 degrees relative to the spinning dipole and the maximum axial ratio was measured at 16 dB at the 90 and 270-degree points. However, it decreased by less than 1 dB at the 0 and 180-degree points, as can be seen in the curve marked “circularity at 90°”. The Polar Plot circularity indicates that a Quadrifilar Helix antenna is ideal for illuminating the entire surface of a dish with very good circular polarization and has a very small axial ratio from the center of the dish to about its edge.

During the above experimental investigation the unknown circularity direction of a Quadrifilar Helix antenna was determined.
against a reference patch antenna connected for LHCP. A 2400 MHz signal generator as a transmitter drove the patch antenna while the Quadrifilar Helix antenna was connected to a spectrum analyzer as a receiver as seen in Figure 8. If the output from the Quadrifilar Helix antenna remains constant or varies very little, by less than 1 dB, as the patch is rotated manually through 360°, then the Quadrifilar Helix antenna under test is also LHCP. If, however, there are two deep nulls and two peaks observed when rotating the source patch antenna through 360°, then the Quadrifilar Helix antenna under test has opposite polarization or RHCP in this example.

For those who would like to build and duplicate the Quadrifilar Helix antenna for RHCP or LHCP all of the electrical dimensions and materials to be used as well as winding directions for the smaller and larger loops are given in their respective illustrations, Figures 2 to 5. For still more detailed construction designs consult the references (3) and (4). For those who would like to know more about the theory and how Quadrifilar Helix Antennas function in general and who want to learn more details of the workings of infinite baluns, including how the 90-degrees phase shift for circular polarization as well as the self-matching to a 50-Ohm-feedline takes place, should definitely study the references (1) and (2). An additional article being planned will deal with the results obtained with a Quadrifilar Helix Antenna for 2400 MHz used as a feed on dishes with f/D ratio ranging from 0.3 to 0.35 hopefully using the RHCP medium beacon of AO40 otherwise using the 2401.500 MHz LHCP beacon of UO-11.

References:

Figures continue on the next page.
Radiation Pattern of a 2400 MHz LHCP Quadrifilar Helix Antenna when illuminated by a LHCP Source (LHCP) and infinite Balun connected for 90° self-phasing and Endfire Radiation

Polar Plot 3 (above)
Radiation characteristics and hints for the Endfire-LHCP.

Circularity Diagram of a 2400 MHz RHCP Endfire Quadrifilar Helix Antenna when illuminated by a H/2 spinning dipole at 0°, 30°, 60° and 90° from Quadrifilar Helix Radiation Axis

Antenna Axial Ratio Pattern

Polar Plot 5 (left)
Antenna axial ratio pattern and measurement bench to determine the circularity of the Quadrifilar-Helix at different squint angles against a spinning half wave dipole.