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GPS ANTENNA DESIGNS

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Application of the current GPS NAVSTAR system to civilian service requires that a right-hand, circularly polarized, -160 dBW spread spectrum signal be received from an orbiting satellite, where the antenna environment is also moving. This presents a design challenge when inexpensive antennas are desired. The current trend of the industry is a quadrifilar helix design first perfected by C.C. Kilgus [1], which has become commercially available in a variant form. This is not the only antenna which is usable, however.

A hybrid Archimedian spiral antenna by R. Milne [2] provides signal pattern advantages over the quadrifilar helix, but sacrifices small size and ease of construction. Other types of antennas, such as conical spirals or turnstiles, have not been considered as of yet. The intent of this survey is to provide information on the antennas mentioned above and to construct and test prototypes to determine whether the choice made by industry (of the quadrifilar helix) is the best.

The quadrifilar helix antenna is currently the low cost standard for GPS. It provides cardioid or omnidirectional coverage and right-hand circular polarization. The small size of the antenna at 1575 MHz minimizes wind loading on aircraft. With care in construction, a 20 MHz bandwidth is also achievable at this frequency. A modified version of this antenna provides ruggedness and simplicity.

Prototype versions, based on information from an article by C.C. Kilgus, were constructed using 12-gauge wire and subminiature coaxial hardline. The antenna can be matched using two 90 degree sections of different impedances. The half-turn half-wave helix provides an impedance of 10 to 100 ohms. SMA connectors were used and the copper wire was silverplated after assembly. The equations used to design the antenna and the final working dimensions are shown in figure 1.

The 90 degree balun can be eliminated by increasing one set of element lengths by 45 degrees and decreasing the other set by 45 degrees. This allows feeding the antenna from the top of the helix by using one of the elements as the feeder. Since this is a half-wave configuration, all elements are grounded at the base of the antenna. The helix must have a chosen radius, which determines the pattern of the antenna. The active area of the antenna is limited to the vertical elements. The radial parts of the elements have no radiation. Radial choice provides the cardioid pattern, front-to-back ratio and 3 dB beamwidth. Kilgus provides several graphs and experimental data in his article, and one only has to choose what parameters need to be satisfied for desired GPS antenna characteristics.

The constructed antennas were tested using a signal generator and a reference turnstile. A spectrum analyzer was used to measure the level of the received signal. Measurements were conducted in a large hall at Clippinger labs. The reflections in the hall were found to interfere, so future tests will take place in an open field. The 1575 MHz signal is of relatively short wavelength, so reflection occurrence was more prominent than expected. Testing was done, as shown in figure 2.

The modified Archimedian spiral was developed by R. Milne. The antenna is basically an Archimedian spiral reflector elements and ground plane radials. The spiral is excited by a cavity which can be mounted inside the aircraft skin. The pattern is a basic cardioid with lobes towards the horizon. The lobes on the horizon are due to the external reflector elements, which provide gain in the direction where it is most needed. The reflector elements are mounted in the radome that covers the spiral. The bandwidth of this antenna is broad enough to cover both the 1575 and the 1227 MHz GPS signal format. Complexity of the antenna makes construction difficult.

Turnstiles and conical spirals offer some usefulness, but lack good cardioid patterns. Using reflectors and directors can provide useful antenna patterns, but sacrifice size.

Industry's choice in using the quadrifilar helix is a valid one when it comes to low cost and ease of construction. The narrow bandwidth limits use of this antenna for C/A GPS work only. The helical spiral offers a better approach when P code reception is desired.

References

[1] Kilgus, C. C., "Resonant Quadrifilar Helix Design," Microwave Journal, pp. 49-54; December, 1970.

[2] Milne, R., "Receiving Antennas for the NAVSTAR Global Positioning System," Government of Canada, Dept. of Communications, Communications Research Center, CRC Report No. 1319, Ottawa; October, 1978.

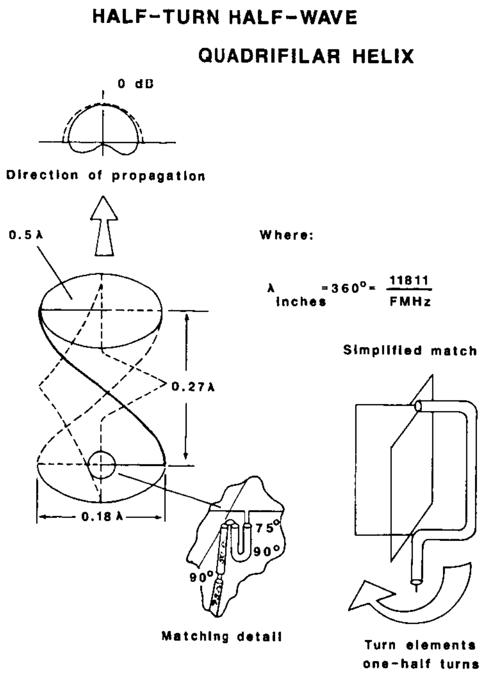

Figure 1.

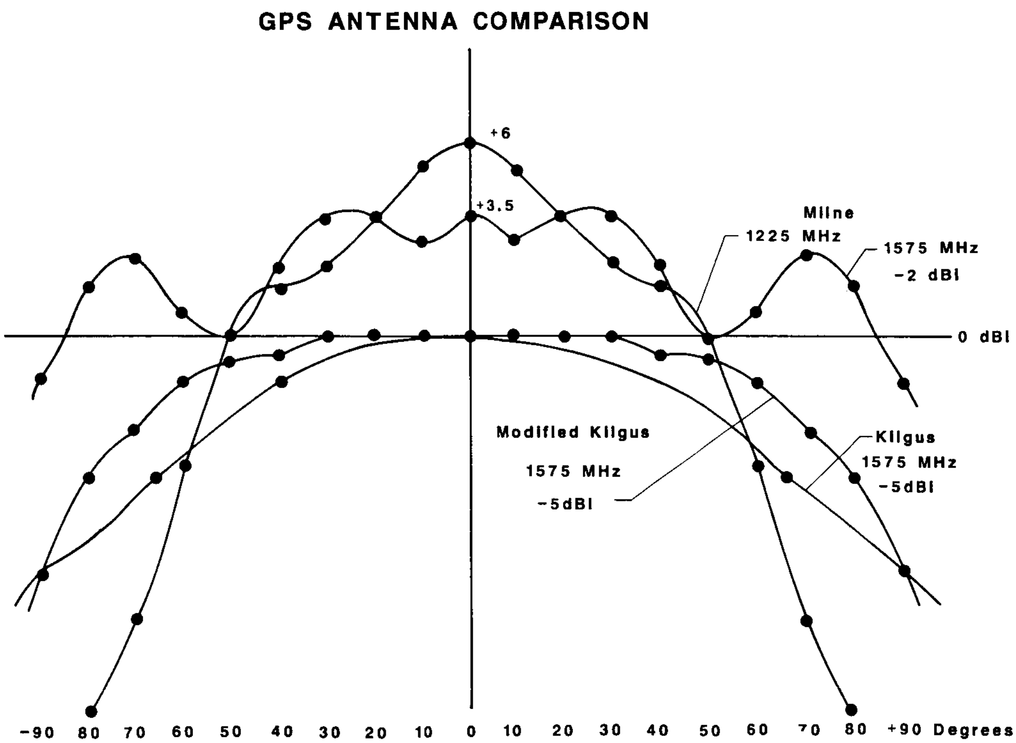

Figure 2.