UWB Magnetic Antennas

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Introduction:

A wide variety of electric ultra-wideband (UWB) antennas have seen commercial use. A few examples of these include diamond dipoles [1], and elliptical dipoles [2]. These electric antennas tend to have relatively large electric near-fields that are prone to undesired coupling with near-by objects.

Many commercial applications, however, call for UWB antennas that are less prone to near-field coupling. Magnetic antennas are well suited for these applications, because the relatively large magnetic fields tend not to couple as strongly with near-by objects. The purpose of this article is to provide a brief overview of some UWB magnetic antennas. In particular, this paper will discuss large current radiators, monoloop antennas, and magnetic slot antennas.

Large Current Radiators:

A "large current radiator" is ideally a current sheet whose return currents are isolated by a ground plane (see Figure 1). Harmuth pioneered this basic design [3,4], and variations of the large current radiator concept have been developed by various investigators [5].

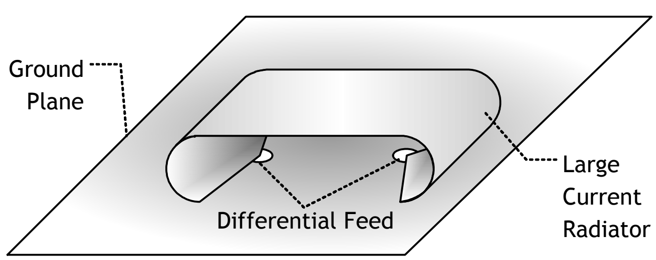

Figure 1: *Harmuth's large current radiator*

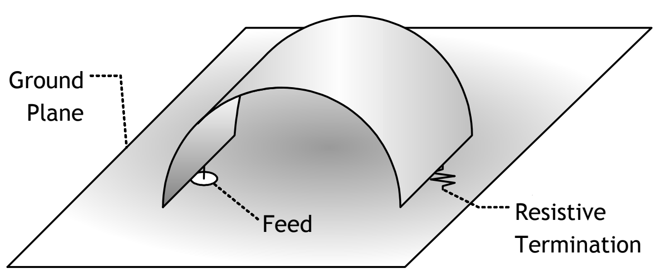

Figure 2: *Balanced-dipole antenna of Farr et al*

Farr et al proposed an interesting variation on this basic architecture [6]. The "balanced-dipole" antenna (shown in Figure 2) has the interesting property that it can be fed from either end, while the opposite end is terminated with an appropriate impedance. Thus, the pattern of this antenna may be dynamically switched.

The principal dis-advantage of large current radiators is that they tend to be lossy antennas. A current sheet will necessarily radiate from both sides. This energy is trapped between the large current radiator and the ground plane yielding undesirable resonances.

Accordingly, a ferrite or other absorptive coating is typically used to dissipate these undesired emissions. Thus, large current radiators are generally not very efficient.

Monoloop Antennas:

The main disadvantage of large current radiators follows from the fact that these antennas trap energy between their radiating elements and their ground planes. This suggests that it might be fruitful to consider radiating elements oriented in a plane perpendicular to the ground plane.

One early antenna with this architecture was Turner et al's scimitar antenna shown in Figure 4 [7]. This antenna is characterized by an operating bandwidth in excess of 1:10. Although well matched, the scimitar antenna exhibits some variation in pattern as a function of frequency. Ideally, a UWB antenna should have a stable and consistent pattern as a function of frequency.

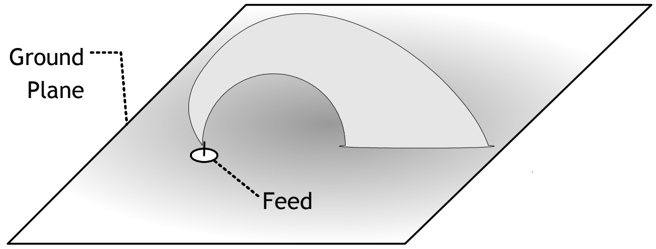

Figure 3: *Scimitar antenna of Turner et al.*

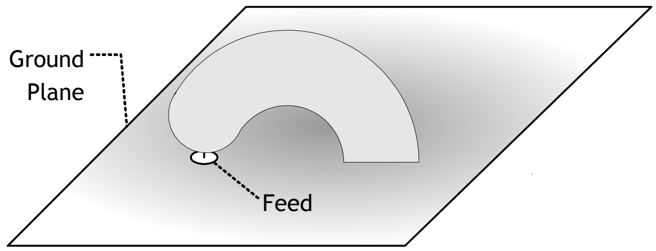

Figure 4: *The author's monoloop antenna.*

The author devised a similar antenna, dubbed a "monoloop" [8]. The "monoloop" name follows from the fact that antennas with this architecture are essentially half a loop driven against a ground plane, just as a "monopole" is half a dipole antenna driven against a ground plane.

The author's monoloop antenna differs from the scimitar antenna in the feed region. This antenna has a round, bulbous end that offers an excellent match to 50 ohms. Like the scimitar antenna, the author's monoloop antenna suffers from some variation in pattern as a function of frequency. Also, the monoloop pattern is not uniform in the plane of the monoloop element. The reason for this behavior may be understood by considering the current flow in the monoloop element and the resulting radiation.

Assume each infinitesimal current element along the monoloop is the source of radiation along the radius of curvature at that point. If the monoloop element is considered in cross-section, this means that each infinitesimal current element generates a direct ray of radiation radially outward, and a radially inward ray directed toward the ground plane. This radially inward ray ends up reflected.

The radiation in any given direction is the sum of a direct ray from one part of the monoloop and a reflected ray from a different part of the monoloop element. A quick calculation of the path lengths involved demonstrates an asymmetry of the direct and reflected paths: the relative path lengths varies as a function of angle. This variation is the root cause of the non-uniform pattern as a "direct" impulse waveform combines with a "reflected" impulse waveform with a relative delay that varies as a function of look angle. This behavior is illustrated in Figure 5.

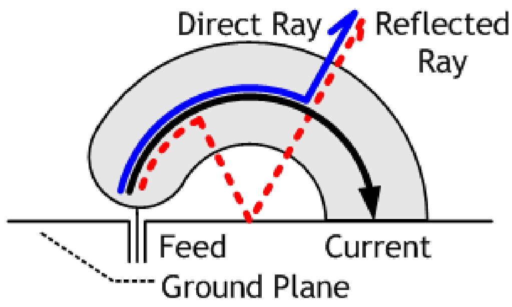

Figure 5: *Current and radiation from a monoloop element.*

One way to rectify this undesired asymmetry is to feed the monoloop in a symmetric manner. This was the fundamental idea behind the author's center-fed monoloop (see Figure 6). By moving the feed to the center top of the monoloop antenna, symmetry is restored. The direct and reflected paths are now the same length as the look angle is varied. Thus the pattern of a center-fed monoloop is more uniform as a function of look angle. Figure 7 shows characteristic current and radiation rays for the center-fed monoloop.

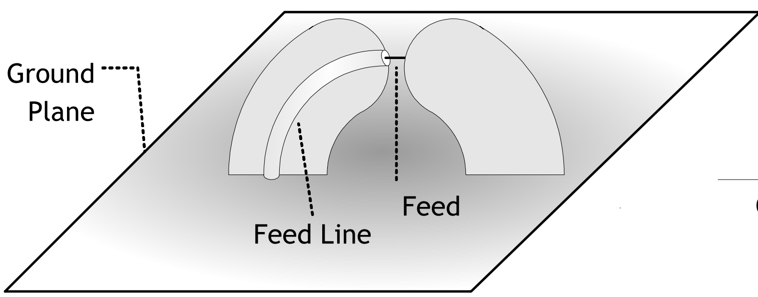

Figure 6: *A center-fed monoloop.*

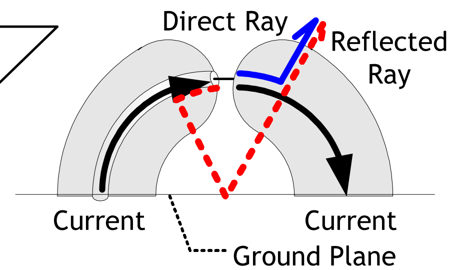

Figure 7: *Current and radiation from a center fed monoloop.*

Magnetic Slot Antennas:

Magnetic slot antennas are a final UWB magnetic antenna architecture. One example is Barnes's UWB magnetic slot antenna shown in Figure 8 [9,10]. If an appropriate taper is chosen for the slot line of this antenna, excellent matching can be obtained. A magnetic slot antenna like the one shown in Figure 8 exhibits a quadrupole type radiation pattern with a pattern lobe lying in the normal direction on either side of the plane. When driven against a reflecting back plane, this antenna exhibited good performance in the Time Domain Corporation's RV1k through-wall UWB radar.

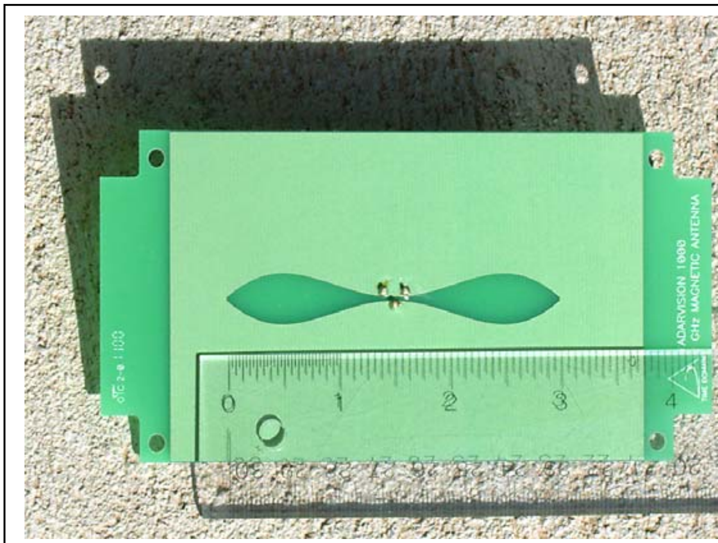

Figure 8: *Barnes's UWB magnetic slot antenna.*

Conclusion:

In conclusion, there are a wide variety of magnetic type UWB antennas available for commercial applications. This paper has surveyed three general kinds of magnetic UWB antennas: large current radiators, monoloops, and slot antennas. Although far from being exhaustive, this paper provided examples of each type to illustrate the variety of antennas possible within each of these magnetic UWB antenna architectures.

Acknowledgement:

The author's monoloop and center-fed monoloop antennas described in reference 8 were originally invented while the author was employed as an antenna engineer by the Time Domain Corporation.

References:

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