Producing Large Transient Electromagnetic Fields in a Small Region:
An Electromagnetic Implosion

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One approach to producing a large, fast transient electromagnetic field in a small region consists of focusing an incoming approximately spherical wave on the position of interest. This paper discusses some of the design features involving a prolate spheroidal reflector for this purpose. This is based on the two foci of an ellipse. A prolate sphere Sp is a body of revolution (special case of an ellipsoid) with an equation for the surface

$$\left[\frac{\Psi}{b}\right]^2 + \left[\frac{z}{a}\right]^2 = 1, \quad \text{a=major radius, b=minor radius}$$

based on cylindrical (Ψ, ϕ, z) coordinates with

$$x = \Psi\cos(\phi),\ y = \Psi\ \sin\ (\phi), \Psi^2 = x^2 + y^2$$

There are two foci at

$$(\Psi,\phi,z) = (0,\phi,\pm z_0) = \pm\ \vec{r}_0,\ \ z_0 = [a^2 - b^2]$$

The distance traveled by all rays from $-\vec{r}_0$ to $\vec{r}_0$ is

$$d_1 + d_2 = 2a = 2\,[z_0^2 + b^2]^{\frac{1}{2}}$$

A real reflector would consist of some sector S'_p of S_p As with the usual reflector IRA there could be flat-plate conical feed arms. Two are shown here, but the usual 4-arm system (with terminating resistors) would be appropriate. The wave leaving $-\vec{r}_0$ to $\vec{r}_0$ needs to be in uniform, isotropic dielectric medium (whether air or whatever), of permittivity ε (ideally lossless), extending around the target. This includes all the ray paths reflecting from S'_p. Note that one may have some special high-voltage source region around with special equipment and perhaps a lens to shape the spherical wave centered on $-\vec{r}_0$.

At later times (after first signal arrival at $-\vec{r}$) truncation of the dielectric medium will influence the fields near $\vec{r}_0$. So some consideration of the shaping of such a boundary is appropriate. The edge of S'_p (perhaps a circle, or even a more sophisticated shape) is chosen based on feed-arm locations and the orientation of the fields incident on the reflector so as to give the best results at $\vec{r}_0$.

Here we have considered a metal (ideally perfectly conducting) reflector. If, however, $\varepsilon > \varepsilon_0$ one can utilize the positive, instead of negative, reflection with S'_p taken merely as the boundary between the dielectric ε and air ε_0.

The basic concept is fairly simple. The practical implementation, however, involves many details. There are both theoretical and construction questions to be addressed.