Directional High Front to Back Ratio Low Frequency (< 90 MHz) Plasma Antenna That Can Fit on an Aircraft or Terrestrial Vehicle.

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Haleakala R&D, Inc.'s Low Frequency Directional and Electronically Steerable Plasma Antenna Solution

A low frequency, steerable, directional, smart plasma antennas can be made from cluster of plasma antennas which is realized by a multipole expansion of the plasma antennas when properly designed and programmed. In the far field such a configuration can be a multipole expansion of transmitting and receiving plasma antennas are on and the rest are turned off (plasma gone).

To give the reader a better understanding of how the configuration of plasma tubes can have an engineering form, the schematic in Figure 1 shows how the plasma antennas are housed in a rigid and hardened foam called SynFoam. SynFoam has an index of refraction close to 1 and is essentially transparent to electromagnetic waves. The resulting electric far field from the two plasma antennas that are on and oscillating out of phase while the rest of the plasma antennas are off as shown in Figure 1 is:

Note: Darkened tubes are off (no plasma), and white tubes are on (plasma). By turning the plasma antennas on and off in sequence, the beam can be steered or the beam can instantaneously change direction by turning plasma antennas off and on in different directions.

Note: in all cases k is the wavenumber and k is the wavenumber, and $k = 2\pi/\lambda$

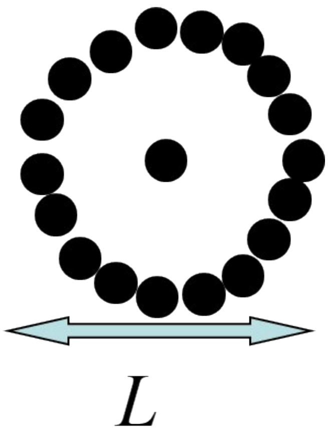

Figure 1. Ring of plasma antennas (now all off) of diameter L with a plasma antenna in the center. L<6 feet.

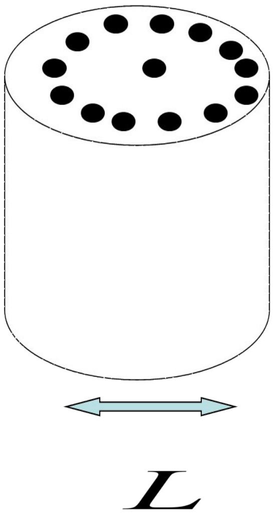

Figure 2. All plasma antennas placed in cylindrical mold of Synfoam. SynFoam is a rugged and fireproof syntactic foam which has an index of refraction of nearly 1. L is the width of the antenna system. L is 6 feet or less.

Case 1. Two plasma antennas turned on at opposite sides out of phase. Note: in all cases k is the wavenumber and k is the wavenumber, and $k = 2\pi/\lambda$

<u>Note: Darkened tubes are off (no plasma), and white tubes are on (plasma). By turning the plasma antennas on and off in sequence, the beam can be steered or the beam can instantaneously change direction by turning plasma antennas off and on in different directions.</u>

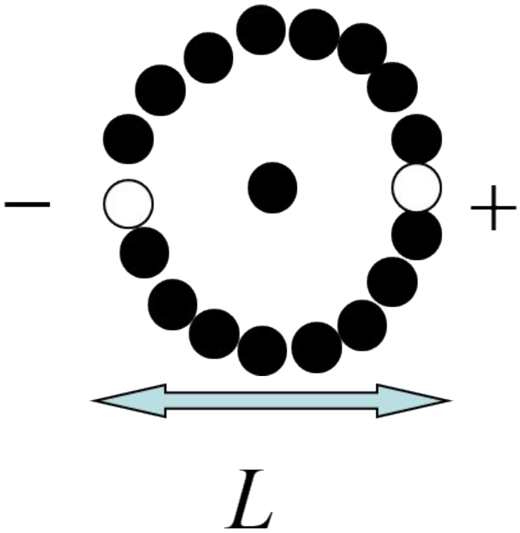

Figure 3. Two plasma antennas turned on at opposite sides out of phase. The beam can be steered or the beam can instantaneously change direction by turning plasma antennas off and on in different directions.

The far field electric field is:

$$E = E_0 \cos k(x - \frac{L}{2}\cos\theta) - E_0 \cos k(x + \frac{L}{2}\cos\theta)$$

Equation 1.

Where:

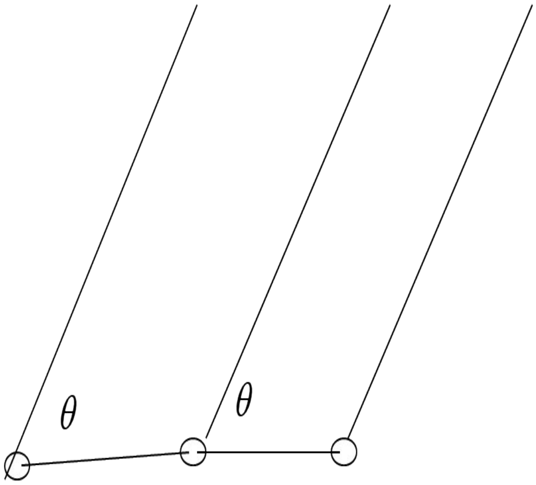

Figure 4.

Assume that:

$$\frac{kL}{2} < 1$$

k is the wavenumber, and k = 2π/λ

Equation 2.

The wavelength is large compared to the plasma antenna system of diameter L which is 6 feet of less.

The result is:

$$E = E_0 (\sin kx) kL \cos q$$

Equation 3

This is a two lobe radiation pattern, but directional. The two lobes of the plasma antenna are oscillating out of phase. The beam can be steered or the beam can instantaneously change direction by turning plasma antennas off and on in different directions.

Case 2: Three plasma antennas in a straight line.
Two outside antennas radiating in phase.
The center antenna radiating out of phase but with double the signal strength. Note: in all cases k is the wavenumber and k is the wavenumber, and k = 2π/λ.

Note: Darkened tubes are off (no plasma), and white tubes are on (plasma). By turning the plasma antennas on and off in sequence, the beam can be steered or the beam can instantaneously change direction by turning plasma antennas off and on in different directions

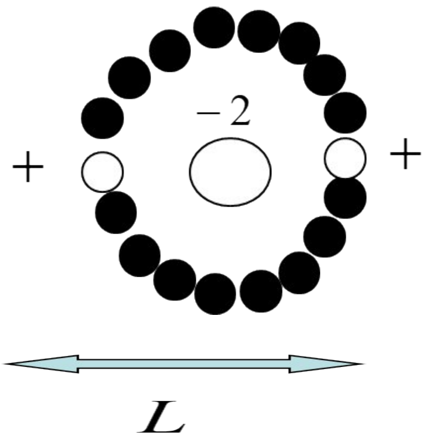

Figure 5. Two outside antennas radiating in phase. The center antenna radiating out of phase but with double the signal strength. The beam can be steered or the beam can instantaneously change direction by turning plasma antennas off and on in different directions.

The far field E field with the two plasma antennas radiating in phase and a plasma antenna with double the signal strength and oscillating out of phase is:

$$E = E_0[\cos k(x - \frac{L}{2}\cos\theta) - 2\cos kx + \cos k(x + \frac{L}{2}\cos\theta)]$$

Equation 4.

Assume that the wavelength is large compared to the antenna diameter L.

$$\frac{kL}{2} < 1$$

The result is:

$$E = E_0[-\cos kx[(\frac{kL}{2}\cos\theta)^2]$$

Equation 5.

This is a two lobe plasma antenna with both lobes in phase.

Case 3. Three plasma antennas in a straight line. The two outside plasma antennas are radiating out of phase which is a dipole. The center antenna oscillates in phase with one of the antennas in this case the one on the right which is a monopole. Note: in all cases k is the wavenumber and k is the wavenumber, and k = 2π/λ.

Note: Darkened tubes are off (no plasma), and white tubes are on (plasma). By turning the plasma antennas on and off in sequence, the beam can be steered or the beam can instantaneously change direction by turning plasma antennas off and on in different directions.

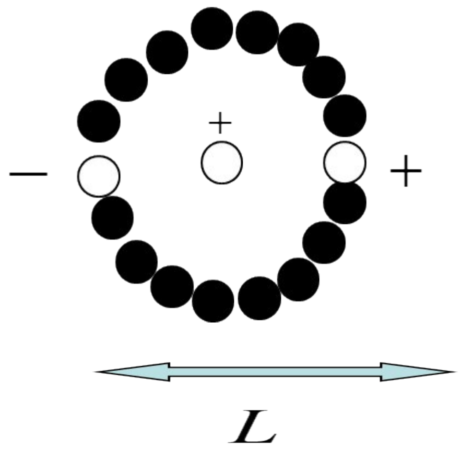

Figure 6. The two outside plasma antennas are radiating out of phase which is a dipole. The center antenna oscillates in phase with one of the antennas in this case the one on the right which is a monopole. The beam can be steered or the beam can instantaneously change direction by turning plasma antennas off and on in different directions. The resulting radiation E far field from the plasma dipole and monopole plasma antennas is:

$$E = E_0 \lfloor 1 + \cos\theta \rfloor \sin kx$$

Equation 6.

This is a one lobe directional radiation pattern which is un-attenuated in wavelength. The antenna beam is at maximum directivity in the forward direction and zero in the opposite direction.