HIGHPOINT SECURITY
TECHNOLOGIES Inc.

White Paper

Discone Antenna Design

Written by Bill Pretty
Highpoint Security Technologies

A discone antenna derives its name from its unique appearance. The antenna is composed of a disc shaped radiator on top of a cone shaped ground plane. The two elements can be either solid or composed of separate elements. An antenna constructed from separate elements is lighter and more cost effective to construct. Inexpensive discone antennas are available with only three elements in the disk and cone portions of the antenna. Due to the large gap between the elements, these antennas are not nearly as effective as a solid cone and disk would be. An antenna made from a solid disk and cone could weigh several pounds and would offer a considerable wind resistance. For this reason, trade offs are made in the design of these antennas. The first of two designs uses wire radials for both the disk and the cone portion of the antenna. In the second design I decided to use a solid disk and wire radials. This seemed to be the best trade off between weight and efficiency.

When calculating the dimensions of the antenna, the *lowest resonant frequency* required is used. The upper frequency will be determined largely by the diameter of the top of the cone. The length of the cone elements should be ¼ of the wavelength of the minimum frequency to be received or transmitted. The diameter of the disk should be 70% of ¼ of the wavelength of the minimum frequency to be received by the antenna. The skirt diameter of the cone should be equal to the length of the elements or ¼ wave length.

A properly designed antenna is capable of receiving up to 10 times the lower frequency limit and transmitting up to 5 times the lower limit.

Cone Element Length (mm) = 75000/ Frequency (MHz)

Disk Diameter (mm) = 52550 / Frequency (MHz)

The distance between the disk and the top of the cone should be about ¼ of the minimum radius of the cone.

Example:

For a Minimum Frequency of 200MHz

Cone Element Length (mm) = 75000/ Frequency (MHz)
= 75000/200
= 375 mm or ~ 15 in

Disk Diameter (mm) = 52500 / Frequency (MHz)
= 52500/200
= 263 mm or ~ 10 in

In addition to the formulas above, there is also a discone antenna calculator available from http://www.qsl.net/ve3sqb . This guy has a number of useful antenna design programs which he has written and provides free of charge. The program produced the following results when I input a minimum frequency of 200MHz.

Disk Diameter:	11.45 in
Cone Side Length:	16 in
Insulator Width:	.15 in

It is always easier to trim than to add. For that reason I chose to use the larger of the two dimensions for both designs. Wires 16 ¾" long were used for the cone portion while wires 5 ¼ inches long were used for the disk portion of the antenna. The resulting disk diameter was 11 ½ inches.

Design #1: Wire Cone and Disk

The wire cone and disk design used two one inch diameter circular pieces of PCB material as the supports for the wires. One disk had a 3/8" diameter hole drilled in it to accommodate the body diameter of the BNC connector. The other disk had a 1/16" diameter hole to accommodate the center conductor of the BNC connector. A chassis mount BNC connector was used. The BNC connector was inserted in the first disk and held in place with the mounting hardware. The connector was then soldered to the disk using a large tipped soldering iron. The second disk was slipped over the back of the connector so that the center conductor protruded through the disk. This disk was used to connect the wires that would form the 'disk' portion of the antenna to. The wires forming the 'cone' portion were soldered to the other disk. The center conductor protrudes out of an insulator that extends about .15" from the body of the BNC connector. This insulator was used as the spacer. Eight wires were soldered to each disk; one wire every 45 degrees. Once these wire were soldered in place, the insulator tended to rotate inside the body of the BCN connector. Epoxy putty was used to prevent this and to give the antenna more physical strength. Masking tape was used to align the top and bottom wires with one another.

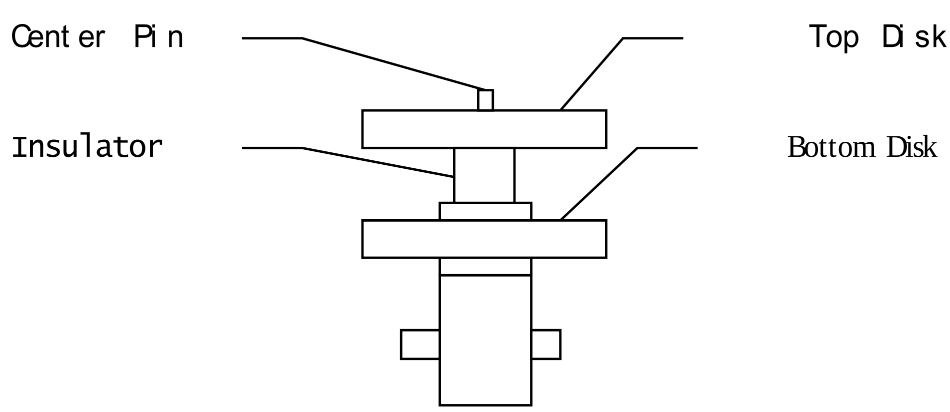

Figure 1 Antenna Body

The epoxy putty was allowed to harden overnight. Once the putty was hard, the wires attached to the bottom disk were bent downward to form the cone portion of the antenna. Figures 2 and 3 below are photographs of the finished antenna. Note that the ‘disk’ wires are soldered to the top of the PCB disk, while the ‘cone’ wires are soldered to the bottom of the PCB disk.

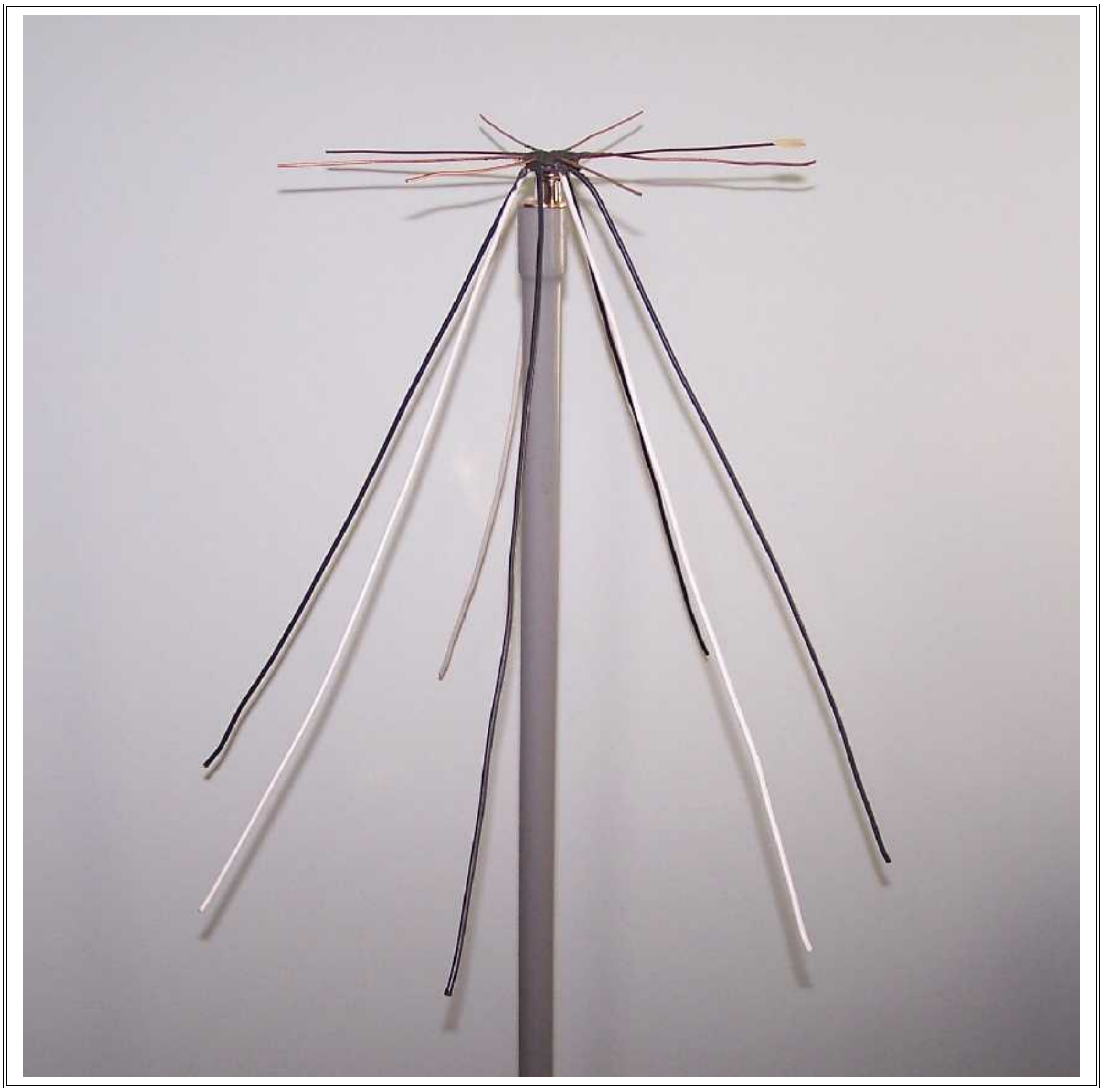

Figure 2 Prototype Antenna

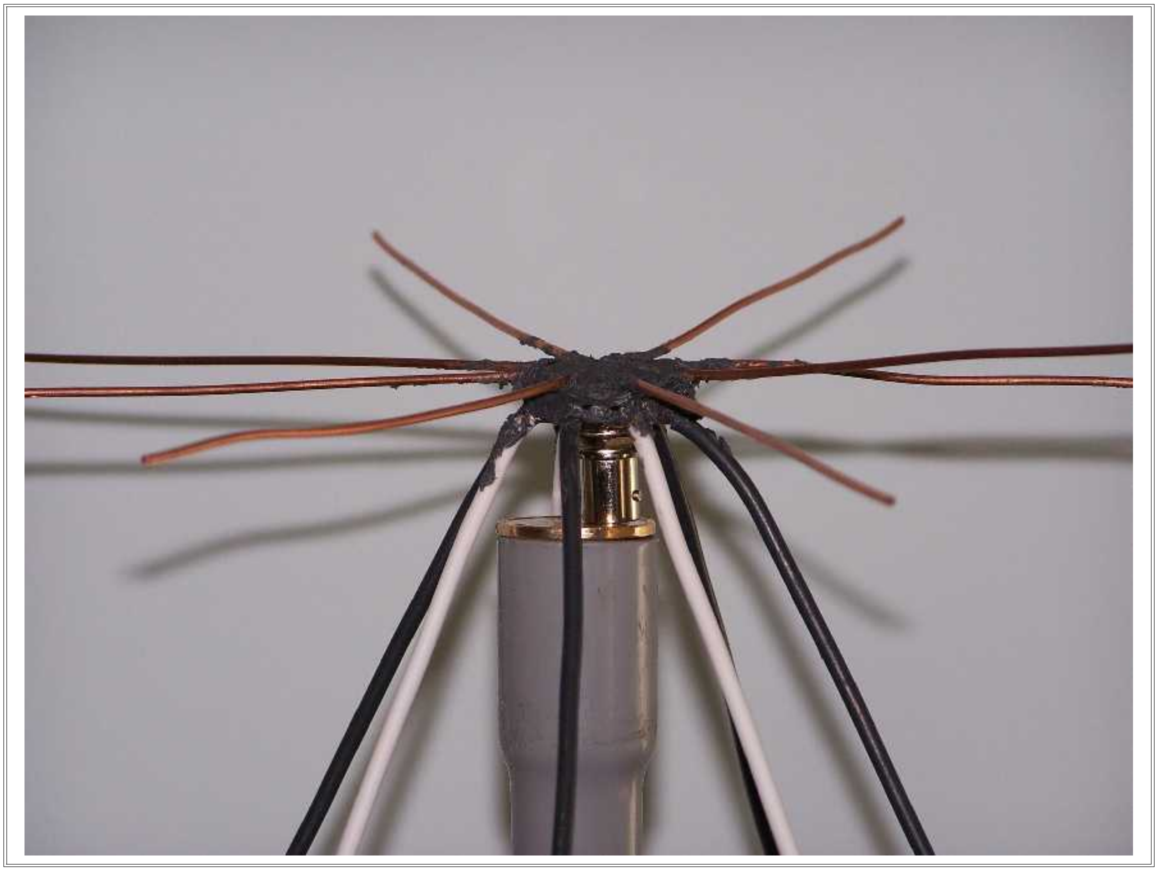

Figure 3 Close up of the Body Assembly

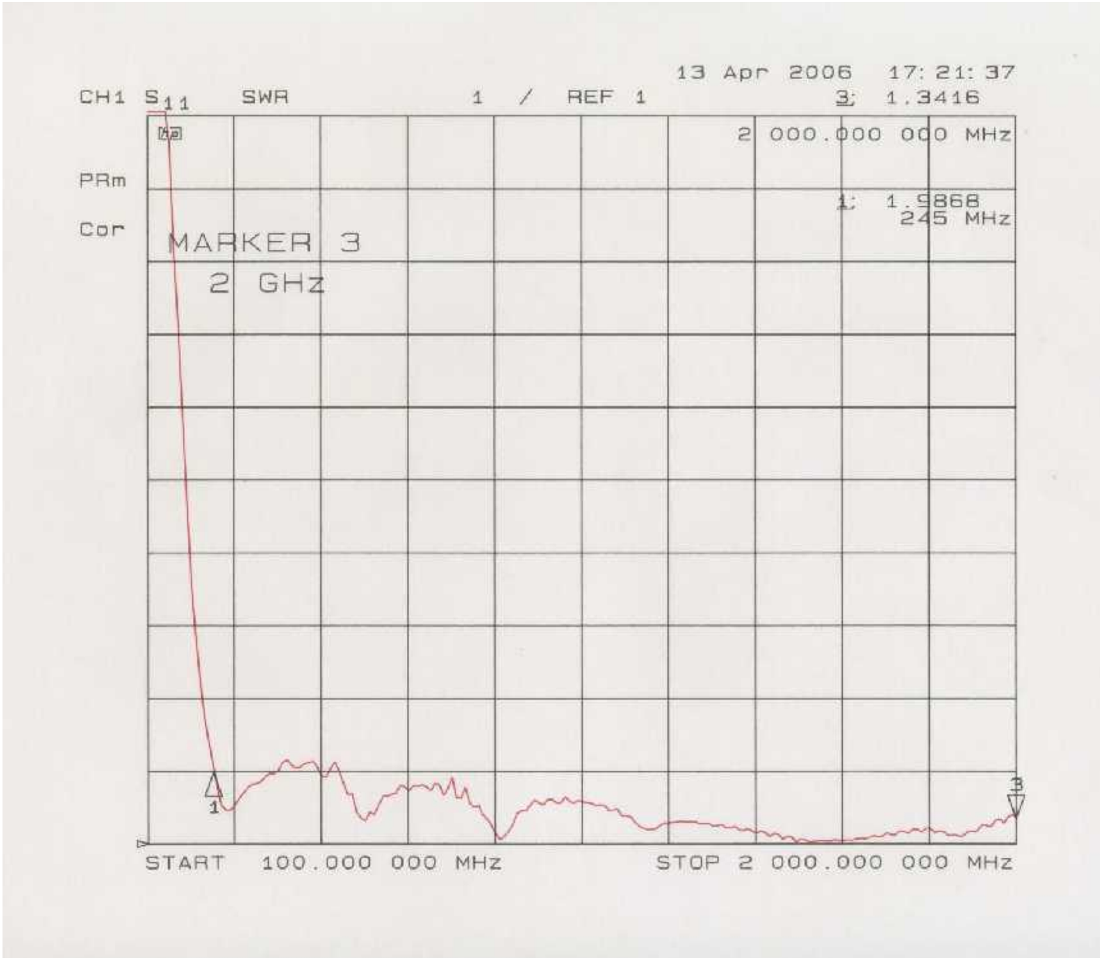

Figure 4 Antenna SWR Plot

Figure 4 shows the VSWR plot of the antenna. I draw the reader's attention to two things. First of all, you will recall that the lower frequency limit was supposed to be 200MHz. As you can see the VSWR doesn't fall off until about 230MHz, even though I went with the larger dimensions of the two methods. This suggests that the legs of the cone should have been slightly longer and perhaps the disk should be larger as well. The good news is that the VSWR is less than 2, from 245 MHz to well beyond 2GHz. This is physical evidence that discone antennas have a bandwidth up to 10 times their lower frequency limit.

Design #2: Solid Disk and Wire Cone

For this design a solid disk was used instead of the wires in the previous design. A BNC connector with a mounting flange was soldered to a disk of 1/8" PCB material. Four holes were drilled thru the mounting holes in the connector with a #51 drill. Four additional holes were drilled into the sides of the connector as shown in Figure 5 below.

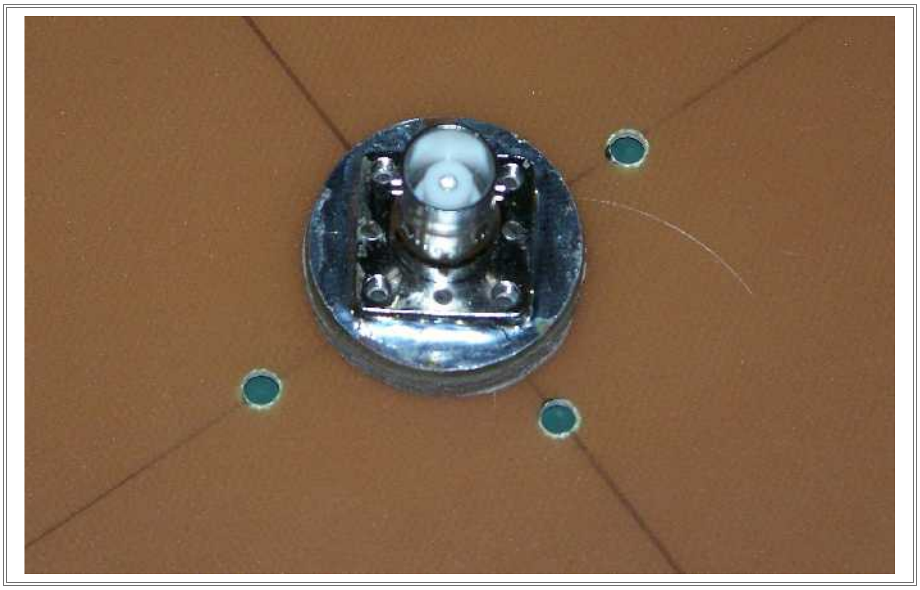

Figure 5 Top View of BNC

A spacer was cut from 1/8" plastic and inserted between the PCB assembly and the disk portion of the antenna, as seen below in Figure 6.

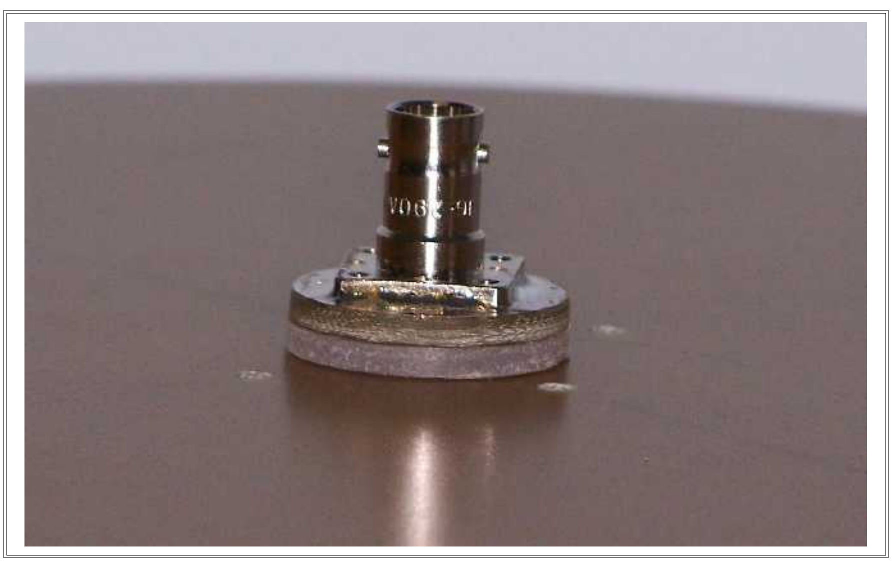

Figure 6 Side View of BNC

Wire radials were cut from #14 solid copper wire and approximately ½" of the insulation was removed. The bare end of the wire was bent at a 90-degree angle to form a hook. This hook was inserted into the holes drilled into the connector and the mounting disk. The center conductor of the BNC connector was soldered to the disk part of the antenna. The disk with the wires soldered in place is shown in Figure 7 below.

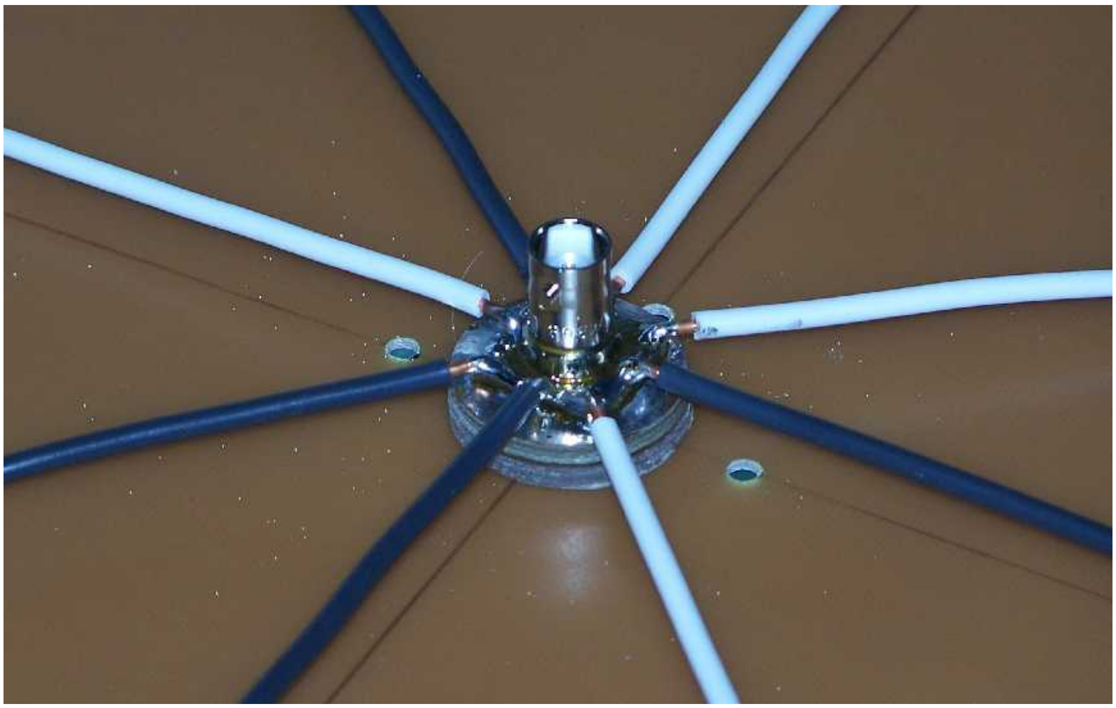

Figure 7 Disk with Wires

The PCB assembly was fastened to the disk portion of the antenna using a hot glue gun. The glue was allowed to dry and the wire radials were then bent upward to form the cone as seen below in Figure 8.

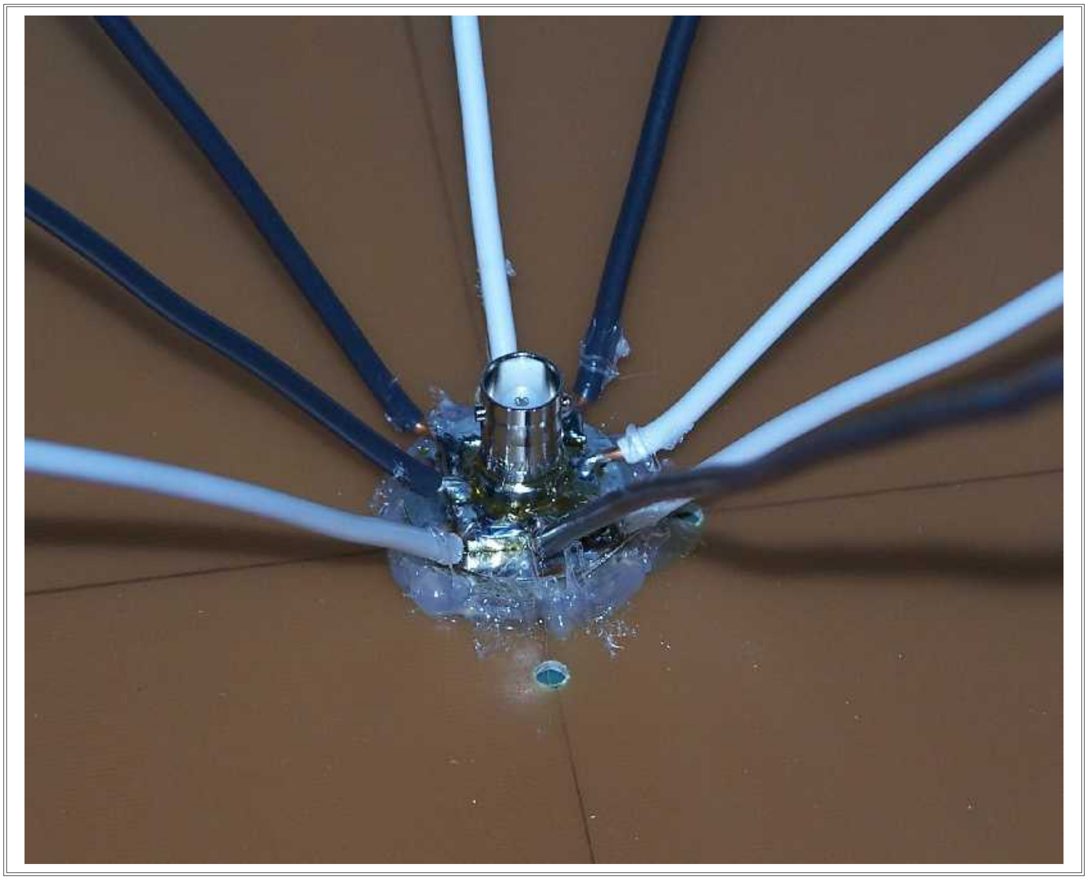

Figure 8 Assembly glued in place

Figure 9 shows the finished antenna mounted on an antenna mast made from ABS electrical conduit. The COAX cable runs down the center of the conduit.

Figure 9 Finished Antenna

The antenna was then tested with an Hp Network analyzer. Due to calibration problems with the setup, measurements were made in two bands. The first set of measurements was made from 100MHz to 1000MHz. The second set of measurements was made from 800MHz to 1600MHz. It was not possible to test the antenna beyond 1600MHz. Measurements of return loss and VSWR were made. As you will see the SWR seems to be excellent well beyond 1600MHz. However no test data is available. These measurements are shown in the graphs on the following pages.

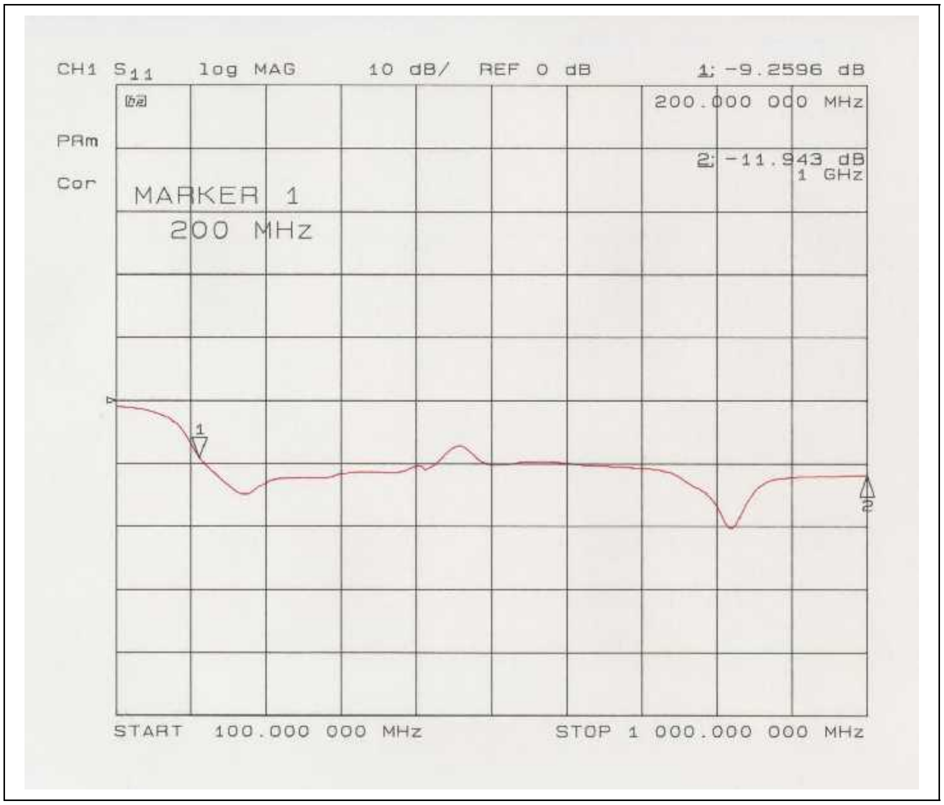

Figure 10 Return Loss 100MHz - 1000MHz

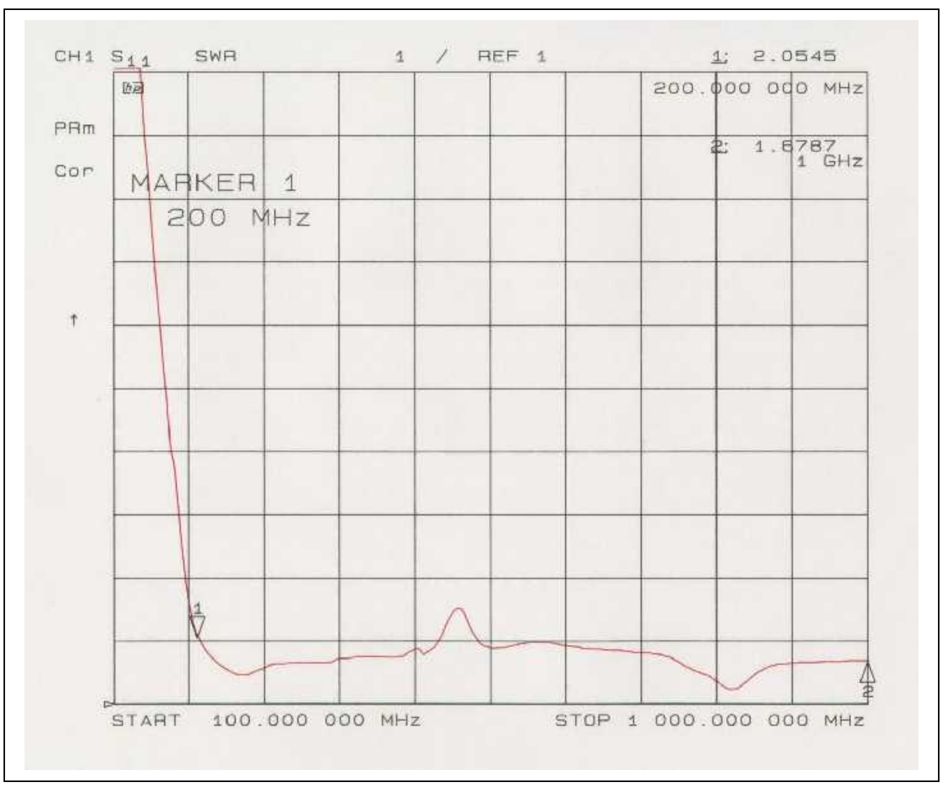

Figure 11 VSWR 100MHz - 1000MHz

Figure 12 Return Loss 800MHz - 1600MHz

Figure 13 VSWR 800MHz - 1600MHz

In this design the radials of the cone were lengthened to 17 ¾" from the 16 ¾" of the first design, and a 12" diameter solid disk was used. These measurements appear to produce acceptable results.

Due to the wide bandwidth of this antenna, the designer should be able to add about a 20% safety margin to their dimensions without affecting the upper operating frequency. The length of the radials required for frequencies below 200MHz makes for a mechanical design challenge. It is for this reason that most good commercially available antennas use stainless steel for their radials. Also the solid disk version of this antenna could present some interesting wind loading problems. For designs below 200MHz the design becomes as much a mechanical engineering problem as it is an RF engineering one.

This design was intended for indoor laboratory use. If either design were to be used out of doors then some improvements would have to be made to the mechanical construction of the antenna. For example the PCB disks in design #2 should be fastened to the top disk with epoxy resin and fiberglass cloth. The whole antenna, with the exception of the connector should be protected with a weatherproof paint. The BNC connector can be attached to the antenna and the COAX cable passed thru the ½" electrical conduit. The top of the conduit can then be filled with RTV silicone in order to waterproof the BNC connector and hold the antenna to the conduit.

It is this author's hope that this article has been both informative and useful to the reader. Should you have any questions or comments, I can be reached through the Highpoint Security Technologies website: www.hipoint.ca or via email at billp@hipoint.ca.