3D Printed Ultra Wideband Antenna Construction
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September, 2018

Designing and construction a wideband antenna can be a daunting task. The literature describing wideband antenna design is, at best, ambiguous. To make matters worse, the software used to simulate antennas, in general, is astronomically priced. Student editions of these software packages are frequently nearly impossible to obtain. Assuming you have acquired all of the design tools, which is the best geometry and corresponding dimensions for a particular application, which in this case is ultra wideband response? Once the design geometry has been selected and the design process completed, the antenna must still be fabricated. That always means custom metal parts. Anyone familiar with model shops knows the cost is usually out of reach for most people. So, the only solution is 3D printing.

I needed a wideband antenna for my SDRs that could span from 900 MHz to at least 11,000 MHz. I wanted to cover all of the cell phone bands, WiFi and Bluetooth up to 6 GHz as well as the new UWB band from 5 GHz to 10 GHz with just one antenna installation. One of the newer SDRs is coming out with an up/down converter attachment that covers the UWB band. I did not want to maintain a dozen different antennas with multiple ranges and tuning; just one ultra wideband antenna.

That means a bandwidth of 10:1 was required with a 50 Ohm characteristic impedance across the entire band. A nearly resistive characteristic impedance that is as flat as possible over the UWB bandwidth is required to achieve accurate pulse reproduction with a minimum of distortion. A sphere had the bandwidth, but not the desired impedance. A discone had the desired characteristic impedance, but not the bandwidth. Combining them, I came up with the best of both worlds.

I found a couple of papers that show this basic geometric configuration in combination with other features, but the small features that make it work were not elucidated. Those small features that must be carefully dimensioned to achieve stable performance over the entire frequency range are the product of dozens of simulations and several prototypes to verify the results. And, they added other complimentary structures that I considered a complication in the design; both difficult to simulate and to construct. I was able to achieve the performance I required with a simple hemisphere and cone configuration as shown in Figure 1.

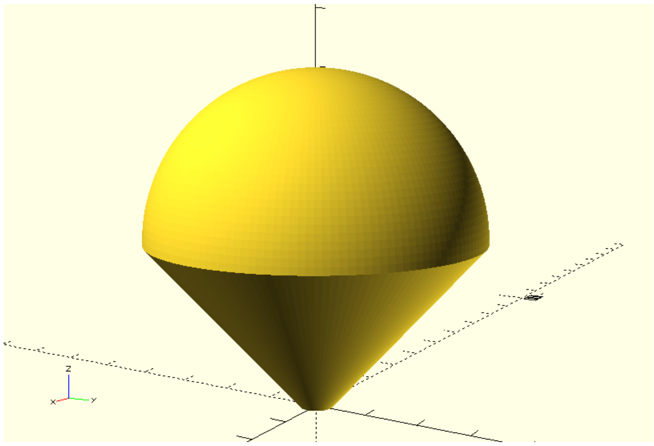

Figure 1: Basic Geometry

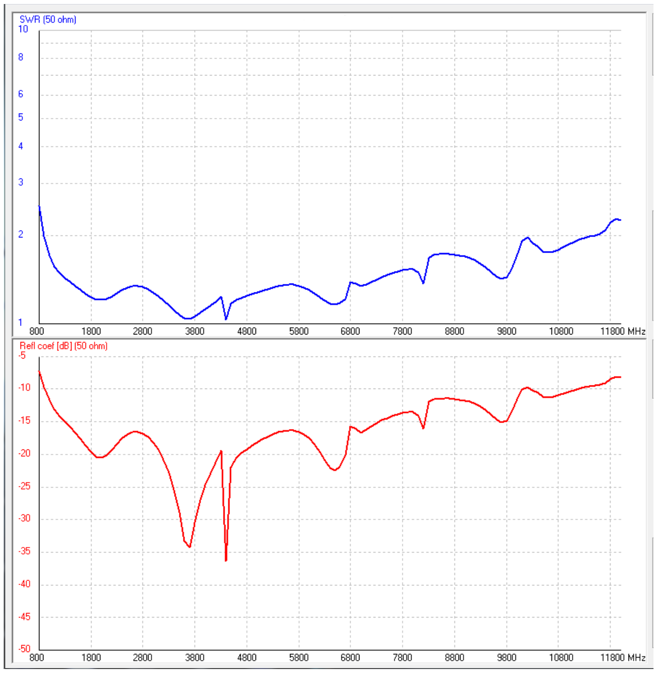

Figure 2: SWR and Return Loss

The cost of machining this structure in a model shop is prohibitive. Stamping limited quantities, such as one or two, requires expensive tooling as well. It is also quite large, so it should be hollow to reduce both weight and unusable material, which divides the antenna into two pieces; one hemisphere and one cone. The RF energy on the antenna is a surface wave, so the interior can be air. The most cost effective means to fabricate the antenna structure is to 3D print it in metal. The radome, Figure 3, and the antenna supporting structure, Figure 4, are 3D printed in plastic. The antenna hemisphere, Figure 5, and the attaching cone, Figure 6, are 3D printed in brass. These four parts are available at my online store: https://www.shapeways.com/shops/jr-magnetics

The SWR and return loss (s11) are shown in Figure 2. The SWR over the entire range of operation is less than 2.0. The return loss over the same range is everywhere less than -10 db. This is fed into a 50 Ohm transmission line. The impedance at the tip of the cone near the ground plane is nearly 50 Ohm over the entire band. This makes excellent pulse reproduction with very low distortion in the UWB band.

Figure 3: Radome

Figure 4: Internal Antenna Mount

The antenna hemisphere top and the cone bottom can be either soldered together in an oven or bonded with an electrically conductive epoxy. The entire assembly procedure is available online at: https://jrmagnetics.com/rf/rf-uwb-antenna/jran900-build.php

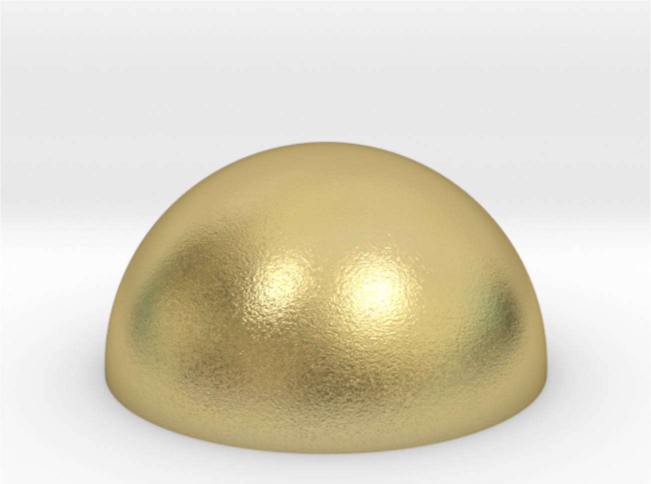

Figure 5: Hemisphere - Antenna Top

Figure 6: Cone - Antenna Bottom

Figure 7: Prototype

The original prototype, Figure 7, was too large to be 3D metal printed. The present model is just within the boundary limits of the available 3D metal printer. I printed my own plastic parts before uploading the modified designs to accommodate the smaller diameters.

Experience with this assembly shows SWR and return loss sensitivity to the assembly tolerances around the ground plane extension and SMA connector. The ground plane can also be aluminum and have a much larger base diameter. Large stainless steel dishes were easier to obtain than having large diameter aluminum plates cut in a machine shop, which also greatly reduced cost.

This antenna works extremely well with my SDR equipment. It should be a lot of fun to build.