A Printable .1 – 2 GHz Antenna

This article describes a broadband antenna which can provide good performance over the amateur VHF-UHF bands above 6m. It can be easily and inexpensively fabricated through use of common parts and a home 3D printer.

The development of this antenna grew from the author’s desire to have a .1 to 2 GHz antenna which could be used with a parallel all-band transverter project. In the past operation on amateur VHF and UHF bands has been relegated to single-band solutions. This usually required that the antenna and the transmit and receive equipment have been for single band use. Now with SDR equipment broadband operation is readily available. The goal of this antenna is to make reception on any of the amateur bands from 2m (144 MHz) through 23 cm (1296 MHz) available without changing any hardware configuration. Although this antenna is not intended to provided the performance of large, highly directional arrays, it does provide good performance for general listening over the entire .1 – 2 GHz range – performance generally equal to that of banded dipoles, monopoles (groundplane antennas) or discones.

In essence this is a biconical antenna[1], a dipole formed from dual tapered conic altransmission lines. Its central support and feed point is fabricated using a printed plastic center support while common copper-weld TIG welding rods make up the two conductive lines. Along with these materials, a panel mount BNC connector and some telescoping brass tubing are all that are required for its construction and keep material costs extremely low and fabrication in a home workshop pretty easy.

A drawing of the central portion of a completed biconical is shown in Fig. 1. This shows top and bottom sections meeting in the middle. The feed point connector, seen at the bottom (green), is a panel mount BNC with a short extension of coaxial line fabricated from inner and outer conductors of brass tubingabove it. The outer conductor fits around the BNC threads while the top is soldered to eight TIG rods sloping down and away at a 30 degree angle . A large solder lug is soldered to the bottom of the outer conductor and traps the locking nut of the BNC connector. The center conductor is made from 5/32” tubing and extends upward and past the end of the outer.

1 Antennas 2nd Edition, Ch. 8 ,John Krauss, McGraw- Hill 1988

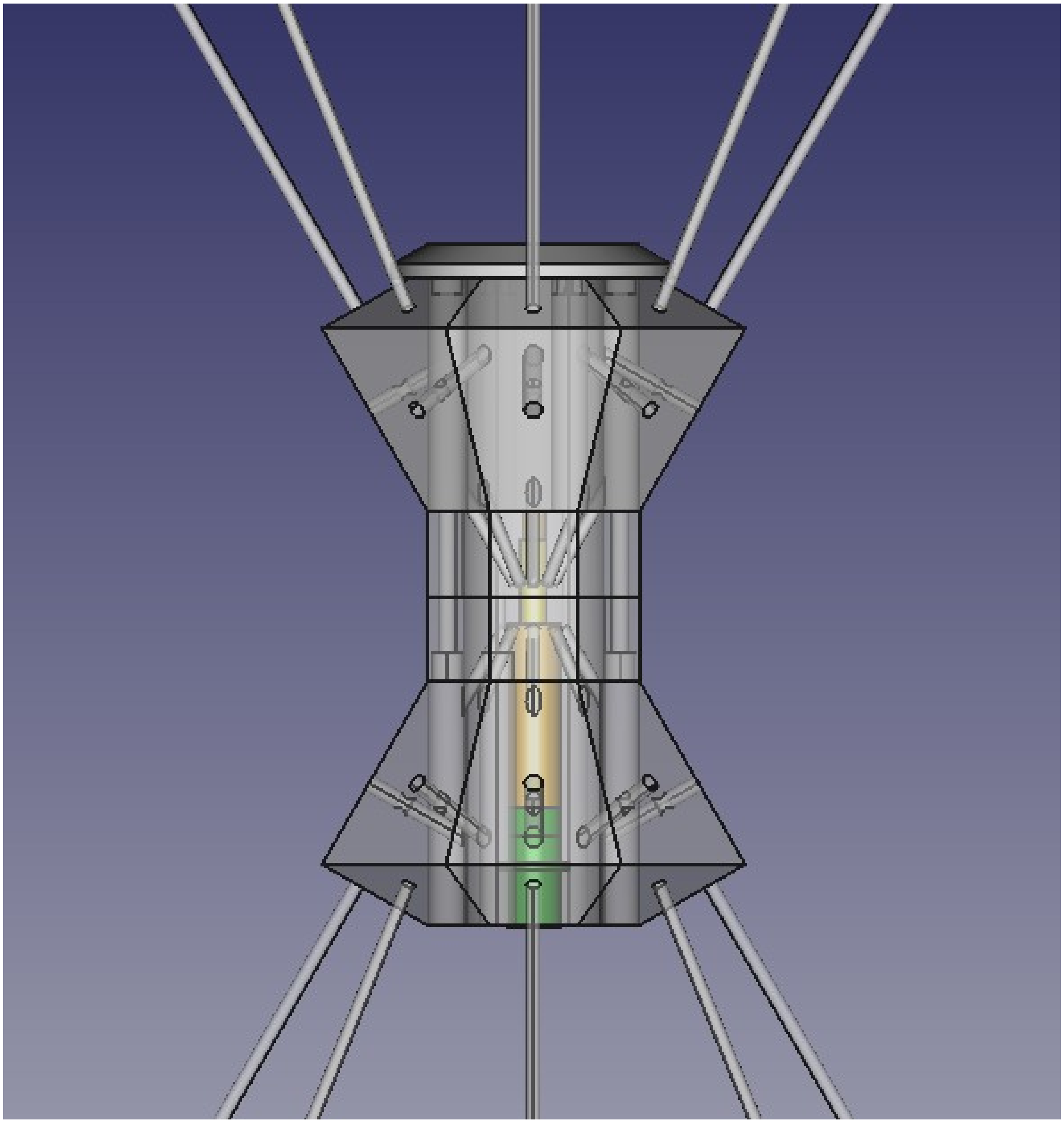


Fig. 1: Central portion of the biconical antenna with see-through detail showing the BNC at the bottom with a short 50 ohm extension transmission line above it. This line is made from telescoping brass tubing that are each soldered to the 8 rods, bottom rods to the 3/8" diameter outer tubing and top rods to a short section of 3/16" tubing that slips over the inner 5/32" conductor of the transmission line.

The top section is similar. A short section of 3/8" tubing is soldered to the eight upper rods and when assembled slips over the inner conductor to the coax extension of the lower section. This allows the two halves to be assembled and soldered separately and joined at the end, with four mounting screws securing them togher. An access hole in the top section allows soldering the 5/32" and 1/8" conductors prior to the addition of a top 'cap' which snaps on to keep precipitation out of the central area.

The antenna may be constructed in different sizes. The element lengths may be adjusted, shorter or longer, to allow for different low frequency limitation and to perhaps mitigate home-owner association concerns about visibility, something that many amateurs have to contend with these days. Although 18” /.5m rod lengths work well from just above the FM broadcast band to past 2 GHz, other lengths producing a 1m – 2m tip to tip dimensions can be configured as desired. The assembled antenna can be mounted on a vertical section of PVC pipe of the sort used for lawn irrigation systems.

Fabrication

Materials for the antenna are as shown in Fig. 2:

- 8 3/32” (2.4mm) 36” or 1m TIG welding rods
- 1 BNC female panel Mount Connector
- 1 circular heavy gauge wire termination having a .3375”/9mm hole
- 1 1.5” length .375” diameter” brass tubing
- 1 2.5” length 3/32” diameter brass tubing
- 1 1” length 1/8” diameter brass tubing
- 16 ¼” long brass screws (only necessary during assembly)
- 3 3D printed PLA plastic parts – bottom, top and cap (.stl and gcode files provided)
- Epoxy glue

Except for the printed parts, these materials are commonly available at local hardware and radio supply outlets or on-line. The 3D printed parts use common PLA filament and can be printed on home 3D printers such as the Ender3. The top and bottom mounts each take about 5 hours to print. Printing using ‘supports’ results in a slightly nicer finish at the penalty of requiring a little more cleanup after the print is complete. The cap is simply a cover which will snap on to the top mount to protect the inside connections from rain and snow.

The BNC and short transmission line assembly are as shown in Fig. 4

After printing and cleanup of the plastic parts, the setscrew holes and four central mounting holes can be threaded with a 6-32 or 3mm hand tap. These are not required to be strong, they only provide for alignment during assembly and once final assembly and testing are complete they may be left or removed.

The BNC/transmission line assembly that connectos the elements to the feedline is as shown in Fig.X

The 8 + 8 rods that comprise the top and bottome conic sections can be made by cutting 8 pieces of the original material in half and sending the ends to allow snug but easy assembly into the holes provide in the plastic. These are slid toward the center where they serve to trap the central tubing section, 3/8” for the bottom and 1/*” for the top. Once these are all alligned so that the tubing is centered and lies along the axis of the plastic parts the setscrews can be tightened to hold all in place while the rod ends and tubing are solf soldered.

This connects the shield of the BNC and its short line section created from the tubing to the bottom rods. Similarly the rods and tubing of the top section can ge soldered to connect the BNC center conductor to the top rods.

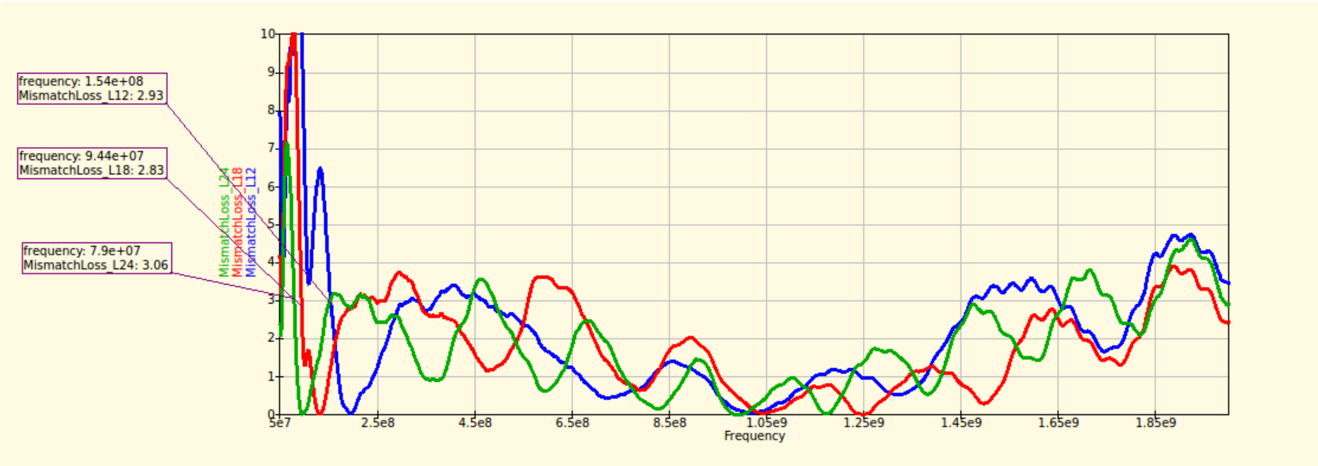
Final assembly is just a matter of inserting the 3/32” bottom center conductor tubing into the1/8” tubing soldered to the top rods and pushing the two halves together, finally securing them with four mounting screws. At this point the entire antenna is ready for testing and eventually final seal-up.

The rod setscrew holes may be filled with epoxy and the top and bottom sections can be glued together as well. Lastly the 1/8” and 3/32” tubes can be accessed from the top and talk soldered to ensure connection. The cap can then be snapped into place with epoxy or silicone sealant to keep water out.

Results

A comment is in order before describing measured results. While many antenna descriptions and articles choose to show match in terms of SWR, here I deliberately show it in terms of return loss. This is because SWR tends to give a very skewed picture of performance. By using return loss and the associated mismatch loss instead, these antennas can be directly compared against ideal antennas such as dipoles or monopoles. In practice, an SWR of 2.7:1 results in only 1 dB of mismamatch loss to a 50 ohm source or load. This is not even detectable except in laboratory conditions. Amateur and even commercial radio equipment is seldom exactly 50 ohms which further distorts the picture. In fact, typical equipment may inherently have 1 1.5:1 or 2:1 SWR ! By considering return and mismatch losses instead of SWR, a much better idea of performance can be directly discerned. I pick 3 dB, half of one Sunit as a reasonable comparison point. This may just be discernible in some communications conditions.

To show performance as well as the effect of different rod lengths, three antennas identical except for element lengths – 12”, 18” and 24”, are compared in Fig. 3.



Mismatch loss is shown with the 3 dB low frequency corner   for each of the three indicated. Above this line, the antennas are within one half an S-unit of 'perfect' which probably can not be discerened in almost any over the air measurement by ear. In a perfectly quiet receive environment the additional loss would negatively impact received Signal-to-Noise (SNR) ratio by 3 dB however in typical residential environments noise floors are elevated many dB above the thermal noise limit of -174 dBm/Hz and there will likely be no negative impact. On transmit with no feed line loss the transmitter (already stated as having something different from an exact 50 ohm source impedance) could see higher reflected power but with typical installations Feed line loss will likely reduce this, e.g. 3 dB of coaxial cable loss will add 6 dB to return loss of the antenna and the 10% reflected power will very likely not cause difficulty for any transmitter.

The 24" version has a -3 dB low end of about 80 MHz, followed by the 18" version at around 95 MHz and the 12" version at 154 MHz. All three antennas perform well, though not identically, up through 2 GHz. So except for possible exclusion of low end communication services any of these three can provide coverage of amateur bands from 220 MHz through 1296 MHz. The two longer versions also will cover Aircraft band and 144 MHz and higher.

Fig. 4 shows transmission between two 18" versions. This is a sort of proof-of-the-pdding measurement in that it includes not lonely mismatch loss but ground reflections, losses as well. Measurements were made at three spacings 2m, 5m and 10m. Even at the lowest frequency of interest, somewhere around 100 MHz, this results in the test antennas being in one another's far-field.

Summary