Folded Dipoles for VHF/UHF Yagis

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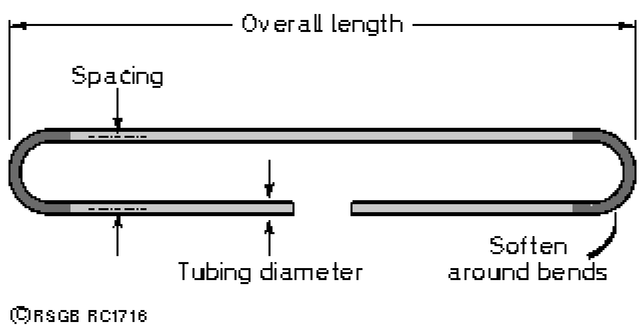
How do I make my own VHF/UHF folded dipoles from aluminium tubing? Which dimensions are critical?

Introduction

Surprisingly, the only critical dimension seems to be the overall length (see below). The second most important dimension is probably the tubing diameter, but both of these are less critical for a folded dipole than for a plain rod dipole or yagi directors. The spacing between the two arms of the 'trombone' can vary between quite wide limits, which is a great comfort for DIYers.

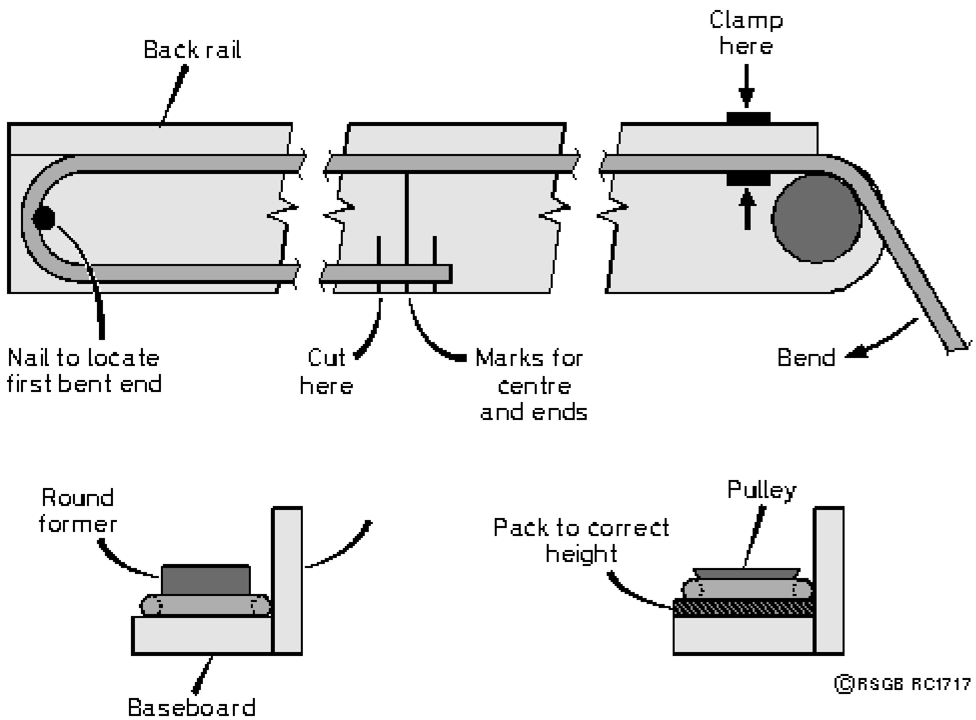
Having said that, you should obviously try to reproduce the dimensions given in the antenna design details as closely as possible.

Typical tubing diameters for the 2m and 70cm bands are from 0.25in or 6mm, up to 3/8-in or 8-9mm.



Making a Bending Jig

The key to good results is to invest a little time in building a bending jig. As the diagram shows below, this can be very simple and can be made out of scrap wood. The diameter of the round former needs to be about 5mm less than the inside diameter of the bend you're aiming for, to allow for some 'spring' when bending the tubing by hand. A former diameter of 35-45mm is usually about right; 50mm is possibly too big for a 144MHz dipole, and definitely too big for 432MHz.



A good way to make the round former would be to use a metal pulley (or a wheel with the rubber tyre removed) because the groove will help to locate the tubing as you bend it. However, the former could be nothing more elaborate than a short sawn-off length of antenna mast, secured to the wooden base of the jig by a few strong nails down the inside.

The purpose of the back rail is to support the straight part of the tubing, and make sure that the bend starts with the tubing held tightly on to the former. If you're using a grooved former, you'll also have to provide a packing strip to make the tubing enter the groove at the right height. It's also useful to round-off the end of the base, in case you need to use a mallet to persuade the tubing to go round the former.

Softening the Tubing

Some grades of aluminium alloy tubing may be soft enough to bend without collapsing, but then the straight parts of the dipole aren't as strong as they might be. If you have a choice, buy a hard, stiff grade of tubing and soften it only where it needs to be bent. If you try to bend that grade of tubing without softening it first, it will either break or collapse. If you pack the tubing with sand to prevent it from collapsing, that only makes it stiffer and even more likely to break the jig. (Don't ask how I know this...)

The answer is to soften the parts of the tubing that need to be bent, shown shaded above, leaving the straight parts at full hardness for mechanical strength. Begin by measuring out or calculating which parts of the original straight length will need to be softened, and mark these clearly. Make the softening zone longer than the theoretical limits of the bends. Then heat each of those zones in a blowlamp flame until they're softened.

That isn't quite as easy as it sounds, because you have to heat all the metal uniformly to the right temperature. One time-honoured method of indicating the temperature is to rub soap on the metal, and notice what colour it darkens to. Even so, you have to develop your own feel for the right temperature. If you don't get it hot enough, the metal is still too hard to bend successfully; if you overheat it, the end drops off! To bring all the metal up to the necessary temperature without melting anything, you cannot rely on the thermal conductivity of the aluminium to equalize the temperatures. You must use a big, bushy flame, keep it moving up and down the tubing all the time, and also rotate the tubing in your fingers.

When you're sure that all the necessary metal has been up to temperature, allow the tubing to cool naturally in air. After a few trials you'll soon get the hang of it.

Bending the Elements

To make the first bend, calculate and mark exactly where the bend should begin, and locate the tubing in the jig. Clamp the straight part in the jig, and pull the free end tightly around the former. After it has been softened, normal tubing of 16swg wall thickness should bend quite easily without collapsing significantly. If necessary you can use a soft mallet to encourage the tubing to follow tightly around the former, especially towards the finish of the bend.

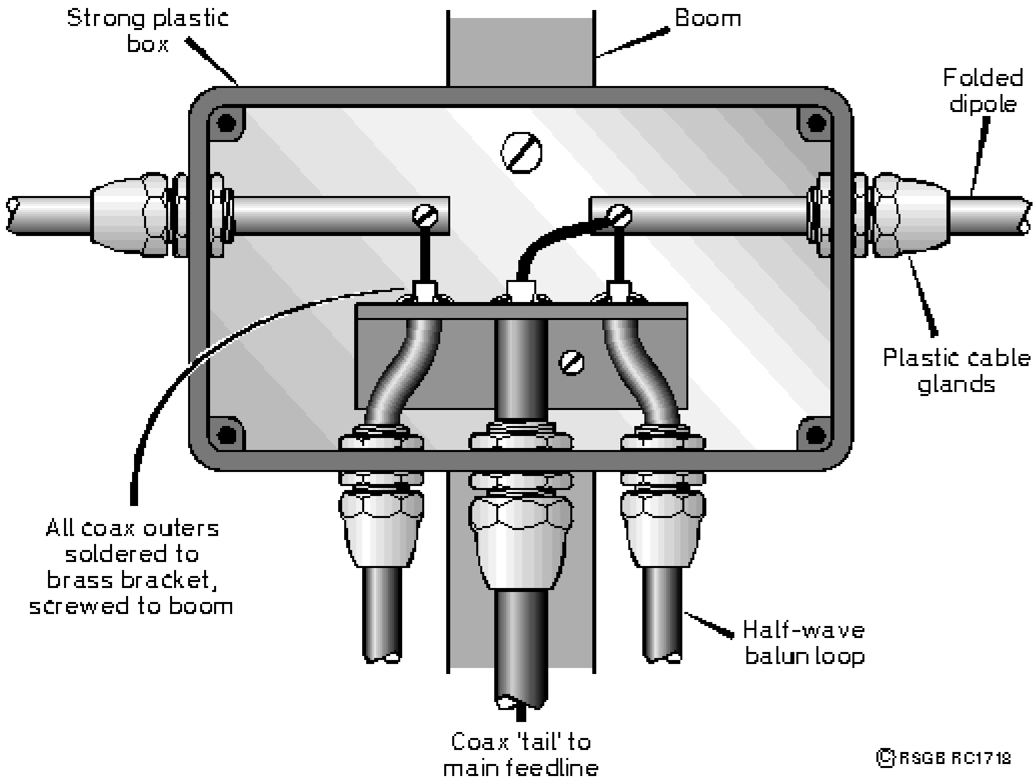
You will find that the trombone bend tends to spring off the former, so you'll need to make an allowance for this when you mark-out for the bend at the opposite end, in order to finish with a folded dipole of the correct overall length. You really can't do this by guesswork, only by measurement and careful marking-out. Take care to get this right because it's very difficult to change a bend once it has been formed. Once you have the correct dimensions, a nail at the far end of the jig will locate the inside of the first bend and ensure that all subsequent dipoles will be the same overall length.

When you make the second bend, also make sure that the two ends of the folded dipole will be in the same plane - it's easy to make small corrections by twisting. Because the DIY bending process isn't completely reproducible, it is best to leave some extra length so that the ends of the tube overlap in the centre when the dipole is folded. Then you can find the exact centre and trim the ends correctly, using marks on the jig.

After a few initial trials you should be able to make folded dipoles with an overall length that is repeatable to less than 3mm. That's accurate enough for any frequency up to 440MHz.

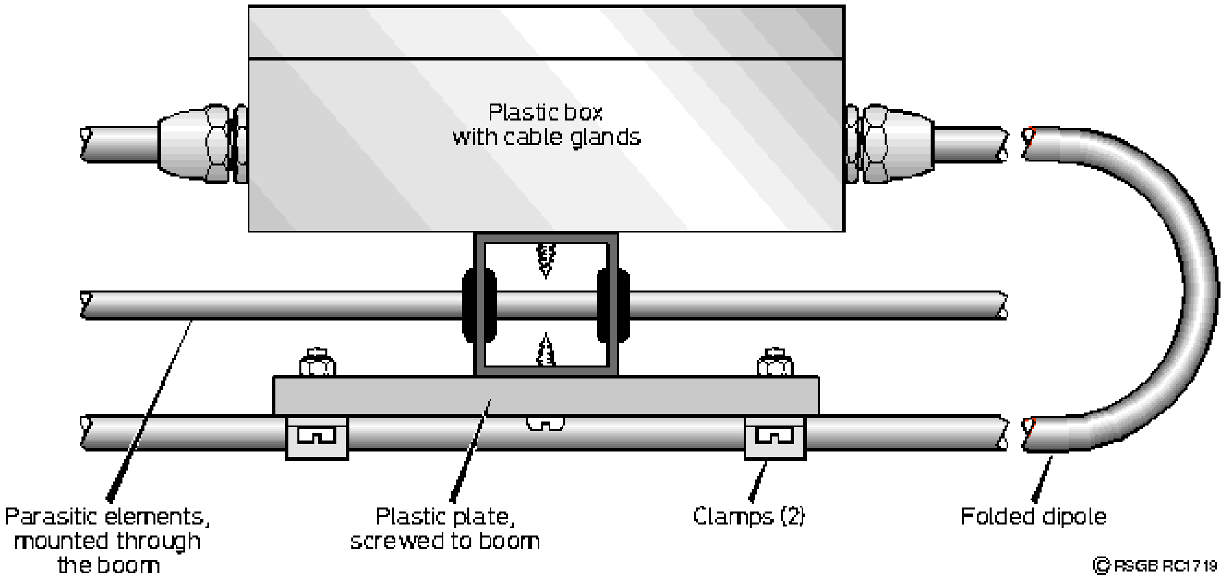
Fixing the folded dipole to the boom

When VHF TV antennas were common, it wasn't too difficult to find suitable plastic mouldings. You can still get these from specialist suppliers of antenna parts, but they won't necessarily fit your size of tubing, and may not have enough internal space to connect a balun. A clever solution, described in DUBUS by PE1DAB, is to use a strong, thick-walled plastic conduit box, with plastic cable glands to support the ends of the dipole. The centre of a dipole is a relatively low-impedance area, so the grade of plastic is not critical.



Supporting the folded dipole

It isn't always necessary to support the opposite side of the folded dipole, because cable glands of the right size will grip the tubing tightly when tightened, and will probably support a 430-440MHz folded dipole firmly enough on its own. If you do need to support the opposite side of a longer folded dipole, do not drill through the relatively thin tubing - the hole makes the whole thing weaker, not stronger. Instead, use some form of clamps on to a plastic plate that is screwed to the opposite side of the boom, as suggested below.



Do **not** attempt to "ground" the middle of a folded dipole to the boom, because that will almost inevitably result in unwanted RF currents running along the boom. The only connection to the boom should be through the balun, allowing the opposite side of the folded dipole find its own electrical centre.

Note that the diagram shows the boom running through the middle of the folded dipole. This doesn't seem to de-tune the dipole significantly. You'll also notice that some yagi designs have the parasitic elements level with the driven side of the folded dipole, others level with the continuous side, and yet others split the difference as shown above. Once again, this doesn't seem to have any significant effect on the performance.

This relaxed approach may come unstuck if the first director is very close to the driven element, as in most of the modern long yagis that have been influenced by the DL6WU design. In such yagis you can easily adjust the VSWR to compensate for minor differences in driven element mounting, by bending the ends of the first director either closer to the driven element or farther away.

Waterproofing

Waterproofing of the driven element is controversial. Either you can attempt to keep the whole system completely sealed, or else drill a vent hole in the bottom of the box to allow it to 'breathe'.

The sealed system is fine if it truly is sealed for life, but if there is even the slightest leak, the repeated daily temperature cycles will quickly pump in disastrous quantities of condensation which cannot run out. The vented system avoids the accumulation problem, but it allows slow atmospheric corrosion because moisture and dissimilar metals are always present.

As basic precautions you should waterproof the open ends of the coax using hot-melt glue or some other sealant, and spray the exposed metalwork with polyurethane or similar lacquer. If the folded dipole is mounted vertically, you will also need to drill a small hole in the bottom end to allow condensation to drain out. Otherwise water can accumulate in the bottom loop, and may split the tubing when it freezes.

One thing I can strongly recommend from bitter experience: to connect your main coax feedline, **do not use a flange-mounting socket directly on the wall of the box** - it is an almost impossible shape to waterproof reliably! Instead, use another cable gland as shown earlier, and bring out a 'tail' of coax to a normal line jack. The in-line connection to your main coax then becomes a very easy shape to waterproof with a wrap of self-amalgamating tape, followed by ordinary PVC tape.