construction guide
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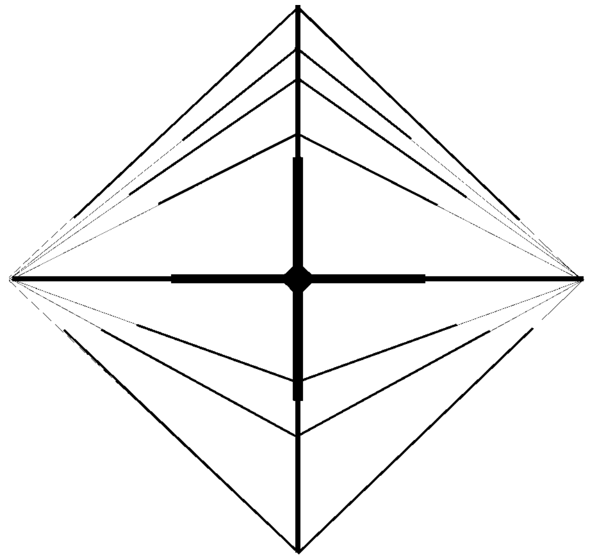
spider beam
20-15-10



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Contents

1. Introduction

By following this step-by-step construction guide you can build your own spider beam from scratch!

It was written with the intent to make it suitable for newcomers as well. Send me an e-mail or letter if there is still something not clear. Any further suggestions are very welcome.

All the necessary parts can be found on the parts list (page 4).
With enough people interested I will make the antenna available in kit form.

The chapters in this guide follow what I consider the most appropriate sequence for assembling the antenna. Of course it does no harm to read through the whole guide once before beginning…

In every chapter you will have to do some **preliminary tasks** first, then the **assembly**. You will have to do these preliminary tasks only once, before the first assembly of the antenna. The assembly tasks have to be done every time you put up the antenna.

You will notice that the preliminary tasks cover the larger part of the construction guide. Once you have completed these chores, assembling the antenna is done quite quickly:
- mount the center joint, put in the fiberglass rods and guy them, affix the wire elements, done!
All you need is two #10 spanners, some cable-ties, and some sticky tape.
So the first construction of the antenna will take you a few days. Afterwards, with a bit of practice, assembly can be done in about 2 hours.

One part of the preliminary tasks is the machining of the aluminum sheet metal and tubes (drilling holes and slots etc). In the Material kit I am preparing all these machining tasks will be done already. Thus they will be marked with a little note on the side of the text:

Already done in Material Kit

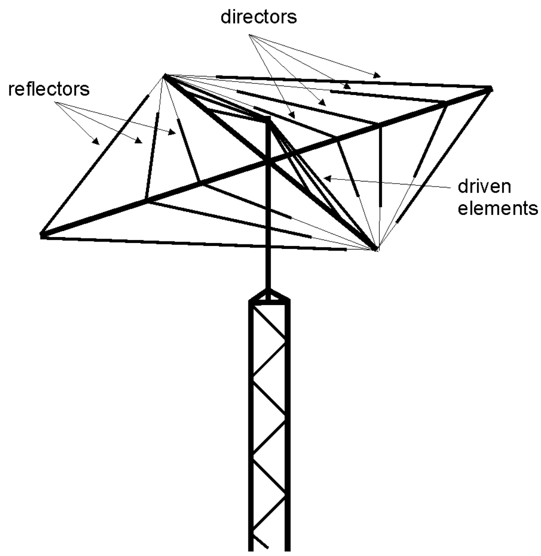
At the beginning of every chapter is a list of all the parts you will need in that chapter. Before starting to work on the chapter it is a good idea to put all the necessary parts in one place. Thus, when you finish the chapter you will have an automatic check whether you used up all the parts.

Please excuse the somewhat crude 3D drawings. At present I do not have a suitable software program at hand, true CAD drawings will follow.

Have fun building the antenna!
Best of luck and successful working!

1.1. spider beam fundamentals

The spider beam is a tribander yagi for 20-15-10m. It is constructed of 3 interlaced wire yagi antennas strung on a common fiber glass spider.
These are: a 3-element yagi for 20m, a 3-element yagi for 15m and a 4-element yagi for 10m. In contrast to a regular yagi the director and reflector elements are bent in V-shape.



The driven element is a multi band fan dipole for 20/15/10m, i.e. 3 individual dipoles connected at their center feed point. Feed point impedance is 50Ω.

Forward gain and F/B ratio of the spider beam is equivalent to a regular tribander with 6-7m boom length.

This antenna was designed and optimized for portable operation. It is a lightweight construction with a low wind load. It can be put up by a single person in a few hours – and needs only a lightweight push-up mast as a supporting structure.

The next design goal is to build a lightweight stack of 2 spider beams for fixed station use, by means of an appropriate phasing system (e.g. WX0B stackmatch).

The first one to build a 3ele Yagi with the elements bent in V-shape was G4ZU, who called it the "Bird-Yagi" or "Bow-and-Arrow Yagi". I heard of this principle for the first time in 1998 by W9XR. I could not find a multiband design anywhere in literature and decided to design one myself. Many thanks to everybody who helped during the development phase, especially W4RNL, DF4RD, DJ6LE, WA4VZQ.
Also MNI TNX to everybody who helped translating this document to other languages:
G3SHF (& Team), G3MRC, 9A6C, YU1QT, LX2AJ, CT3EE.

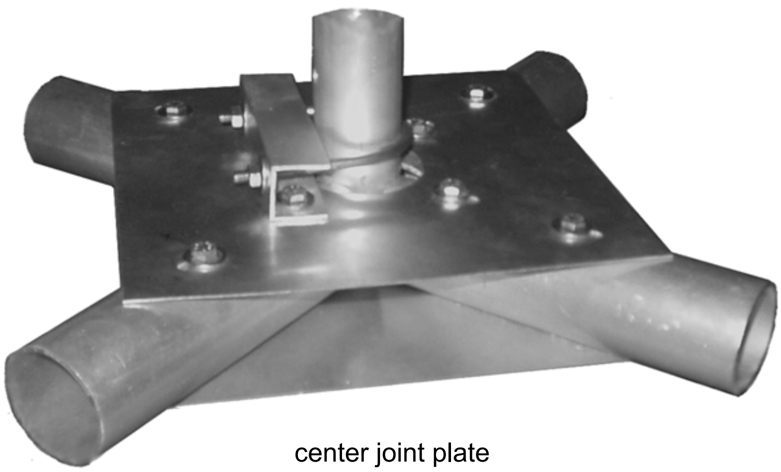
1.2. materials list

Nr.	quantity	description
1	4	telescopic fiber glass rods, length = 5.00m outer diameter of thickest segment: approx. 43mm outer diameter of thinnest segment: approx. 27mm
2	4	aluminum tubes, outer diameter 48mm, wall thickness 2mm, length = 175mm *important: the fiber glass rods of Nr.1 must fit tightly into these tubes!*
3	8	aluminum tubes, outer diameter 10mm, wall thickness 1mm, length = 42mm
4	2	aluminum sheet metal, thickness 1mm, length x depth = 220x220mm
5	2	aluminum 'U'-section, 25x25x25mm, wall thickness 2mm, length = 110mm
6	8	bolts, V2A, M6x60 *(V2A = stainless steel)*
7	2	bolts, V2A, M6x20 *(M6x20 = 6mm diameter, 20mm shaft length)*
8	2	U-bolts, V2A, M6, U-diameter 60mm, shaft length 95mm, thread length 45mm
9	16	M6 nuts, V2A
10	24	M6 washers, V2A
11	8	M6 tubular cable lugs, tin plated copper, two of them with 90° angle
12	72m	DX-Wire®,1mm diameter, or Copperweld® (copperclad steel wire)
13	46m	monofilament carbon fiber line, 1mm diameter, e.g. fishing line (or nylon monofil)
14	57m	Kevlar guy line, 1.5mm diameter
15	1	packet of cable-ties (100 pcs), polyamide black, UV-resistant, 200mm long
16	2.2m	polyamide hose, UV-resistant, outer diameter 8mm, wall thickness 1mm
17	1	packet of 5-Min Epoxy or similar epoxy resin
18	1	plastic 'U'-section, 30x30x30mm, wall thickness 2.5mm, length = 350mm
19	1	flat plastic panel, 25x2.5mm, length = 500mm
20	1	Teflon coax cable RG142 (or RG303), length = 300mm
21	16	ferrite beads CST9.5/5.1/15-3S4 (or 50 ferrite beads Amidon FB-73-2401)
22	1	PL Coax-Socket SO239
23	1	M3x10 V2A screw, with M3 nut
24	1	M3 soldering tag
25	1	Spool (20cm diameter, can be found in kite stores)
		GAFFA® Tape (can be found in live musicians stores)

2. Constructing the spider center joint

parts necessary:

Nr.	quantity	description
2	4	aluminum tubes, outer diameter 48mm, wall thickness 2mm, length = 175mm
3	8	aluminum tubes, outer diameter 10mm, wall thickness 1mm, length = 42mm
4	2	aluminum sheet metal, thickness 1mm, length x depth = 220x220mm
5	2	aluminum ‘U’-section, 25x25x25mm, wall thickness 2mm, length = 110mm
6	8	bolts, V2A, M6x60 *(M6x60 = 6mm diameter, 60mm shaft length)*
9	8	M6 nuts, V2A *(V2A = stainless steel)*
10	16	M6 washers, V2A



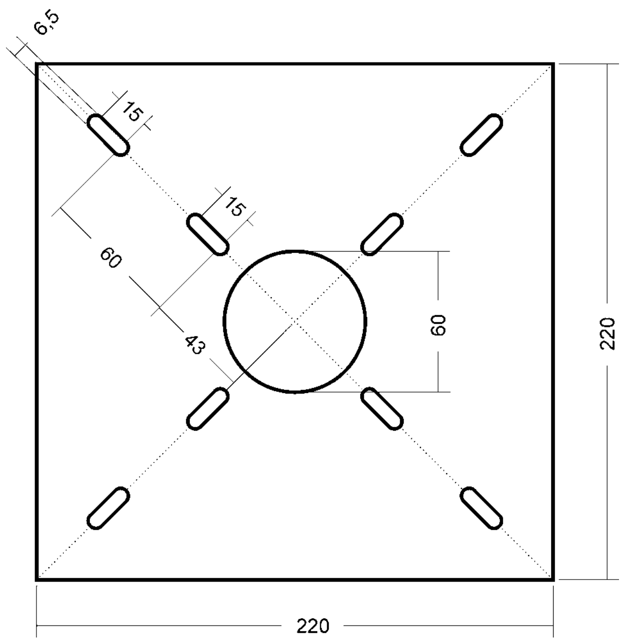
center joint plate

2.1. Preliminary tasks

Prepare both of the 1mm thick aluminum plates in the following way:

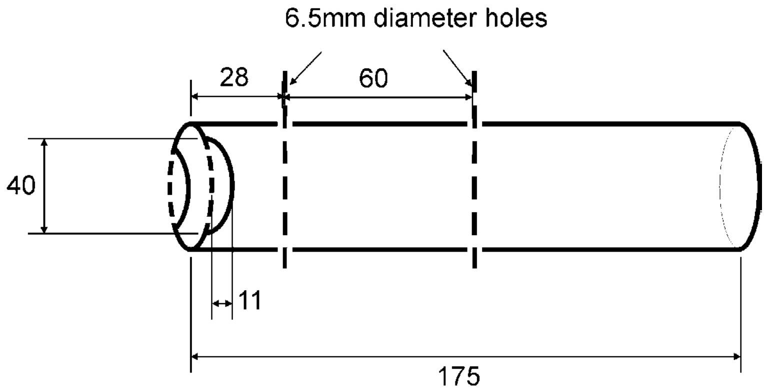
Cut a 60mm diameter hole in the center. Drill or punch 8 slots positioned symmetrically according to the drawing. These slots should be 15mm long and 6,5mm wide:

(all dimensions are in mm:)



Already done in Material Kit

Drill 2 holes (6,5mm diameter) into each of the 4 aluminum tubes. Use a saw or file to make 2 cutouts (half round, 11mm deep, 40mm wide) on one end of each tube. These cutouts will be necessary when mounting the tubes as a cross later on. (See page 7).

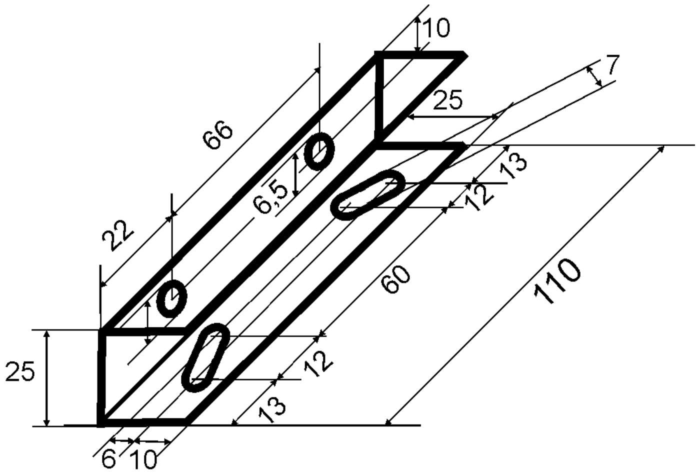


Already done in Material Kit

Depending on where you bought your fiber glass rods you should also check whether the thickest segment of the rods fits into the aluminum tube. There can be problems due to manufacturing tolerances. In case the fiber glass poles are a not a tight fit, just wrap a few turns of sticky tape around them. In case the tubes are too narrow you might have to get out your file and sandpaper and widen the inner diameter until it fits...

Now prepare the two 110mm aluminum “U”-sections:

Drill two 6.5mm holes into the center leg
and two 12mm long slots (7mm wide) into one side leg:



Already done in Material Kit

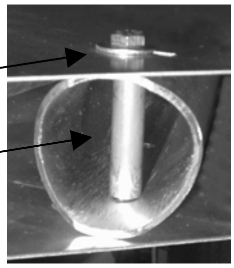
Already done in Material Kit

As a last step, cut the 10mm diameter aluminum tube into 8 pieces of exactly 42mm length. They will serve as sleeves when assembling the center joint (see next page):

2.2. Assembly

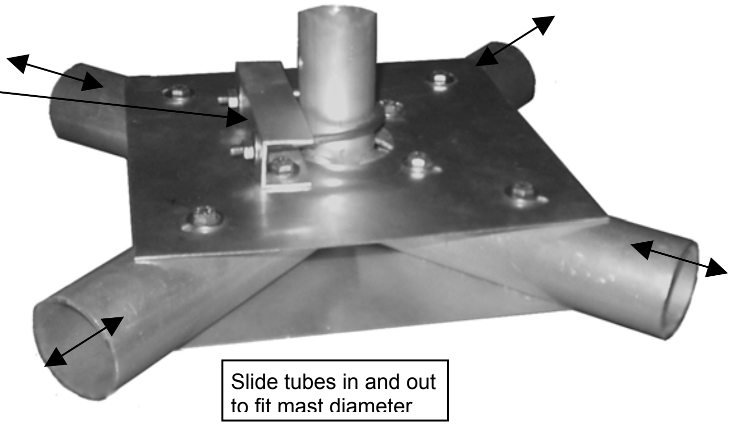
You are now ready to assemble the center joint

Put the four tubes between the two aluminum plates, then put a bolt through each slot and mount it. Use washers on either end of the bolts so they have a better grip. Stick the bolts through the 10mm sleeves inside the 48mm tubes. These sleeves are quite important because without them the tubes will crush when firmly tightening the bolts.



On one side of the 60mm hole, the same bolts also serve to mount the U-sections. Mount one angle on the upper plate and the other one directly below it on the lower plate.

The U-bolts that secure the antenna to the mast are mounted to these angles later on. (see Chapter 3.2.).



By now you will understand the reason for drilling the long slots instead of just round holes:

Sliding the aluminum tubes in and out makes it possible to vary the diameter of the vertical antenna mast from 30-60mm. With the long slots the tubes can always be positioned in a way that the mast is perfectly pinched between them. Hence most of the load that normally stresses the U-bolts is transferred to the tubes. The U-bolts are only necessary to prevent the antenna from rotating on the mast.

With this construction it is possible to use a wide range of vertical mast diameters without compromising stability. The wide diameter range means more flexibility when putting up the antenna.

Now you will also understand the reason for the cutout made at one end of each tube. Without the cutout the variation range of the antenna mast diameter would be only 48-60mm. Many push-up masts have top sections smaller than 48mm.

Most boom-to-mast plates put the antenna on one side of the mast, thereby putting its center of gravity on one side of the mast.

With the center joint described here the mast goes right through the center of gravity. Antenna weight and vertical torque momentum are optimally distributed on the mast and rotator, which means the load on these parts is reduced.

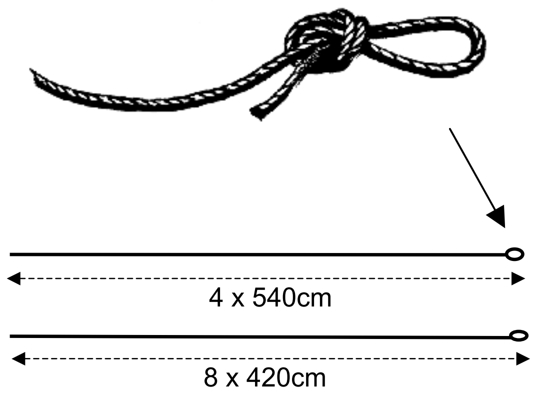
3. Constructing the Spider

parts necessary:

Nr.	quantity	description
		assembled center joint from chapter 2
		vertical antenna mast
1	4	telescopic fiber glass rods, length = 5.00m
8	2	U-bolts, V2A, M6, U-diameter 60mm, shaft length 95mm, thread length 45mm
9	4	M6 nuts, V2A
10	4	M6 washers, V2A
14	57m	Kevlar guy line, 1.5mm diameter
15	30	cable-ties, polyamide black, UV-resistant, 200mm long
		Tape, e.g. GAFFA® Tape

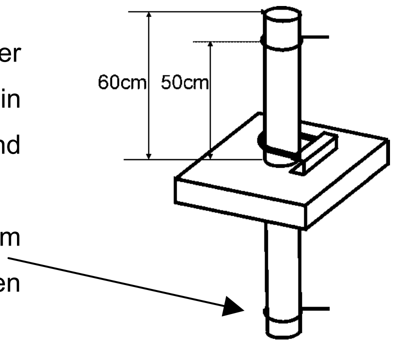
3.1. Preliminary Tasks

Cut the Kevlar rope into 4 pieces of 550cm and 8 pieces of 430cm. Bend back 10cm of the rope and use the knot pictured here to knot a small eye (10mm diameter) on one end of each rope:



3.2. Mounting the vertical mast

Mount the center plate to the vertical mast. Adjust the hole in the center joint so it matches the diameter of your vertical mast (as described in chapter 2.2). Put the vertical mast through the center joint, let it stand out 60cm at the top and tighten the U-bolts.
Affix two cable-ties to the vertical mast, one 50cm above and one 50cm below the center joint. They will serve as an anchor later, when installing the vertical guy lines. (see chapter 3.3.).

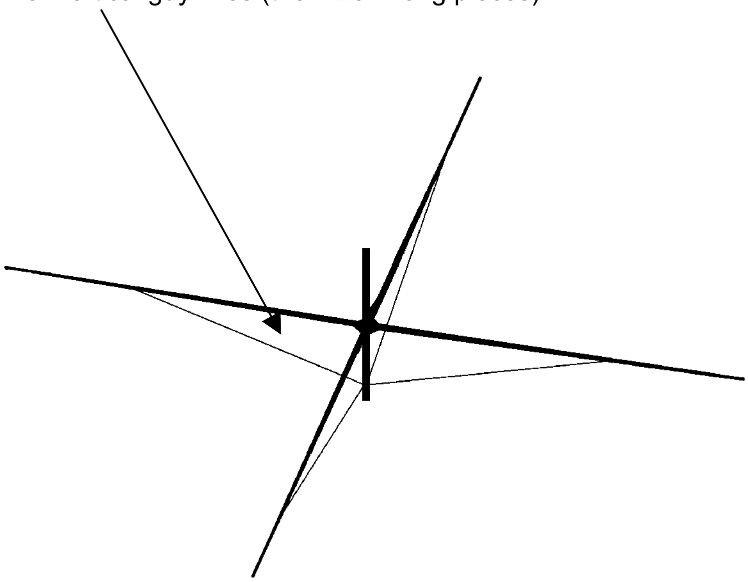


3.3. Mounting the fiber glass poles

Extract the telescopic fiberglass poles to their full 5m length. Carefully twist the sections in the telescopic joints so they lock, and cannot slip back in again. Better still, wrap the joints with some high-quality tape (GAFFA®) and put a cable-tie around it. This will ensure the connection stays together for years. (It is best to put the cable-tie on the smaller tube of the joint). If you assemble and disassemble the antenna a lot you should wipe off any residual glue from time to time. For permanent installation you might wish to use some epoxy resin to glue the joints together permanently.

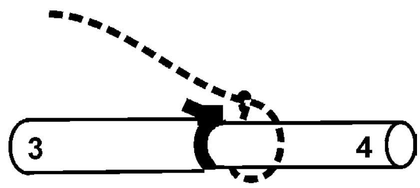
Insert the 5m poles into the tubes of the center plate.

Then first affix the lower vertical guy lines (the 4.20m long pieces).:



To do so, pull a short length of the Kevlar rope through the eye, forming in a variable slipknot:

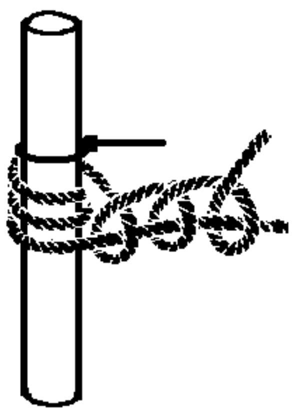
Slide this slipknot over the 5m pole until it rests at the joint between the third and fourth tube segment. Pull it tight here. The cable tie installed here serves as an anchor and prevents the slipknot from sliding further inwards:



Fasten the other end of the rope onto the mast, just below the cable tie you fitted here (50cm below the center plate). A very suitable sailors' knot for this job is some „round turns with some half hitches". It is very easy to untie later and is formed as follows:

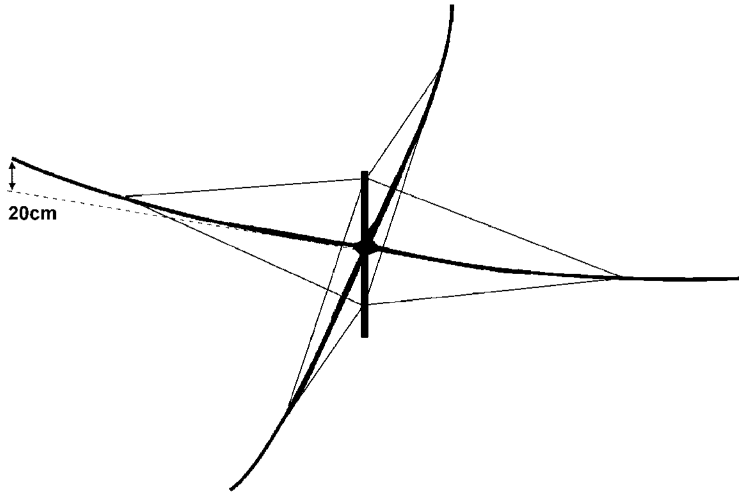
wind at least 3 (or more) turns around the mast and then secure the end with some "half hitches" (as shown in the picture). This knot is very easy to untie because the turns take the force out of the rope, so the "half hitches" do not lock up but can be undone easily.

The cable-tie serves as an anchor, preventing the guy line from sliding upwards.

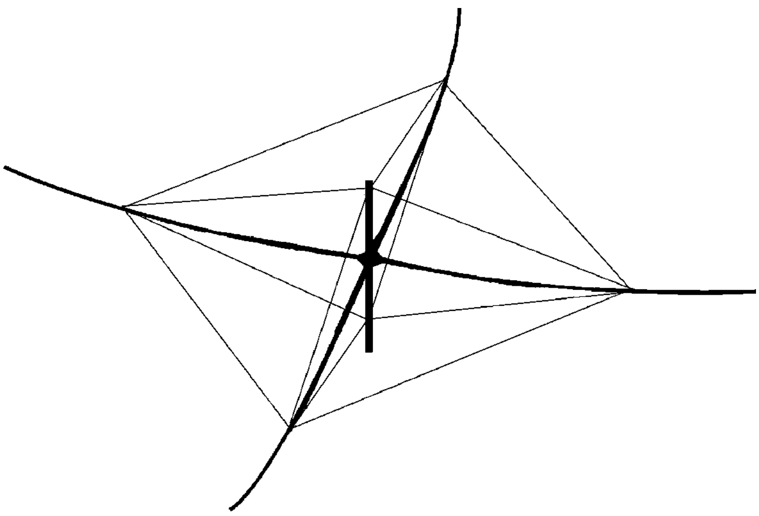


Tension these ropes only lightly, i.e. do not bend the spreaders downwards, just make them look straight. These ropes will be tensioned later when tensioning the upper vertical guy lines.

Next, attach the upper vertical guy lines (4.20m long pieces), using the same procedure and sailors knots as for the lower ones. Fasten them on the mast 50cm above the center plate (above the cable-tie). Pull these guy lines as tight as you can! The spreaders will bend upwards slightly, depending on how much slack was left in the lower vertical guy lines. The ends of the spreaders should not bend upwards more than 20cm, otherwise you should realign the lower vertical guy lines:



Now install the horizontal guy lines (5.40m long pieces).
Same procedure again, make a slipknot at the end of the line and pull it tight at the joint between the third and fourth tube segment of the fiberglass pole. Tie the other end of the rope to the next 5m pole, using the same sailors knot as before.
Then install the next 3 guy lines. Tension the first 3 ropes only lightly, i.e. do not bend the spreaders excessively. Only when installing the last guy line, pull it really tight, thus tensioning all 4 lines.



All guy lines will be very easy to untie when dismantling the antenna, as you used the sailors knots to fasten them. The slipknots on the telescopic joints will untie equally well.

The basic spider is now assembled. Our next step is to attach the wire elements.

4. Attaching the reflector and director wires

parts necessary:

Nr.	quantity	description
		assembled spider from chapter 3
12	49m	DX-Wire®,1mm diameter, or Copperweld® (copperclad steel wire)
13	41m	monofilament carbon fiber line, 1mm diameter, e.g. fishing line (or nylon monofil)
15	7	cable-ties, polyamide black, UV-resistant, 200mm long
16	1.3m	polyamide hose, UV-resistant, outer diameter 8mm, wall thickness 1mm
17	1	packet of 5-Min Epoxy or similar epoxy resin
25	1	Spool (20cm diameter, can be found in kite stores)

4.1. Preliminary Tasks

Cut the polyamide hose into 14 pieces of 4cm and 7 pieces of 10cm.

4.1.1. Cutting the wire element lengths

A few words regarding the wire material in advance, before cutting the wire:

Copperweld® is a trade name for copper clad steel wire. Lately this kind of wire has also been sold in Germany under the name DX-Wire®.

This wire has the HF conducting properties of copper wire combined with the strength of steel wire. In the beginning it is probably somewhat difficult to work with because it behaves a bit springy and not nearly as smooth as soft stranded copper wire.

You have to get used to it, only open one roll at a time, be careful and calm when (un-)rolling it, so you do not pull any kinks or eyes into it nor get it tangled up.

Anyway, this kind of wire has the following very good properties that may help you forget the troubles you may have when first using it:

- it does not stretch

  This feature (nearly zero elongation) is very important, because the element lengths must be kept exactly to the specified lengths (even 1cm does matter!).

  The first versions of the spider beam were built using normal (soft) enameled copper wire. Each time when assembling and disassembling the antenna, some elements had stretched up to 10cm. As a result, the resonant frequencies of the elements change, leading to a bad deterioration of the radiation pattern, especially the front-to-back ratio.
- low weight
- low wind load
- very thin and smooth, helps against ice build-up
- negligibly low velocity factor

  This feature is quite useful during the development phase because it guarantees a very good match of computer simulation and reality. Thus the lengths derived from the computer model can be used directly in the real world. This is not the case when using any kind of insulated wire or stranded wire. The insulation introduces some kind of velocity factor which is difficult to determine and is different for each kind of insulation (approx. 1 – 5%). So we cannot directly use the lengths calculated in the computer model but have to go through a correction phase. Therefore I would like to point out once again that the lengths specified in the tables below are only correct when using the wire specified here! When using other kind of wires (especially insulated ones) you must determine its velocity factor and adjust the lengths accordingly! Otherwise the radiation pattern will be affected badly, as mentioned above.

One last advantage over stranded wire seems to be a lower noise level. Stranded wire seems to have a higher inherent noise level, because of oxidation leading to diode action between the small individual strands of the stranded wire.

Hopefully these explanations make it easier to accept the somewhat stubborn wire chosen here. ☺
The same thing goes for the monofilament fishing line. Anyway, once you have gotten used to the peculiarities of these materials, handling will be no problem to you anymore.

However, let us cut the wire lengths now:

ATTENTION! THE WIRES MUST BE CUT VERY PRECISELY!

Even an error of one centimeter (!!) will make a difference.
A yard-stick is not suitable for this task because you can only measure partial lengths and must add them together. This procedure will easily introduce a cumulative error of ± 10cm or worse. The measurements must definitely be done in one piece!
A non-stretching plastic tape measure (minimum 11m long) is best suited for the job.

Perform the measuring and cutting on a plain and even surface (minimum 11m long), like on a concrete street or parking lot. Pull the wire straight and tension it to measure precisely. Have somebody help you pulling, or at least affix the wire and tape measure somewhere and pull yourself.

Because the wire comes on a small spool it behaves a bit like a spiral spring and rolls itself into a coil immediately. Secure this coil with a piece of sticky tape and label it accordingly before you cut the next one, so there will be no confusion later on!
(After completing all wire elements and guy lines you will wind them on a spool for storage and transport (see page 14))

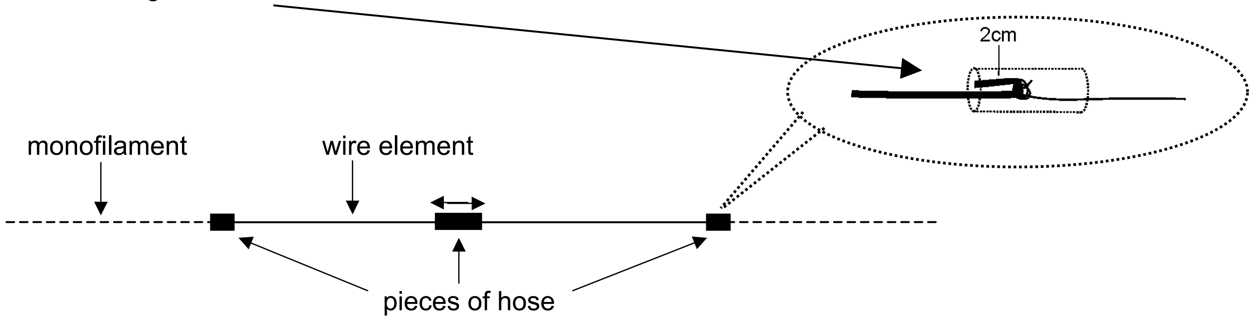
Cut the following pieces of wire for the 3 reflector- und 4 director elements:

band	reflector	director 1	director 2
20m	1051 cm	979 cm	- - -
15m	700 cm	647 cm	- - -
10m	527 cm	489 cm	489 cm

Important N.B.: In the next step you will knot together the wires and monofilament guy lines. During this procedure you will fold back 2cm of wire at both ends of the element. These extra 4cm are already allowed for in the lengths specified above. I.e. after assembly the electrically effective length of the 20m reflector should be 1047cm, for example.

4.1.2. Constructing the wire elements (attaching guy lines)

After cutting all wire elements to their correct length, attach the guy lines and stress relief devices on both ends of the wire:
First pull the wire end through a 4cm piece of polyamide hose. Then bend back 2cm of the wire end, thus forming a flat hook in the wire.



Then knot the appropriate length of monofilament line to this hook, as specified in the table below. (In the lengths specified, there is already 10cm allowed for making this knot). Cut off the excess monofil after fastening the knot, slide the 4cm piece of hose back over the joint and fill it with epoxy. Before you do the same thing at the other end of the wire, pull the wire through a 10cm piece of polyamide hose. This piece stays loose and will later on slide into the middle of the wire element. It serves as a stress relief device when mounting the wire element to the fiberglass spreader.

The monofilament guy lines must be cut to the following lengths:

Band	Reflector	Director 1	Director 2
20m	2 x 207 cm	2 x 240 cm	- - -
15m	2 x 242 cm	2 x 301 cm	- - -
10m	2 x 292 cm	2 x 325 cm	2 x 423 cm

As a last step knot a small eye to the end of each line. Bend back 10cm of the line, then use the knot pictured here to knot a small eye (10mm diameter) on each end:

As mentioned above, the extra 20cm for making both knots are already allowed for in the lengths specified in the table. E.g. this means for the guy line at the 20m director: after assembly the guy line length should be 220cm, measured from the eye to the joint with the wire element.

The 5-Minute-Epoxy hardens quite fast (in approx. 5 minutes ☺). Therefore you cannot mix a large amount and fill all the 4cm pieces of hose at once. Instead mix a small amount separately each time, stir it up properly for at least 1 minute and fill it into the piece of hose from the top. The epoxy slowly flows into the hose. If necessary use the knot to stuff it into it. If the epoxy flows out on the lower side of the hose, turn it upside down and let it flow back. Ensure that the knot is somehow in the center of the hose when the epoxy finally cures. It will get warm after a few minutes and become very sticky shortly afterwards. Now you can put this joint aside and begin with the next one. After another 10 minutes the joint will be totally hardened.

(**Important N.B.:** Even these short pieces of sleeving filled with epoxy affect the resonant frequency of the wire element: it goes down approx. 100-200kHz! Take this into account, should you want to use a different way of assembling the wire elements, and correct the wire lengths accordingly!)

As soon as you have completed each wire element, mark it (e.g. write 20m REF on the pieces of sleeving) and wind it onto the spool. Attach the beginning and end of the element to the spool with a piece of sticky tape.

Then you can wind the next element on top of it, without any problems of tangling or mixing them up. When transporting the antenna you can even wind the Kevlar guy lines on the same spool, on top of the wires, and also the driven elements.

In fact, it makes sense to wind the wire elements and guy lines onto the spool in the following order:

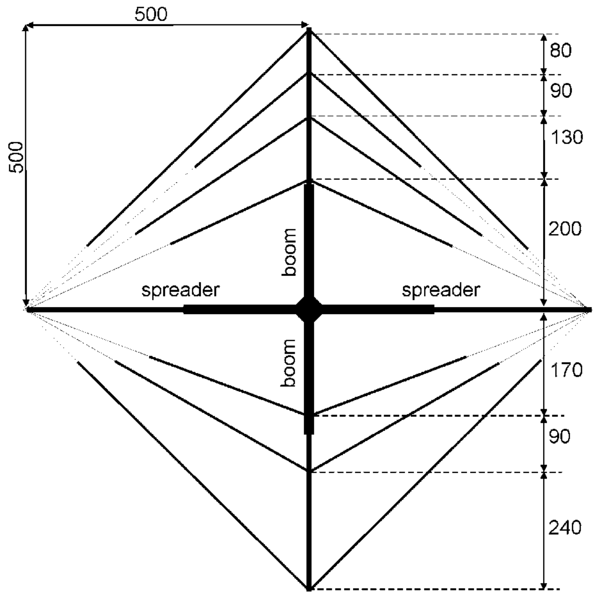
- first the driven elements 10m, 15m, 20m
- then 10m ref, 10m dir1, 15m ref, 15m dir, 10m dir2, 20m ref, 20m dir.
- then the guy lines

This is because when assembling the antenna later on you will start with the guy lines (on top of the spool), then install the 20m parasitic elements, then proceed with the parasitic elements of the higher bands, then install the 20m, 15m and 10m driven elements (see following pages).
Disassembly of the antenna is done in the opposite order.

4.2. Assembly

Once the wire elements are completed as described in 4.1., attaching them is very easy. First of all decide which pair of fiberglass poles will form the boom and which will form the lateral spreaders. Mark on the boom the attachment points for the elements (see drawing next page). At the end of each spreader pole install a cable tie exactly 5m from the center cross. It serves as an anchor preventing the guy lines from sliding inwards.
Before attaching and stretching the wire elements it is very helpful to raise the fiberglass spider assembly approx 50cm above ground level, e.g. by mounting it on a short stake driven into the ground.

Mounting a wire element:

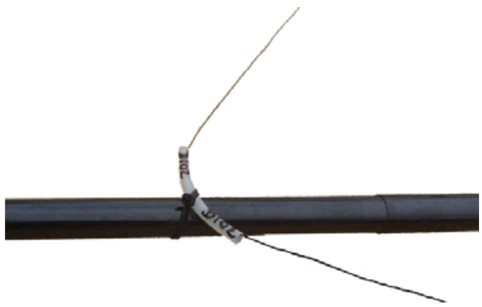


1. As you have now done often before, make a slipknot at the end of the guy line by pulling a part of the end through the eye you have knotted there.
Push this slipknot over the end of the spreader until it rests neatly against the cable tie and pull tight.

2. Unroll the wire element.

3. Mount the other end of the wire element at the opposite spreader just as described in **1.**

4. Attach the element center point to the boom. I.e. fasten the loose 10cm sleeving firmly using one or two cable-ties. The sleeving forms a strain relief to ensure the element does not bend too sharply at the cable tie:



Now the element should be stretched in the form of a V or triangle. (At least they should, if the element and guy line lengths were made as described in the last section.) Should the lines need adjusting when assembling the antenna for the first time, symmetry should be maintained by ensuring the line lengths are kept equal on both sides.

The element attachment points on the boom measured from the center are:

band	reflector	director 1	director 2
20m	500 cm	500 cm	- - -
15m	260 cm	330 cm	- - -
10m	170 cm	200 cm	420 cm

These distances are not nearly as critical as the wire element lengths! ± 5cm or perhaps more is OK.

The elements are installed from the outside working inwards, i.e. the 20m reflector and director first, followed by 15m etc. Care should be taken not to over tension 'inside' elements to avoid slackening the outer elements!

5. Attaching the driven elements

parts necessary:

Nr.	quantity	description
7	2	bolts, V2A, M6x20 *(M6x20 = 6mm diameter, 20mm shaft length)*
9	4	M6 nuts, V2A *(V2A = stainless steel)*
10	4	M6 washers, V2A
11	8	M6 tubular cable lugs, tin plated copper, two of them with 90° angle
12	23m	DX-Wire®,1mm diameter, or Copperweld® (copperclad steel wire)
13	5m	monofilament carbon fiber line, 1mm diameter, e.g. fishing line (or nylon monofil)
15	20	cable-ties, polyamide black, UV-resistant, 200mm long
16	90cm	polyamide hose, UV-resistant, outer diameter 8mm, wall thickness 1mm
17	1	packet of 5-Min Epoxy or similar epoxy resin
18	1	plastic 'U'-section, 30x30x30mm, wall thickness 2.5mm, length = 350mm
19	1	flat plastic panel, 25x2.5mm, length = 500mm
20	1	Teflon coax cable RG142 (or RG303), length = 300mm
21	16	ferrite beads CST9.5/5.1/15-3S4 (or 50 ferrite beads Amidon FB-73-2401)
22	1	PL Coax-Socket SO239
23	1	M3x10 V2A screw, with M3 nut
24	1	M3 soldering tag

5.1. Preliminary tasks

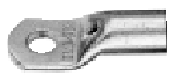
5.1.1. Constructing the driven elements

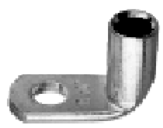
Cut the polyamide hose into 6 pieces of 10cm, 6 pieces of 4cm and 2 pieces of 2cm.

The beam driven element consists of a multiband dipole, i.e. 3 individual dipoles connected at their center feed points. These dipole elements are cut according to the table below:

band	driven element
20m	2 x 502 cm
15m	2 x 347 cm
10m	2 x 266 cm

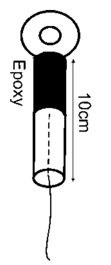
Again, marking each length as it is cut with a piece of tape will avoid confusion later. Also, when cutting these element lengths please remember the reference to accuracy in chapter 4.1.





After cutting all the element wires, carefully remove approximately 1cm of isolation from one end of each and solder it to a solder lug. The two solder lugs with the 90° angle are used for the 15m driven elements. Stainless steel soldering lugs are best suited for this outdoor job but most people seem to have problems soldering stainless steel. Galvanized tin plated copper soldering lugs (used in high current technology) are very easy solderable and quite weatherproof too, because of the tinned surface.

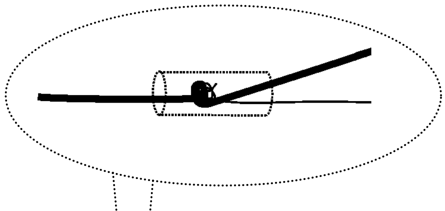
A hot (100 W) soldering iron is essential. We certainly do not want a bad soldering joint here!

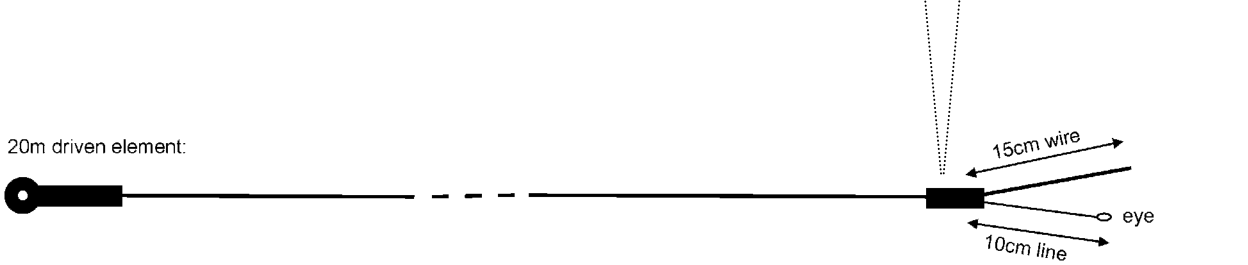


Slide onto each wire a 10cm length of polyamide sleeving as far as the solder lug leaving only the connector visible. Now use the epoxy to seal the wire and solder lug into the sleeve. This is best achieved by filling the sleeving with epoxy before finally drawing the tag into the sleeve. Only fill half the sleeve with epoxy leaving the rear half (where the wire exits) flexible, forming an effective strain relief.

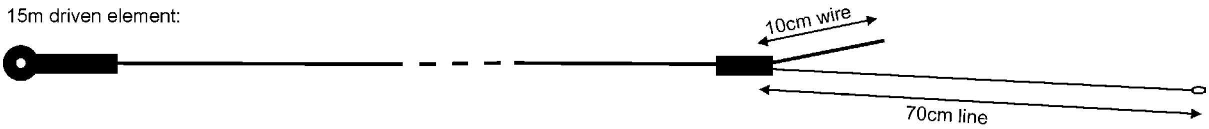
After attaching all the solder tags, connect monofilament guy lines to the elements.

First, take the free ends of the 20m driven elements.
15cm from the wire ends knot a piece of monofilament line to the wire. (see detail drawing). Slide 4cm polyamide sleeves over the knots and fill them with epoxy. As you have done often before now, knot a small eye (approx. 10mm diameter) to the end of the line, so the distance from the eye to the joint with the wire is 10cm:

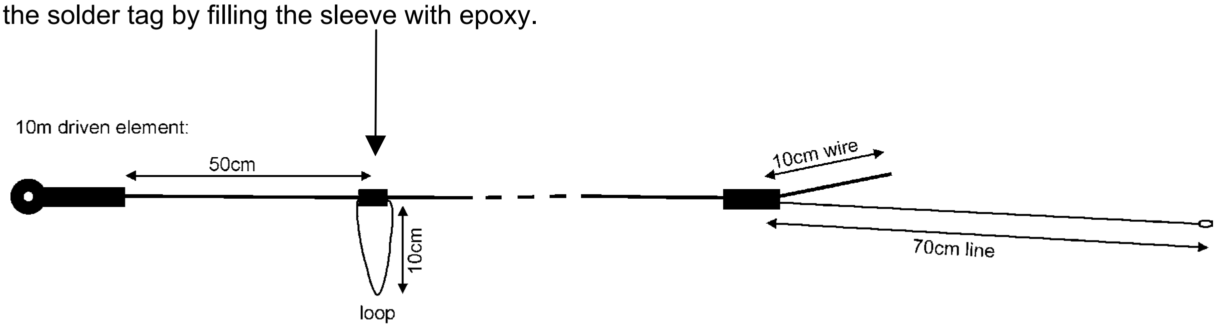




Quite similarly attach a 70cm piece of monofilament guy line to the ends of the 15m driven element:



Before connecting the guy line to the ends of the 10m elements pull the wire through a 2cm length of polyamide sleeving. Pull a 30cm length of monofilament line through this sleeve and knot the ends together, thus forming a 10cm long loop. Then secure the sleeve and loop to the element 50cm from the solder tag by filling the sleeve with epoxy.



Now attach a 70cm piece of monofilament guy line to the ends, in a similar fashion as on 20 and 15m.

The protruding short pieces of wire at the end of each element will make it easy to adjust the resonant frequency of the driven elements later on, thus optimising the SWR for each band.

5.1.2. Constructing the Balun

The feed point impedance of this antenna is already very close to 50 Ω. Therefore no impedance transformation is necessary, but only the unsymmetrical coax cable must be matched to the symmetrical antenna (balanced antenna – unbalanced coax).

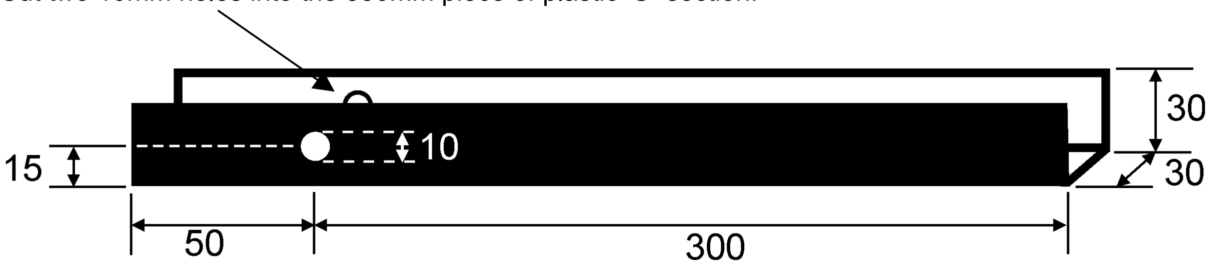
So, instead of winding a ferrite core toroid transformer (with all the problems and losses that may arise then) it is possible to use a simple coax choke here. The simplest version of a coax choke is constructed by coiling up a few turns (5-10) of coax cable right at the feed point. Anyway, the performance of such a choke is highly dependent on the operating frequency, the coax cable used, the diameter and height of the coil. Another problem is using a smaller coil diameter than allowed for the specific coax, which will make the cable deteriorate over time.

A much better solution is the coax choke developed by W2DU (QST 3/1983): take a piece of thin coax cable and slip a number of ferrite beads over the outer plastic jacket, which effectively increases the impedance of the coax sleeve. This stops current from flowing on the sleeve (outer conductor), resulting in a good match of the balanced antenna to the unbalanced coax cable. Using a piece of Teflon coax makes such a coax choke easily capable of handling 2KW continuous HF power.

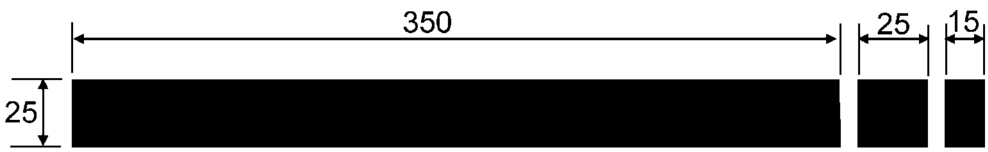
The coax choke described in detail below is not only suited for this antenna, but for a lot of antennas in the frequency range between 1.8 – 30MHz, e.g. for any kind of dipoles.

First prepare the housing for the balun:

Cut two 10mm holes into the 350mm piece of plastic 'U'-section:



Cut the 25x2.5mm plastic panel into one piece of 350mm length, 4 pieces of 25mm length, and two pieces of 15mm length:

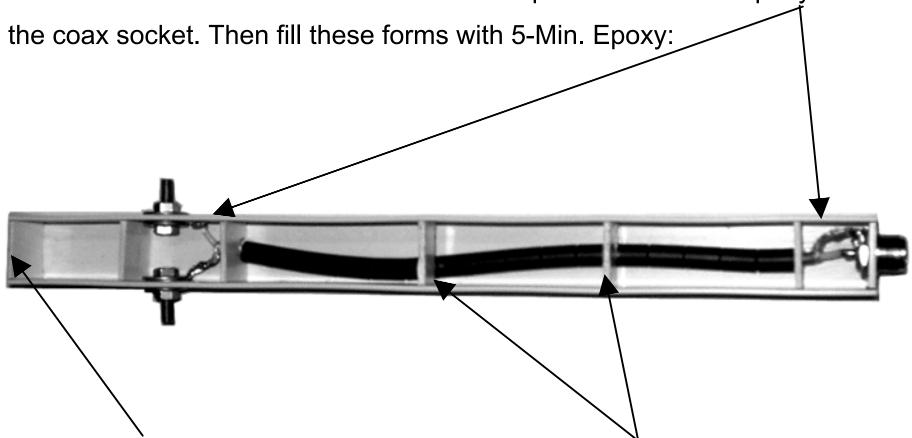


Use the M3x10 screw and nut to mount the M3 soldering tag to one of the 4 little holes in the SO239 coax socket. You will later solder the coax braid to this tag.

Now prepare the coax cable. Carefully adhere to the specified dimensions because otherwise the coax might not fit into the balun housing.
Remove 20mm of the outer plastic jacket on one end of the coax. Carefully separate inner conductor and sleeve. Twist the coax braid so it forms one big stranded conductor. Carefully remove 10mm of the insulation of the inner conductor. Then solder tags to both the inner and outer conductors.
Remove 30mm of the outer plastic jacket on the other end of the coax. Slip the 16 ferrite beads over the coax, then separate inner conductor and sleeve. Twist the coax braid so it forms a big stranded conductor. Cut off 15mm of the inner conductor, then carefully remove 5mm of its insulation. Then solder this end of the coax to the PL coax socket:

Now you can mount the coax choke to its housing.
Use an M6x20 screw, 2 washers and a M6 nut to mount each soldering tag to the ‘U’-section. Tighten these screws very firmly. They will later become the feed point for the driven elements.
(The screws are a bit difficult to insert, therefore we drilled 10mm instead of just 6.5mm diameter holes, to provide some extra room.)

It is not necessary to fill the whole balun housing with epoxy, only the feedpoint and coax socket need to be sealed 100% water tight. So take 3 of the 25x25mm pieces of the flat plastic panel and make a little cutout for the coax cable on 2 of them. Use these pieces to make “epoxy forms” around the feedpoint and the coax socket. Then fill these forms with 5-Min. Epoxy:

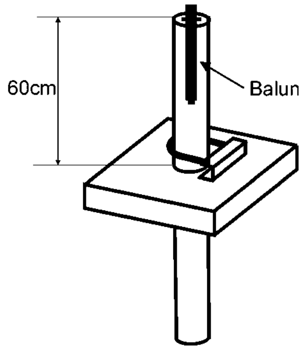


Epoxy another 25x25mm piece to the left end. The two 15x25mm pieces can be used to stiffen the housing. The 350x25mm plastic panel serves as the lid of the box. Use some more epoxy to glue it to the top of the balun housing. This connection does not need to be water tight, it is even a good idea to leave a small gap where condensation water can run out.

Thats it, the balun (coax choke) is finished. Please let the epoxy cure for one day (because of the large amount).

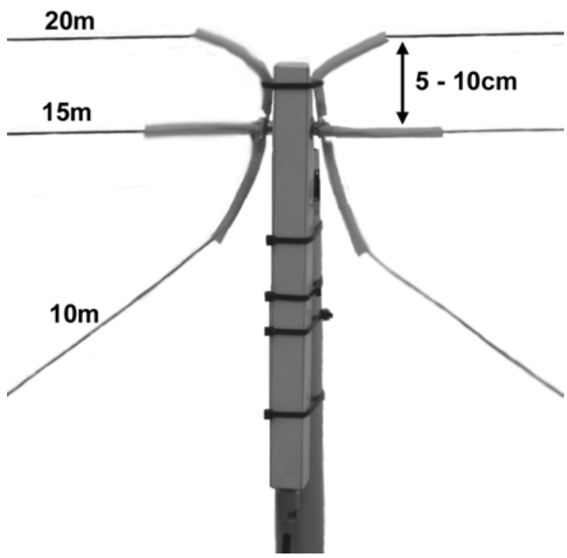
5.2. Assembly

Attaching the driven elements is quite easy, all we need is a few cable ties.



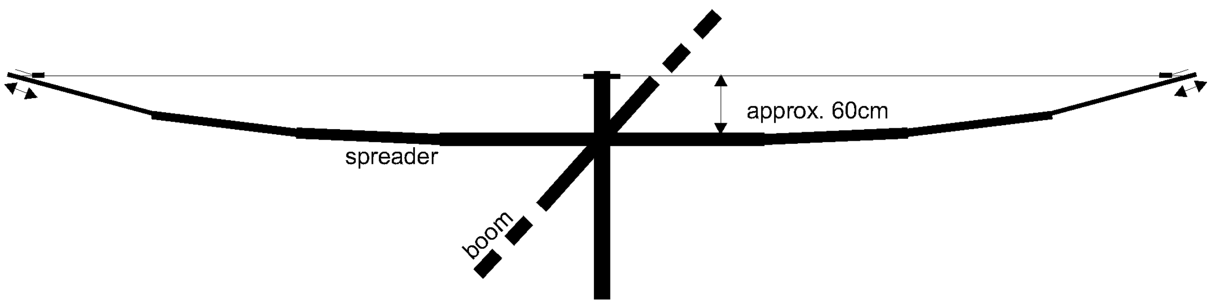
In chapter 3.3. you mounted the vertical antenna mast with about 60cm extending at the top. Attach the balun to the antenna mast with some cable-ties or sticky tape, so the feed point is located up there, 60cm above the center plate:

First attach the solder tags of the 20m dipole to the feed point and fasten them with M6 nuts.



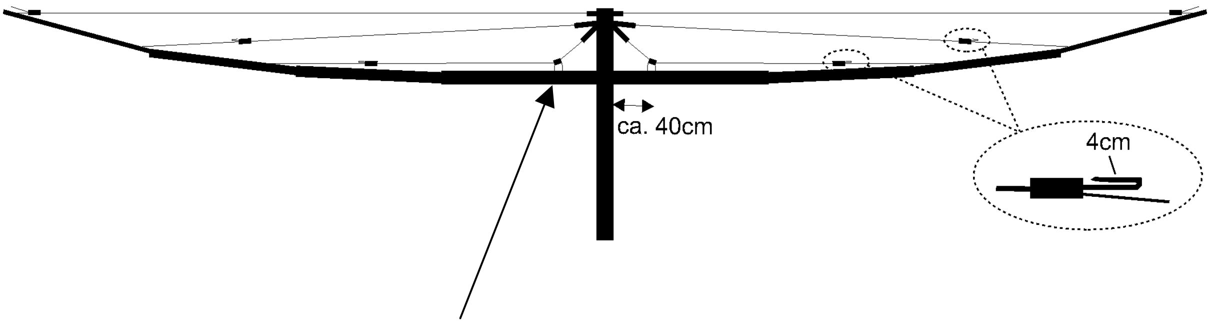
Align the polyamide sleeving so it points upwards and use a cable-tie to attach it to the balun housing there (at least 5cm above the feed point screws):

Now stretch the 20m dipole across the spreader poles. Insert a cable-tie through the eye at the end of the guy line and attach it to the end of the spreader. By moving this cable-tie the dipole can be adjusted until it is fully stretched horizontal. This will result in the end of the spreader pole being flexed upwards by 50-60cm:



In the same way install first the 15m dipole, then the 10m dipole.

As shown in the drawings, the individual dipoles of the multiband dipole should be mounted with a fair amount of vertical separation. As with any multiband dipole, the further they are spaced apart, the less is the mutual interaction. The spacing between the upper dipole (20m) and the lowest dipole (10m) should be around 50cm. The 20m and 15m dipoles should be separated at least 5-10cm directly at the feedpoint, as shown in the drawing above. Otherwhise the 15m resonant frequency is shifted high above the 15m band. It is also important to keep the 10m dipole in some distance from the fiberglass spreaders. Otherwhise the SWR might raise substantially when the spreaders get wet from rain.



We mounted an additional guy line loop approx 50cm from the solder tag when preparing the 10m driven element. It is there to increase the distance between the 15m and 10m dipoles. Insert a cable-tie through this loop and attach it to the spreader pole in approx. 40cm distance from the mast. Then use a cable-tie to attach the eye at the end of the guy line to the spreader and stretch the dipole, just as you did with 20 and 15m.

The excess wire at the ends of the 15m and 10m-dipoles should be folded back approx. 4cm, as shown in the detail drawing above.

Congratulations!
The assembly is complete – the spider beam is ready to go on the air!

Quickly connect a coax cable and put it up. One hint regarding the protection of the coax connection against damp and rain: Cut a 20 cm long piece of old bicycle inner tube and pull a part of it over the lower end of the balun. Then connect the coax and leave the remainder hanging over the coax cable. If necessary, secure it with a cable tie – Voila! Protects against rain better than any sticky tape and is much easier to remove.

6. SWR alignment

As mentioned earlier it might be necessary to set the driven element dipoles at resonance in the center of each band: to do so connect an SWR bridge between your transceiver and the antenna and find the frequency of lowest SWR for each band. This is the resonant frequency and you want it to be in the center of your operating band.

Anyway, using the dipole lengths specified, resonance SHOULD be at the center of each band already.
If it is not, move it by folding or unfolding the short pieces of excess wire at the end of each driven element: if resonance is too low fold the excess wire further back, thus shortening the element. If it is too high, open out the folded wire, thus lengthening the element.

Because of mutual coupling the 20m driven element should be adjusted first, followed by 15m and then 10m.

When checking SWR alignment it is sufficient to lift the beam 5m off the ground. When finally erecting the antenna to full height the resonant frequency will change slightly again but this will not affect performance significantly, especially for short-time use. An SWR of 2:1 is definitely good enough anyway!
SWR alignment of the antenna is normally a quick operation and it should be sufficient to erect the antenna only once or twice to complete the task.

Thats it.
And now, have fun on the air!

Where do we go next?

spider beam on 10m aluminum push-up pole

Further experimenting is strongly recommended:
One advantage of this style of construction is that it is not limited to the tribander described here. Once the supporting structure has been built other wire antenna designs can be tried easily and cheaply. Aside from the wire elements everything remains the same. Depending on the desired goal of the moment you can always tailor-make the optimum antenna to fit your needs.
E.g., how about some projects like 6 elements for 6m, 5 elements for 10m in the next 10m contest, a WARC-Beam, 2 elements for 40m…?
There are also different concepts regarding the bending of the elements. For example, on the same supporting cross, a Moxon Beam, an X-Beam or a bent HB9CV could be constructed.
All you need is an antenna simulation software and a few ideas!

7. Addendum

7.1. Element Lengths for single mode use (CW or SSB only)

The element lengths specified in chapter 4.1.1. are best suited for operating both CW and SSB, thus using the antenna on the whole band.
For single-mode use it is of course quite easy to optimize one set of wires for pure CW usage and another one for pure SSB usage. By doing so, the operating range with the best F/B ratio is shifted directly to the CW part or the SSB part of the band. Gain and SWR changes are less significant, and it is still possible to use the antenna throughout the whole band.

The following element lengths are optimised for **pure CW usage**:

band	reflector	director 1	director 2
20m	1056 cm	984 cm	- - -
15m	703 cm	650 cm	- - -
10m	530 cm	492 cm	492 cm

If you compare these lengths to the table in chapter 4.1.1. you will notice that the 20m elements have been **lengthened** by 5cm, and the 15m and 10m elements by 3cm. The lengths of the guy lines should be adjusted accordingly. The element spacings (drawing on page 15) do not need to be changed.

The following element lengths are optimised for **pure SSB usage**:

band	reflector	director 1	director 2
20m	1043 cm	971 cm	- - -
15m	696 cm	643 cm	- - -
10m	523 cm	483 cm	483 cm

If you compare these lengths to the table in chapter 4.1.1. you will notice that the 20m elements have been **shortened** by 8cm, the 15m elements by 4cm, and the 10m elements by 4cm and 6cm. The lengths of the guy lines should be adjusted accordingly. The element spacings (drawing on page 15) do not need to be changed.

As you already know from the table in chapter 4.1.1., these lengths allow for some extra 4cm to make the knots between the wire element and monofilament guy lines. I.e. after assembly the electrically effective length of the 20m reflector should be 1052cm for CW use, and 1039cm for SSB use.