Building HF Aerials – Cheaply **March 2006**

Reason for talk – members have asked about building HF aerials from scratch instead of buying a commercially built one costing over £100, and not aware of how cheap it is, and how easy it is to build them for themselves.

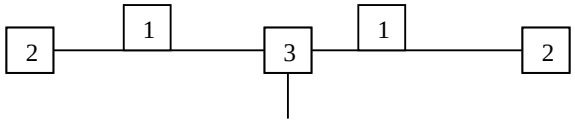
After all, part of our license conditions, permit **Self Training and Experimentation**, so this is a good exercise in doing just that. While your main skills may be non-technical, there is **NO** reason why you should not "**have a go**". After all, we all have to learn whatever skills we have, and by asking others and reading books, you can learn other skills – so have a go at building your own HF aerial system.

A point often mentioned in home construction books on aerials is that - Home made aerials Often work better than commercials ones, and are also cheaper.

Let start with a Commercially purchased aerial, costing around £100.

Component parts of the Commercial Aerial.

1 Main aerial wire. Cut to length of required band(s).
2 2 end insulators.
3 Balun, if using co-axe feeder.
4 1 centre plate for fixing to pole. – May NOT be supplied.



The above diagram shows the items that you purchase when buying a commercial aerial. However, it **DOES NOT** include the other bits and pieces required to erect your aerial.

Extras required – Applies to all aerials – home built or otherwise.

Co-axe down feeder - with suitable plug(s) – (PL259 etc).
Mast(s) – and suitable guys, brackets etc – as required to suit your location.
Nylon fishing line or rope to connect to insulators & guys. - B&Q or Ships Chandler.
Centre plate - - Make from plastic.
U bolt to fix centre plate to pole. - Garage
Or – U bolt to allow movement of centre plate if movable.
Top pulley - Hardware shop
Pulley rope. - B&Q or Ships Chandler

We have mentioned a **Balun, item 3** above. This is a **Matching device** - these are necessary when using Co-axe Cable, which is an **Un-balanced feed line**, that has to be connected to a **Balanced Aerial system**. Further details later.
Any centre feed aerial is a balanced system, such as a ½ wave or full wave dipole.
With a basic ½ wave dipole or a multi-Band aerial, we need a 1:1 Balun.
These may be purchased for around £30, but may be made easily for less than £5.00

A Balun is used to convert Un-balanced co-axe feeder, to a Balanced Aerial system.

However, **Balanced Open wire feeder** does **NOT** require a Balun, except for a built in one on the ATU. See later.

To build your own HF aerial from scratch, you will need the following items, **in addition to the Extras already mentioned above**.

Requirements for home build.

12-14 SWR hard drawn copper wire.
Cut to length, i.e. 130 feet for 80m to 10m. – **See table later** –
Purchase from Westlake - £12.50. Or local electrical suppliers – may be cheaper.
Thinner wire for 30, 17 & 12 m – if required.
2 end insulators – either Dog or Egg shaped, if buying. £1.00 each
Make your own from plastic or Perspex or Bakelite.
i.e. – flat plastic, or piece of plastic tube, ¾ inch - 1inch dia.
Centre plate - Plastic, or Bakelite or Perspex. More details later.

12-14 SWR hard drawn copper wire – Obtained in a roll which will twist and may be straightened by fixing one end to say a vice or fence, and with the other end fixed into a **HAND** drill. The drill is rotated so as to try and remove the twist in the wire. This is important when building **open wire twin feeder**. **TAKE CARE**. Trevor also suggests, that you fix one end firmly, and unroll it slowly, and after about 5 turns, TWIST the remaining coil of wire to remove the UN-Wanted twist.

TAKE CARE, AS THIS WIRE WILL WHIP BACK ON ITS SELF, AND CAN CAUSE DAMAGE TO YOUR FACE AND/OR EYES. WEAR PROTECTIVE GOGGLES.

Take care **NOT** to get sharp bends or twists in this copper wire, as being hard drawn, it will break easily.

We now start the building stage.

However, before we build the aerial, we need to decide where we are going to erect any poles or masts, and the need to take special precautions, regarding preventing the aerial from getting tangled in plants or any other structures in your garden. (One point to note, if you need to obtain planning permission for any "**aerial support**(s)", do ensure that you use the correct words – i.e. a **POLE,** of 2inches diameter is a **POLE** and **NOT a MAST. Whereas,** a 3 sided **Latice Mas**t is a **MAST**. **Calling a Pole a Mast may cause your application to be refused**.

Pole/mast. – Decide where the pole is to go first before fixing the centre plate. More later on centre plate.

Look at ease of raising and lowering the mast.

If mounted against a wall, can it be hinged at the base? Think on this point, especially if you have a pole with a rotator and beams on the top for VHF/UH|F or even a HF Beam. Multiply the weight of the rotator and beams, by the length of the pole, and this gives you the overall weight that is at the end of the pole when being raised – can be over 600 lbs, (300Kg). If it slips and hits the ground – expensive!

If mounted against a wall – fit suitable wall brackets, (and base pivot plate if required. Get local Blacksmith to build you one. About £20).

If not standing against a wall, then fit guys to keep pole upright. Suitable brackets can be purchased to fit around the pole, which have small bolts that allow guys to be fitted to them. Ensure suitable ground fittings/stakes for other end of the guys.

Will the main aerial wire hit anything when being lowered?

If wires HITING – then think about using a pulley to raise/lower the centre plate. Good idea anyway!

Layout of Aerial - V type or horizontal? – Check for obstructions.

Where will the ends terminate and fix too?

If in a tree, then use a pulley system to support the aerial wire support rope. Use separate rope to tension the aerial. *I use a rope loop over a tree branc that as a pulley connected to it. The loop allows the pulley to be raised and lowered. Through the pulley I have a rope that is connected to the aerial wire. This allows the aerial wire to be raised/lowered. The other end of the rope goes over a 2nd pulley that is fixed to a shorter pole tied to another tree stump, and then tied at the bottom. This pole is flexible enough to allow movement of the tree branch to be absorbed in a high wind.*

If using one pulley and weight to allow for tree movement – Take rope through the pulley, and have a suitable weight at the bottom to absorb any tree movement.

If you want to raise/lower the centre feed point on your pole, (the centre plate), then fit a pulley at top of pole, with a Loop of rope to allow you to pull in both directions. Up & down.

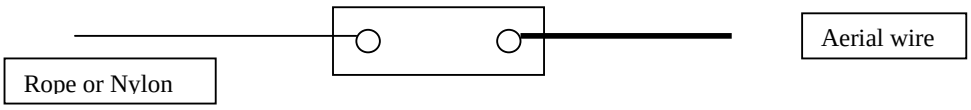
Ensure rope can be attached to centre plate and U bolt fitted which will side up and down the pole.

Ensure rope twisted around pole when not in use – this stops it tapping against the pole in wind.

This should by now have your support system ready for the aerial.

Cut Aerial wire to approx length & fit end insulators.

Plastic insulator for the ends – flat or round plastic with holes at about 1/2inch in from each end.

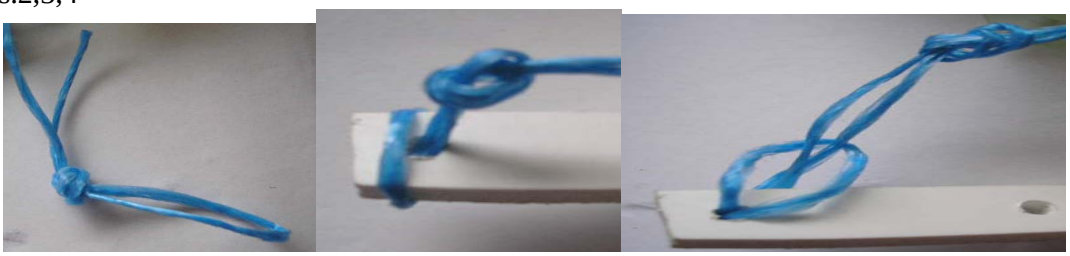


Fit wire through the hole on the insulators. Bring back on itself and twist around the main wire. About 3 turns will do. Use pliers to make tight twists around the main wire. **Cut to required length for band(s) required – see table later**.

Picture 1

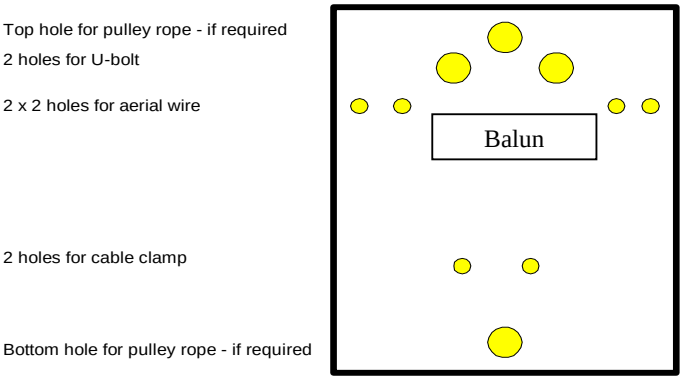
Fit Nylon cord/rope to other end of insulators – remember – if using Nylon fishing twine, normal knots will pull out. Make a loop and pull other end through it.

Pictures.2,3,4



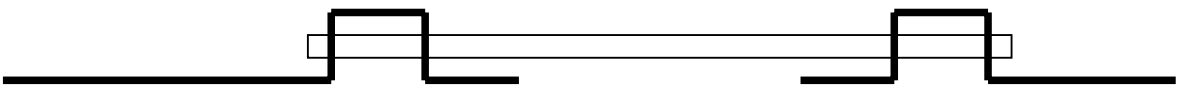
1. Make a loop and tie a normal knot. 2.Either Push through the hole and loop the loop over the end. 3. Or loop the main length of cord through the loop and pull tight.

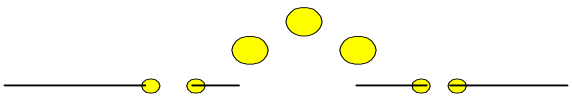
Centre plate. Used to support and connect the aerial ends to Balun – and then fixed to pole.
Cut a square about 6inches square from plastic etc, but **NOT wood or metal** for the centre plate.- Drill holes for U bolt and holes for holding the aerial wire.



Now thread each leg of the aerial through the 2 holes provided – these hold the wire in place. As the copper is stiff, thread the end through the outer hole, and make a loop before threading the end back through the inner hole. Keeping sufficient wire protruding through the 2nd hole to attach to the Balun, carefully push the looped wire back through the 1st hole, untilt he wire is laying flush against the centre plate. Having done this the wire should **NOT** pull out of the holes.

Side view





Front view

At this point we appear to have all bits required except the Balun.

Balun

As mentioned earlier, the Balun is used to **Match** the un-balanced co-axe feeder to a Balanced Aerial system.

The one we are going to make here is a 1:1. **Matching** 50ohm un-balanced co-axe to 50ohm balanced aerial. Should you make a HF aerial system that uses a folder dipole, then to **Match** the co-axe to the aerial, you required a 4:1 Balun – this is built in the same way.

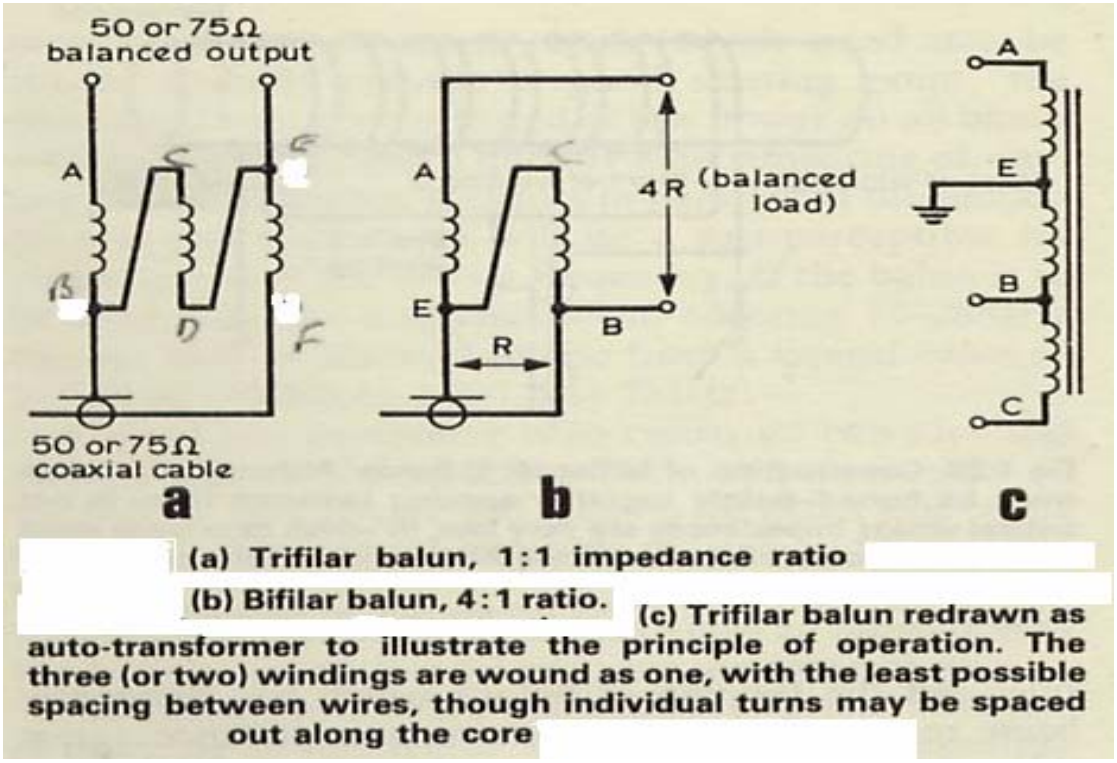
Requirements for building your own 1:1 Balun.

3 lengths of 10inches of enamelled wire – Flatten by rolling between 2 pieces of flat wood. **Solder the ends and label them – using either small paper tags or coloured pens**.

Ferrite rod – ½ to ¾ inch diameter, about 1.5 to 2 inches long. – Not the flat type – cannot bend wire around it! Obtained from old AM radios, or possibly rallies. If too long, may be cut – but very brittle so take care. Put into vice, but wrapped in material to prevent vice jaws cracking it. Using a hacksaw cut a groove and then try to snap it at this point – may/may-not work.

Insulting tape - to bind the 3 wires together.

Making the Balun.



(a) Trifilar balun, 1:1 impedance ratio

(b) Bifilar balun, 4:1 ratio.

(c) Trifilar balun redrawn as auto-transformer to illustrate the principle of operation. The three (or two) windings are wound as one, with the least possible spacing between wires, though individual turns may be spaced out along the core

Lay the 3 pieces of way side-by-side, and tape the ends and the centre together with a piece of cellotape. Then using the Insulating tape, firmly wind it at an angle from one end, down to the other end - leaving about 1inch of wire clear at each end.

Holding the 3 wires very firmly against the ferrite rod, start to wind it around it. After a couple of turns, push the turns together.

Repeat until the complete length of wire has been wound around the ferrite rod.

The finished coil should be a tight fit and NOT slide off the rod. (If slightly loose use a glue).

To complete the Balun, you now need to join some of the wire ends together.

From the diagram above – you can see which ends are the un-balance and balanced terminals.

It can bee seen that the top of the centre coil is connected to the bottom of the 1st coil, while the bottom of the 2nd coil is connected to the top of the 3rd coil.

Find the correct ends and solder them together. The reason for the labels!

Lay the Balun in the centre of the Centre Plate and having identified the correct ends, - the Balanced output - solder them to the aerial wire. **** See ****** below – reference Box.**

Now locate the remaining ends, which have to be soldered to your co-axe feeder.

******Box** It is strongly advised that the Balun is fitted inside either a plastic tube or a small plastic box, with a removable lid. This is to keep water from going down inside the co-axe cable sleeve.

The small plastic box suggestion is better for use with the 12-14 SWR wire. The wire being very stiff, it is difficult to insert both wire and Balun into a small tube.
Push the wire though small holes in the sides of the box and solder to the Balun.
Make a larger hole at the bottom, for the co-axe cable to feed through. Seal all the holes with Silicone.
Holes can be made with tip of a hot soldering iron. Ensure you clean off the plastic from the tip after each hole has been made.

If using a tube, then make a hole in one side for the co-axe to come through, and a hole in the end plugs or pieces for the aerial wire to go thorough.

Ensure all holes etc are well sealed, as the last thing you want is water going down inside your co-axe cable sleeve.

Power loss through the Balun is negligible. Make two and join them back-to-back, .i.e. Balanced to Balanced. Feed a known power level into the first direct from your rig, using the un-balanced input side. Then with a power meter connected to the un-balanced side of the 2nd Balun, check the power out level – you should see only a very low loss of power, if any at all.

We have now completed our Balun, connect it up and fixed it to the Centre Plate. All that remains now is for the Centre Plate to be fixed to your pole, either at the top with a U-bolt, or by using a pulley system.

See picture 5 below – note – sorry about the state of the soldering, but has been done a few times and now a bit rough – NOT my usual standard!

Picture showing Balun connected to the 2 sides of the aerial. All fitted onto the Centre Plate, which is now attached to the pole.

Raise the complete Centre Plate; pull out the aerial ends and tension by using the insulators, by using rope or Nylon cord attached to the end opposite the aerial wire. See diagram on page 3.

There are other designs for HF Baluns, but this is the easiest.

However for VHF and above we cannot use the above design. Maybe I, or someone else will give a talk on them, **any offers**!?

Other thoughts for your aerial system:-

Twin feeder

If twin feeder is to be used instead of co-axe then 2 methods may be used to connect the main aerial to it.

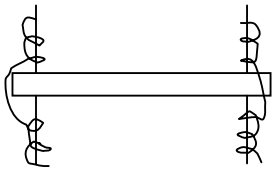
1 Some books suggest that if building a doublet, that instead of soldering the feeder onto the aerial ends at the centre plate, that each leg of the top sections, continues down as the feeder. This removes the need for a solder connection at the top, which have been known to fail and cause SWR problems.

2 If you must solder a feeder onto the main aerial wire, then make it inside a small water-proof container – e.g 35mm film pot, or well seal in amalgamating tape. **Water proof well!**

Twin feeder must come down to a Balance input on your ATU.

Open Wire Twin feeder may be anything from about 6 inches apart down to about 3 inches - the spaces may be made from anything plastic, or even Perspex, but NOT wood - this holds water, causing short circuits. Use the principles as we used to make the insulators. To help hold feeder wire in place, insert the wire though the holes in each spacer, and then using a thinner wire, wind it around the main wire a few turns and then take it to the other side of the spacer and continue to wind the wire **around the same wire** – **do NOT short out the wire across the spacers**. Commercial twin feeder may also be used, but beware the **Pink** 300ohm feeder – heat and damp affect it, so only fit for indoor use!

Diagram



Aerial lengths.

As mentioned earlier, aerials are cut to a particular length. If you want to use one band only, then you can cut the aerial wire to the exact length. However with multi-band aerials, you normally cut the length to that of the lowest frequency and then tune the aerial with an ATU to match the aerial to the rig.

I have included a spreadsheet with aerial lengths and frequencies for your use.

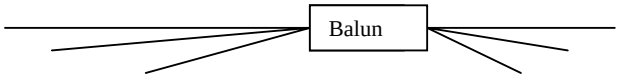
Frequency	Constant		1/2 wave - Feet		1/4 wave - Feet		1/2 wave - metres
3.50	468		133.71		66.86		40.77
3.70	468		126.49		63.24		38.56
3.80	468		123.16		61.58		37.55
7.04	468		66.48		33.24		20.27
7.09	468		66.01		33.00		20.12
10.10	468		46.34		23.17		14.13
10.15	468		46.11		23.05		14.06
14.10	468		33.19		16.60		10.12
14.35	468		32.61		16.31		9.94
18.01	468		25.99		12.99		7.92
18.17	468		25.76		12.88		7.85
21.15	468		22.13		11.06		6.75
21.45	468		21.82		10.91		6.65
24.93	468		18.77		9.39		5.72
24.99	468		18.73		9.36		5.71
28.40	468		16.48		8.24		5.02
28.90	468		16.19		8.10		4.94

Constant divided by Frequency = ½ wave in feet

Extra aerials.

By using about 130 feet of copper wire, with an ATU, we should be able to cover all the normal harmonically related amateur bands. This means we can cover and use, 80 – 10m normally with a low-ish SWR, especially by using an ATU.

However, if we want 10, 18 or 24Mhz, then we really need extra aerials. **These may easily be joined to the existing system, by connecting them to the aerial side of the Balun**. Thinner wire may be used, as narrower bandwidth on these bands.



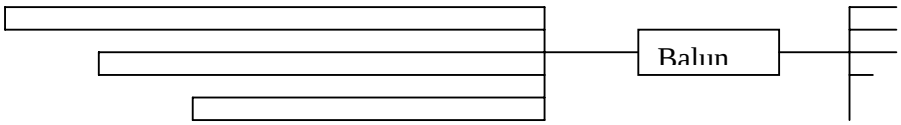
The same principles are used with any extra aerial as the main aerial. The ends are connected to an insulator, which in turn has a rope on the other side, to allow for tensioning of each leg.

Multiband aerial systems.

If you have the space, you may wish to have an aerial for each band. This is simple to achieve, just cut each aerial to the required length and tension the ends as above. The inside ends are all connected to the Balun. Therefore one Balun and fed cable, supplies power to all aerials.

See diagram above.

Because each aerial resonates at its own frequency, it will only accept RF at that frequency, otherwise it rejects other frequencies. There is little or nil reaction between these various aerials, even if spaced only inches apart. One method is to use Computer ribbon cable, and cut to the required frequency/lengths. A number are cut to each length and joined at the outer ends to improve the bandwidth, while ALL the inside ends are joined to the Balun. Ensure the ends are well sealed against water ingress. The whole cable is supported by threading nylon cord through it and connecting it to the insulators and Centre Plate.



Conclusion

I hope that through this talk and these notes, it has given you an idea of what is required to make your own HF aerial – give it a go. Very few of us have large gardens for the perfect aerial system, but by using the above notes and thinking of how to fit it into your garden, you can build a suitable aerial that will work, even although it is a compromise. If fact, if you cannot get a straight run into your garden, then bend the aerial wires, by using an insulator fitted along the wire, with a cord going to a fixing point to keep it all tensioned. Give it and go and see what results you get – I am sure that you will be happy. Good building!

Any queries I am always happy to try and answer – I do not know them all, but will try !

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