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I first read about the end-fire array antenna in *PW's* classic antenna booklet *Out of Thin Air*, which I recommend [1]. In one of the articles, *Compact 2m beam antennas*, the late **Fred Judd G2BCX** describes a two-element 2m band end-fire array that he claims makes a great 'flat dwellers' antenna. I made one of these and I can vouch for its effectiveness – much better than a mobile antenna on a poor ground plane that might well be firing most of the RF up into the sky.

Description

The end-fire array consists of two halfwave verticals spaced about 1/8th wavelength apart. Each halfwave is fed out of phase via an open wire phasing section (fed at the centre). The symmetrical arrangement and centre feed means it has a bi-directional radiation pattern having roughly 4dB gain over a dipole. With this pattern you only have to rotate the antenna by 90° to get 360° coverage. One practical advantage of this vertical antenna is that it does not need any radials.

There is something particularly satisfying about the symmetry of this sort of array. You can feed the antenna with coax, but the wideband characteristics are only achieved if you use open-wire feeder and a proper balanced ATU. I will describe both methods so you can experiment with your own versions.

Other bands

The 2m band version worked so well I decided to explore the concept on other bands. I made a 4m version, which I have been using successfully for a couple of years. The bi-directional pattern allows me to work stations up and down the coast from my location in Brighton giving me coverage all the way from Littlehampton in the west to Eastbourne in the east.

The 4m band version was made simply by scaling up all dimensions in the original article by a factor of $145/70 = 2$. The 10m band version was made by scaling up by a factor of $145/28.5 = 5$. I used 600Ω ladder line for all the antenna phasing harnesses, making it a little longer than the eighth wavelength figures.

As the antenna is matched using the matching stub and shorting bar (or 300Ω feeder and ATU) none of the dimensions are very critical so you can make much of the antenna from 'junk box' parts you might already have.

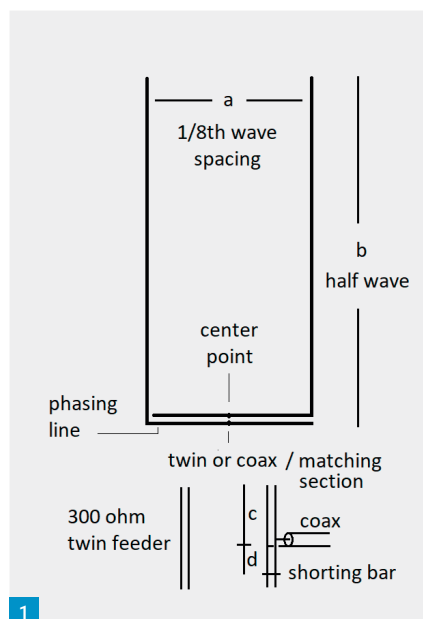
I have summarised the dimensions I used in **Table 1**. The general configuration is shown in **Fig. 1**.

A note on 5m long telescopic rods

I was amazed a few years ago to find you can buy 5.2m long stainless-steel telescopic rods, available on eBay or from Moonraker (search for MRQ213

End-fire array for the 10m band

Jonathan Hare G1EXG describes a full-sized 10m band two-element end-fire array using two 5.2m telescopic rods. It can be collapsed down when not use or in bad weather. Jonathan uses it from his home QTH but it would also make an interesting antenna for portable use from the side of a vehicle.



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17.5ft stainless steel telescopic antenna). They are about 75cm long when retracted and have around 12 sections. Unfortunately, they are quite fragile and can easily be damaged when you pull out the sections. My suggestion is never to completely collapse them, but rather to slide them down very carefully till each section is about 1cm from fully retracted. Otherwise, some of the tubes seem to get stuck and can come out completely (along with the internal copper shims) if pulled too hard, and then the telescopic rod is broken. Unfortunately, this has happened to me twice: once at home and once while out 'portable' – very annoying (and costly too).

The support structure of the end-fire array antenna is shown in **Fig. 2** with the telescopic rods retracted. You can also see the black 3D-printed insulators, the large sheet of plastic support at the centre as well as the 600Ω phasing line and 300Ω feeder to the radio room (sorry about the very dirty North facing wall!).

Centrevs.end fixing

Ideally you want to fix the half-wave verticals at the current maximum, the centre point. However, for a vertical antenna like this, using telescopic rods,

this is impracticable (although you could put a thin Perspex or fibre rod support bar half-way up for stability). The vertical arrangement, fed at the bottom and supported at the base, means the antenna is higher than the equivalent centre supported antenna, which is a bonus.

The photo, **Fig. 3**, shows the 4m band version with the temporary use of croc-clips to home in on the matching positions for the coax and shorting stub. Once near a good match you can remove the clips and solder in place to get the best SWR, then waterproof with feedpoint sealant.

Matching and feeding

I first tried using 50Ω cable (just like the 2m antenna). The coax cable had five large slide-on ferrite beads at the antenna end, to choke any RF flowing down the outside of the coax. I adjusted the matching point and sliding bar to get the best SWR. Small crocs-clips are a useful temporary trick to make an easy to change connection to get near to the best match (see **Fig. 3** again). However, whatever part of the 10m band the 2:1 SWR 'bandwidth' (using 10m of mini-8 coax) was only around 300kHz or so.

I then tried feeding the antenna via a 4:1 balun and found a new matching point and shorting bar position for this arrangement (see **Table**). I kept the ferrite beads to choke any RF that might try and flow down the outside of the coax. The 4:1 arrangement worked and provided a little more 'SWR bandwidth' giving ca. 600kHz on the 10m band (via 10m of mini-8 coax).

The array is inherently wide band, but the 10m band stub matching section is fairly narrow. As this sort of antenna array can work over a wide frequency range, you don't get the best results using coax. It is better to connect 300Ω (or 600Ω) twin feeder at the centre point of the phasing harness, the other end of which is connected to a balanced ATU in the radio room. Losses at 28MHz using ladder line are minimal (it works OK on the 4m version as well).

In this arrangement we don't need the stub line and shorting bar. With this method the antenna can be used over the whole of the 10m band and perhaps down to 18MHz. It has useful performance from 14MHz up to 50MHz if your ATU can stretch that far.

Fig. 1: General arrangement of end-fire array.
Fig. 2: The support structure of the end-fire array antenna shown with the telescopic rods retracted.
Fig. 3: 4m version with croc-clips in place temporarily.
Fig. 4: Balanced ATU circuit.

Balanced ATU

Use a true balanced ATU (see circuit, Fig. 4 and photo, Fig. 5). A lot of unbalanced ATUs offer what they call a 'balanced' antenna connection by utilising a switch-in 1:1 or 4:1 ferrite ring balun. These devices will probably work but may not provide the low noise characteristics or versatility of a fully balanced setup.

The balanced ATU is very simple, consisting of two coils and two variable capacitors. In my prototype L1 was ca. 12 turns (40mm diameter) while L2 was inside L1 and ca. 3 turns (20mm diameter). The feeder taps in one turn from each end of L1. There is a lot of scope for modifications of this circuit to fit the variable capacitors you happen to have etc. You need a dual gang capacitor for C1.

Using the open-wire feeder and balanced ATU I found I could get a perfect 1:1 SWR with the end-fire anywhere on the 10m band.

Antenna construction

I used two pieces of wood about 1.6m x 20mm to form a frame to hold and space the two halfwave telescopic verticals (see photo, Fig. 6). I used vertical wooden pieces to separate and hold the two horizontal bars about 30cm apart. You might get away with using thick bamboo poles, but I expect wind will tend to flex them a bit too much and the halfwaves will then not stay parallel. A few coats of marine varnish is a good idea for all the wooden parts.

At the centre is a ca. 40 x 40cm 8mm thick plastic sheet (old kitchen chopping board) that stabilises the whole system and provides two places for supporting U-bolts.

I 3D-printed plastic (PLA) insulators [2] to hold the telescopic rods. All four insulators cost less than a pound to make. The insulators each have two bolt holes so they can be attached to the wooden supports. The telescopic rod slides into the top insulator and then into the cup-like bottom insulator and secured using the telescopic rod thread and a nut. You don't of course need to use my 3D-printed insulators, but you do need to implement some kind of decent insulation at the base of each vertical. The insulation of the wood supports will probably not be good enough during or after wet weather, for example.

The centre of the 600Ω phasing line goes either to the matching stub and coax or is directly wired to 300Ω ohm feeder. The phasing line goes from one telescopic rod to the other but note that one wire at each end is always left unconnected. The connection to the telescopic rods uses alternate wires of this phasing line and hence is always 180° out of phase. The length of the phasing line is not very critical, as long as it's fed at the centre. Large solder



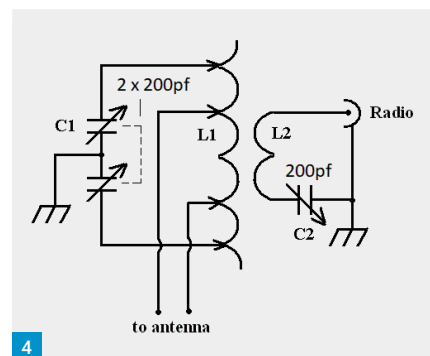
tags connect the phasing line wires to the bottom of the telescopic rods using a nut and the bottom of the insulators.

Side of house and slide mount

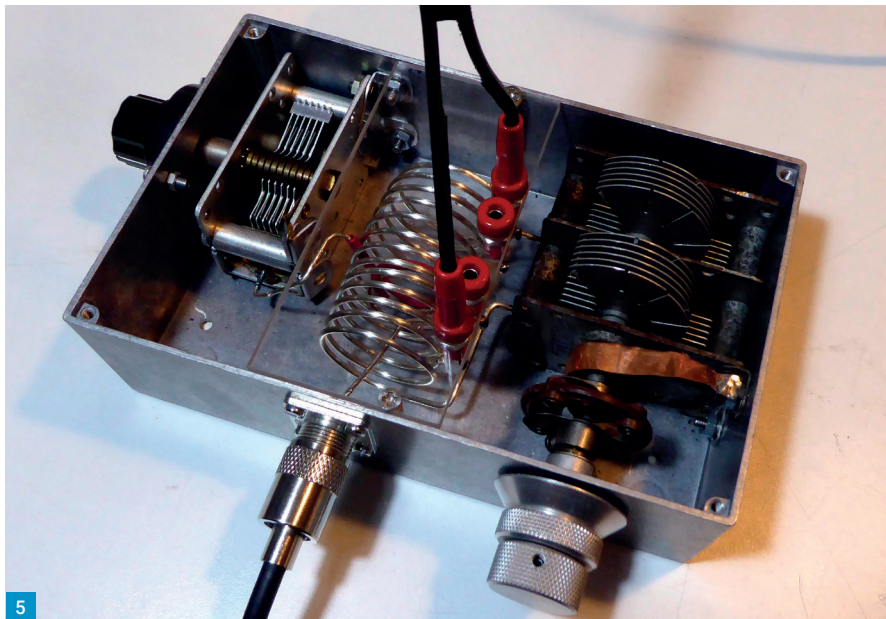
The north side of my house is connected to the garage roof, and a ladder provides easy access. This allows me to get to the antennas mounted on the side of the wall. I recently fixed the end-fire to a home-made slide mount, Fig. 7, that allows me to drop the whole set up so I can easily extend the telescopic rods then I can raise the whole system near to the peak of the roof.

End-fed and RFI

My immediate neighbour south of me has a high-end audio system. I live in a terrace of three hous-



es, so his audio equipment is physically quite close. I cause RFI through his speakers when I transmit on certain bands. I have tried all the obvious things to stop this such as fitting ferrite rings



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Fig. 5: The author's balanced ATU.

Fig. 6: The array in place – see wooden support structure. Fig. 7: Slide mount.

Part	2m band	4m band	10m band
1/8λ spacing (a)	30cm	62cm	1.53m
halfwave length (b)	1m	2.1m	5.2m
stub length (c+d)	18cm	40cm	91cm

(see original article for 2m band dimensions [1])

Note: I have shown the stub length (c+d) a little on the long side; you can cut off the bit past the shorting bar once you have arrived at the best match.

Approximate 10m band matching stub and coax cable position details:

c = 80cm d = 8cm for 1:1 balun

c = 72cm d = 15cm for 4:1 balun

(Note: all these lengths will depend on your own arrangement)

Table 1: Sizes and spacing

on the speaker cables, mains filters, chokes on the input leads etc. but nothing has so far solved the problem completely. However, the possibility of working low power on the 10m band is one way to help and setting up the end-fire so it beams east-west, so that little power is sent south, is another.

Results

As we head into sunspot maximum conditions on the 10m band have become much more perky. Apart from pile-ups and stations who have strong local noise, I seem to be able to work pretty much everything I can hear, and often using just 5 or 10 watts.

The antenna seems to work as well on CW and the beacon part of the band, at the low end of 28MHz, as it does with the USA and Canadian FM repeaters near the top end of 29MHz.

As the halfwave radiators are supported at the ends (voltage maxima) any degradation of the insulators will have a negative effect on performance. At the very least it will tend to detune the system. Water and snow can affect the SWR in the coax driven setup but if you use the open-wire feeder and ATU, it's simply a case of retuning.

As we had such a wet February in 2024 it was useful month to test out the wet-weather results.

I worked all around Europe and into the USA using the antenna and often on regular nets with local amateurs to act as a reference point for comparisons. I found that a wet antenna did de-tune a bit, but this didn't seem to affect performance when using open-wire feeder and the balanced ATU.

I have been having weekly chats with Ukrainian stations on 10m band and seem to get similar performance to G3ZAF who is using a Hexbeam with the same power. I have been able to test the antenna with a station in Florida and find as expected, the end-fire outperforms multiband dipoles. Simultaneously logging into the University of Sussex club station remotely, I have found the end-fire gave roughly similar performance to the club's old horizontal 3-element tribander at 50ft, with interesting moment-by-moment variations between the two setups presumably due to polarisation and propagation differences between our two relatively nearby stations (ca. 8km apart). I have used the array on 21MHz with some success.

I have also found that I can even tune up the antenna with the telescopic rods retracted to less than a metre long. Although I would not transmit using it like this, it does create a basic receive antenna to 'check the band' for activity before going out and extending the telescopic rods.

Acknowledgments

I would like to thank Roger W4/M0TJK, Graham G8BZL, University of Sussex Radio club G4AQG, Colin G3ZAF and Volodymyr US7IGN for on-air tests and comments.

References

- [1] Out of Thin Air, Practical Wireless publication e.g. my copy was 4th edition 1981.
- [2] for details of my other projects and the 3D printed insulators see my website at:

<http://www.creative-science.org.uk/3D.html>

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