

## "Banana", a Half Wave End-Fed Choked Coax Antenna by Callum McCormick, M0MCX

Also know as - and similar to:

### Sleeve Dipole / Flowerpot Antenna

The Sleeve dipole has traditionally been used by VHF antenna designers by sliding an external metal sleeve over the coax and connecting the sleeve to the braid of the coax so that the antenna appears to be centre-fed with an outboard "sleeve". Some commercial CB antennas are also made this way.

### Resonant Feed-line Dipole (J Taylor, W2OZH, 1971)

The first time that I can find any mention of an end-fed Resonant Feed-line Dipole was an article written by James Taylor (W2OZH) in the August 1991 edition of QST entitled the "Resonant Feed-line Dipole". He discusses the idea of using the coax itself as both part of transmission line - and a resonant element. Again, it apparently behaves like a centre-fed dipole - and extremely similar to the Sleeve antenna mentioned above. Various aerial builders have made this antenna, mostly with variable - or in most cases, poor results.

### Tuned Transmission Line Trap, T2LT (CB folks)

CB folks call this type of antenna the T2LT. This terminology appears to be from a German Patent by Prof F. Fischer (Patent Number 733697) from 1939 who apparently mentions "Die T2LT". But the patent surrounds only the use of a tuned choke which has a capacitor across the choke for tuning, not the actual antenna. The term T2LT is perhaps a misnomer.

In the main, all these antennas essentially recommend a  $\lambda/4$  wavelength of coax and  $\lambda/4$  wavelength of bare element protruding above the coax. The coax is not shorted to the element.

The lower part of the antenna acts as both the feed-line to the centre of the antenna and a radiator too. The braid and copper shielding therefore has a dual purpose; on the one hand acting as coax to the pseudo feedpoint, where the braid and shielding stop - and on the other, to act as one single vertical radial that encases the coax. I believe the "Skin Effect" has much to play in this. Using good quality coax is probably key to ensure the whole integrity of this design. Aircell 5 (for instance) has 100% coverage of copper foil as well as an external copper braid and is my choice for this antenna, being light and relatively low loss.

J Taylor discusses the importance of choking the coax  $\lambda/4$  down from the centre of the coax. This method means that it should behave similar to a centre-fed dipole. Some CB and Marine VHF antennas are constructed this way, although often with a separate "sleeve" that encases the coax too, as discussed previously.

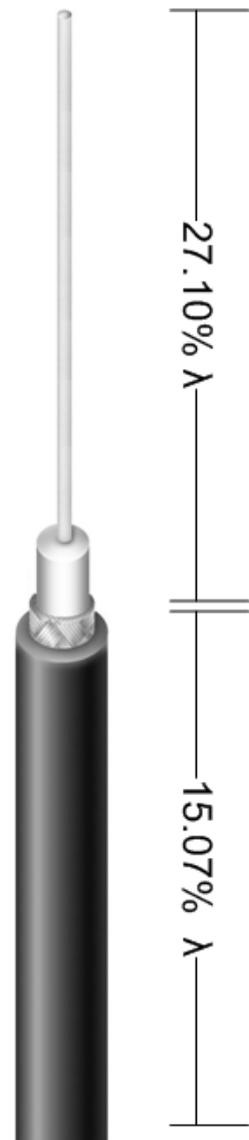
The choke is vital to literally put a stop to any return currents so that your main coax feeder doesn't send return currents back down your coax to the radio. Air spaced choke coils based on "Myth" may not be accurate enough for this purpose. I used <http://www.karinya.net/g3txq/chokes/> to assist my understanding on chokes. I chose to go down the path of a pair of FT240-52 ferrites with 12 turns of RG400. I have also constructed a low-band version too for 80m though 30m.



> 8k choke. 2 x FT240-52 ferrites

Taking this simple idea on face value, I took the plunge and made a 20m version with  $\lambda/4$  (circa 5m length) Aircell 5 coax with a PL259 soldered at the base and a 5m length of D10 military telephone cable to the top and hoisted it up a 10m telescopic pole.

I also applied several sizes of shrink-wrap between the coax, braid & dielectric to keep out water and also to provide some lateral strength against breaking



I erected this wire antenna on a DX Commander 10m pole and set it up against a tree. I discovered that measured with my VNA, I was achieving at best, a 2:1 SWR, showing around 25 ohm impedance, even at resonance. I attempted 20m, 17m and 15m variants. None had SWR below 2:1.

- It should be noted, I used a 35m length of Aircell 7 coax for testing. This was intentional as it was a full wavelength, for 40m band, adjusted for velocity factor (0.83). Knowing that impedance repeats every half wavelength, I would be assured of having a fairly accurate impedance at the VNA (or my radio) for any band above 80m.

Searching the internet, it appears that many other constructors have also discovered similar disappointing results and in the main, not such good signal reports either. I was slightly disheartened but felt there much be some merit in poking this design further.

Rather than trying to match 25 ohms with a twelfth wave matching stub or 1:2 balun arrangement (which would incur more cost if I up-scaled this into production), I remembered that slightly offsetting a feedpoint can increase impedance. So I went about creating a large number of these antennas for 20m band with varying lengths of coax feed-line and upper element lengths to experiment. It was tedious work and I ran out of time since I was about to go on a 1-week vacation to the coast. I took the opportunity to pack all the failed antennas with me along with a TS-590 in the hope that I might get time to do some more experimentation.

### 60m band

After temporarily giving up on 20m band, I dived into the deep-end and tested a 60m variant. I constructed a 9.2m long piece of coax, taped to a telescopic DX Commander pole and a further 15m length element which ran across the top of some bushes similar in looks to an inverted L (without radials). After some fine tuning, I was very pleased that I could tune across the whole of the 60m band with negligible SWR. My receive ability was excellent although the jury is still out on the capability of transmit. Software modelling suggests it should be fine though. I nicknamed the antenna "The Banana" due to its shape and it seems to have stuck.



- How the "Banana" achieved its name

### 80m band

Adding a further 9 metres or so to this 60m antenna I managed to get on to 80m too. This was possibly too much of an off-centre arrangement and my SWR was just under 3:1. I didn't have my VNA with me. It is my guess that the impedance started to go too high unfortunately I didn't have a longer piece of spare lightweight coax to attempt a different coax-to-wire element ratio. However the inboard ATU allowed me on almost all bands and I had a fun day climbing the bands on SSB and some JT65.

### 40m Band

Enthused, I tried a custom 40m version. I had a 6m length of coax from a failed 20m experiment and taped that up the pole with the choke sitting on the grass. and I added appropriate top element which ended up at around 12m long. Certainly shorter than I imagined it should be. It looked just like the 80m and 60m versions, similar to an inverted L, but of course without radials. I had a good day on 40m with this arrangement and a better than 1.5:1 SWR across the band.

### 10m band

Frustrated from my previous attempts the weeks before on 20m, I delayed my experiments on the upper HF spectrum since I was certain failure was on the horizon. However with my success still in mind from the 60m band antenna, I made an attempt at making a 10m version. I cut approximately 2.5m length of coax and added a random top element which was a bit longer. I didn't have a tape measure with me, so I manually guessed all the lengths. It would turn out a stroke of good fortune..

I taped the end of the upper element to the very top of the pole which meant the choke arrangement was about 4m from the ground and headed back to the dining room to see what the radio said. I was also pretty furious with myself for forgetting my VNA which would have helped immensely.

SWR held at about 3:1 SWR on 10m and 12m. I did have a QSO with a Norwegian station, LA2IMA on 10m with the ATU clicked in but I had almost come to the conclusion that a plain vertical in this configuration was probably never going to work. The off-set arrangement with a pseudo inverted L just happened to give me 50 ohms but a plain elevated vertical was probably a non starter and I was back to the drawing board.

### 15m band

On the off-chance, I wondered if this apparent 10m antenna would also tune on 15m band. I dropped down and checked the SWR with the onboard TS-590 SWR meter. Initially I thought something was wrong because I was not registering any SWR at all. However, when I spotted (with some relief it must be said) that the SWR did rise slightly at the bottom end of the CW portion of the band to 1.2:1 SWR, I knew I had done something right. It turns out, I had accidentally cut a perfect 15m vertical with the ideal off-set ratio between length of coax and length of element. I don't think I've ever been so lucky!

I quickly acquired a tape measure from the local hardware shop. It turns out the lengths are 2.13m for the coax and 3.83m for the upper element. This means that the ratio for the length of coax is 15.07%  $\lambda$  and the ratio for the upper element is 27.10%  $\lambda$ . If you add these up, this means the antenna is only 42% of a whole wavelength, not 50% as you would imagine for say a dipole made from aluminium tubing on VHF. I can only assume that velocity factor is playing a major part of the shortening (84%).

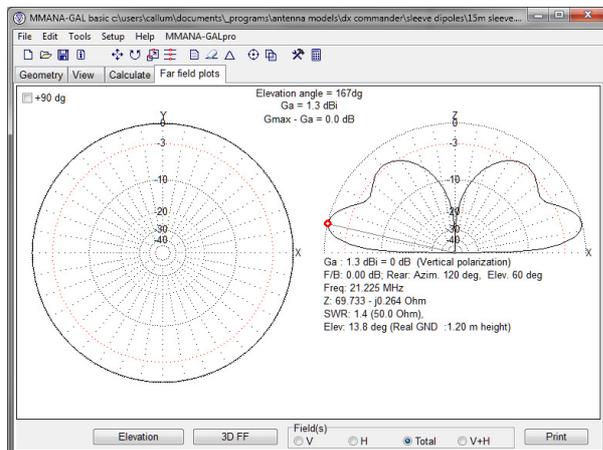
### 20m band

Feeling rather pleased with myself, I constructed another one, this time for 20m band. First, I spent some time putting together an Excel spreadsheet to calculate any frequency I desired for this new off-set ratio, my maths told me that the coax was to be 3.18m and the upper element was to be 5.72. This time, the feedpoint was only a metre or so off the grass so I knew the impedance would change slightly. However, the maths was accurate and I achieved better than 1.4:1 SWR across the whole of 20m, flicking up to 1.5:1 SWR right at the very bottom portion of the CW part of the band. My guess is that if I could elevate this antenna even higher, the SWR would come down. However I can live with 1.5:1 SWR all day.

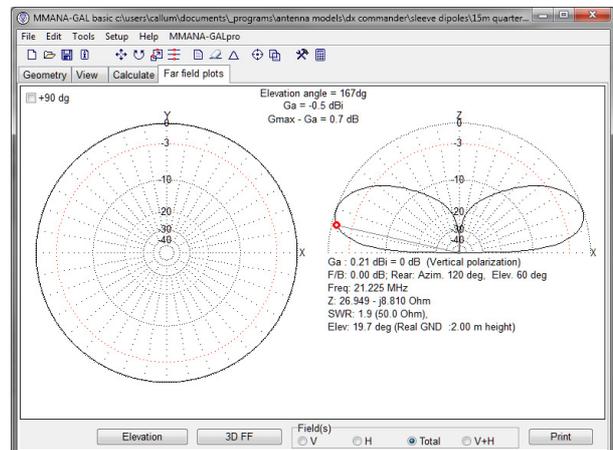
Reception came alive with these new dimensions on 20m and on WSPR mode, I see I've just heard VY0ERC, the most northerly amateur radio station in the world and on transmit, I also seem to be doing a fine job. I tested transmit on 100W SSB with a QSO with IG9/S57DX at 10:00pm at night on a dead band and later, with NE8Z on PSK31, the only station on the band.

Modelling this antenna accurately in software is beyond me. I don't know how to construct a resonant piece of coax in MMANA. It's probably not possible. The bigger NEC engine is probably more suited to this design however I am not versed in that software. Instead, I made a stab at creating a simple vertical dipole, at least to get an idea of the Far-Field plot by simulating an off-centre feed for vertical dipole.

### 15m Band, elevated Banana Vertical -vs - 1/4 wave with 4 x raised radials at 3m AGL



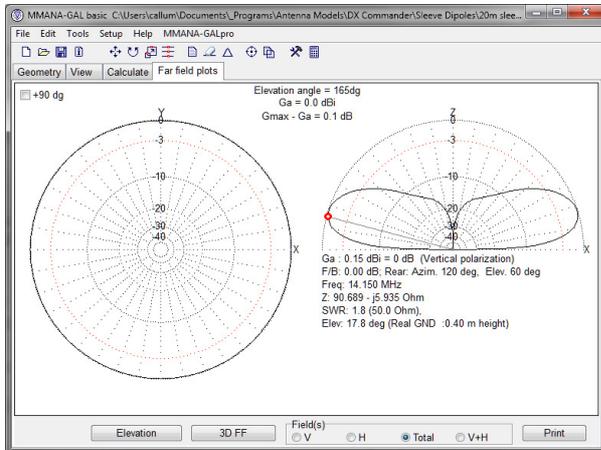
Vertical Resonant Feed-line Antenna  
 At 13 degrees off horizon: 1.3 dBi gain



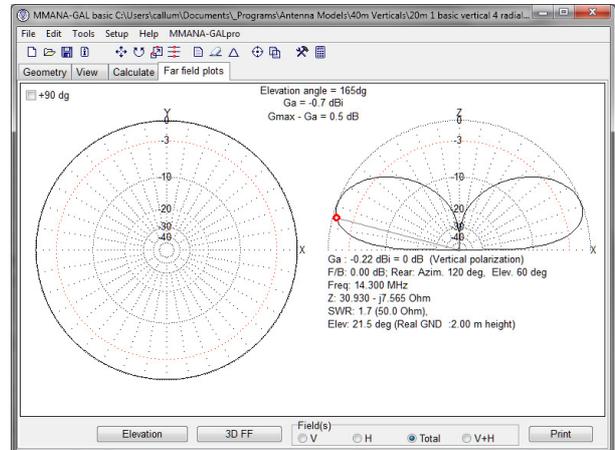
Ground-mounted Quarterwave elevated radials  
 At 13 degrees off horizon: -1.7 dBi gain

Software modelling can be a bit of an art and it's also possible to make your antenna "look" better by adjusting variables behind the scenes. However I have tried to model both these antennas with identical grounds and similar elevation above ground. I tried to increase the gain for the quarterwave by increasing the height of the antenna above ground to perhaps a slightly unmanageable 4.5m and even then, gain was still 1 dBi short of the Banana.

### 20m Band, elevated Banana Vertical -vs - 1/4 wave with 4 x raised radials at 2m AGL



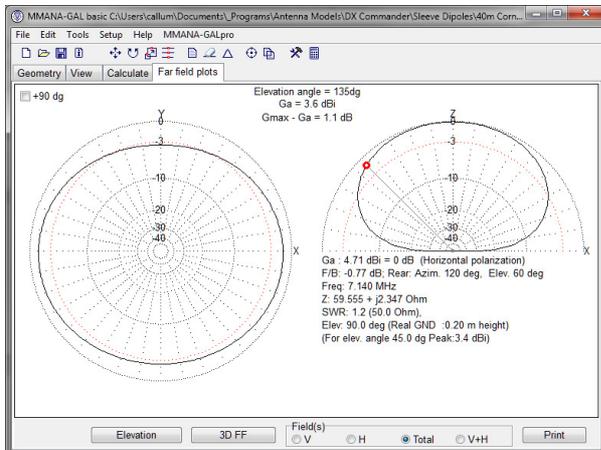
20m Banana antenna  
At 15 degrees off horizon: 0 dBi gain



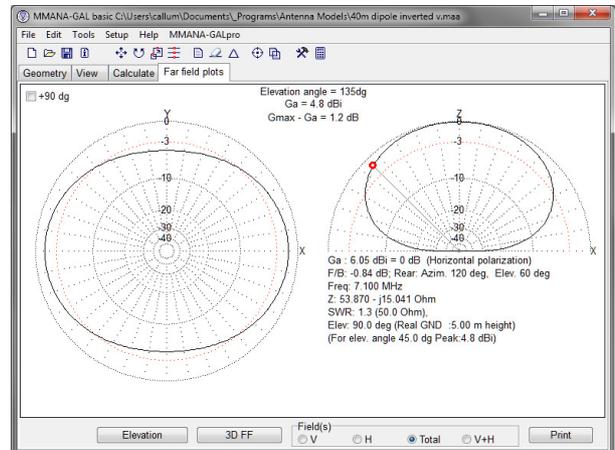
20m traditional 1/4 wave vertical 2m high elevated radials  
At 13 degrees off horizon: -0.7 dBi gain

### 40m Band, Banana Inverted L Vertical -vs - half-wave inverted V dipole 7m AGL

For the low-band Banana versions, the Far Field models look as you would expect for a low-to-the-ground antenna. Of interest, there is quite a lot of embedded vertical polarisation on this 40m version running fore and aft of the horizontal wire, with slightly more gain, low to the horizon in the same direction of the long wire (not shown).



40m Banana antenna  
At 45 degrees off horizon: 3.6 dBi gain



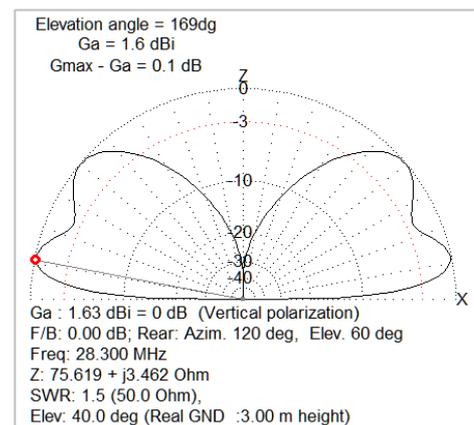
40m traditional inverted V dipole at 7m AGL  
At 45 degrees off horizon: 4.8 dBi gain

### Final test on 10m band

I cut a 10m vertical from the remains of the 15m working version aiming at 28 MHz as per the maths.

I was expecting an impedance anomaly due to this antenna being slightly higher than the 15m version. Dimensions were 1.61m of coax and 2.90m for the upper element. I did achieve almost flat (1.2:1 SWR) from 28 MHz through 28.5 MHz.

Strangely, the SWR was even better all the way down the CB frequencies rising again on 12m Band. Gain at the new height is impressive, showing 1.6dBi gain at 11 degrees off the horizon with useful gain for short skip at 35-40 degrees.



## Conclusion

I am very pleased with the development and success of this antenna. Reception appears very pleasing to the ear. Transmit appears fine too although some more experimentation is required to ensure that the transmit ability matches the quality of receive over the longer term for the low bands. Saying that, my digi-mode contacts were breeze - and Far-Field plot modelling demonstrates that this concern shouldn't worry the operator.

The only final experiment I haven't done is swap the lengths of the coax and upper element lengths around for the 20m variant. There's a very slight chance I may get a better impedance since the virtual feedpoint will be slightly higher. Of course, the antenna will still be 1m above ground level for 20m, assuming I continue using a 10m portable DX Commander pole. I'm almost certain it would have no effect.

As a radial-less vertical though, portable and holiday-home operators will find this a superb solution for two reasons; slightly better DX gain and the removal of a trip hazard due to having no radials laying on the ground - as well as the time element and variable ground quality for radial laying. Of course, building one for permanent installation is also an option to be competitive on a specific band, perhaps high up hanging off a tree.

It should be noted that for non-ATU operators, Banana Antennas are mono-banders although my TS-590 happily tunes the 20m variant on 17m, 12m and 10m. The 10m variant tuned 15m (and 12, although it could be argued that it didn't need an ATU since the SWR was below 2:1 here) and although this 10m variant happily tuned down to 20m, the band appeared very quiet with this solution, so not a good idea for such a short antenna on a lower band than it was designed for. Of interest, the 10m variant tunes on 6m band and the far-field plot looks excellent with a gain of 3.4dBi at 5 degrees off the horizon, probably due to the antenna being over a wavelength off the ground. Further down, the 40m variant tuned on all bands above 20m and the longer variants seemed to tune on all bands.

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## Version control:

Version 1.1 17 May 2017 - Added section on specific 10m band success  
Version 1.0 16 May 2017

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## Resources:

Spreadsheet Antenna Calculator  
<http://www.m0mcx.co.uk/banana-antenna-calculator-off-centre-fed-vertical-choked-radiating-coax-aerial/>

Choke Baluns  
<http://www.karinya.net/g3txq/chokes/>