RADCOM TECHNICAL FEATURE

The EXJAY

Resonant Multiband Antenna System

by Bob Rylatt, G3VXJ

ALTHOUGH AN HF enthusiast, I have never regarded beam antennas a realistic possibility for normal suburban reasons. Equally, family and career commitments have caused patchy activity over the first twenty-odd years of my licensed existence.

However, 1989 was a high spot of activity with sunspots peaking, work load under control and children as partially independent teenagers. Some time for radio was thus a distinct possibility. The antenna system which had evolved over a decade comprised two delta loops (see later) strung in series by a traditional method for a chimney to a distant tree and fed with tuned feeders so that, by phasing, a degree of electronic rotation was possible.

My opinion was that it was quite competitive, but certainly it is difficult to describe (and hence replicate!). The loops, however, contained the gem of the ideas outlined below.

Then - from a radio point of view - disaster struck. The family vote was to move QTH to another suburban location! This clearly would involve the 'education' of new neighbours and I would have to start with simpler arrays than previously in use. This approach also made sense as I wanted to be up and running as soon as possible after the move, so as not to miss the sunspot peak. Also little extra time would be available in the light of the painting, digging, drilling etc required at the new idyllic family home.

What was required was a three-band HF antenna with general all round coverage. A commercial ground plane was quickly fitted to the chimney and commissioned. Equally quickly a TVI problem appeared on a rather sensitive set-up next door. It proved necessary to move to horizontal polarisation, and a half size G5RV was utilised. The TVI was now gone, and G3VXJ was free to operate, but in comparison with the ground plane signals were significantly down particularly on 21MHz. I decided to try something different.

THE FIRST ATTEMPT - *or How Things Didn't Work the First Time*

FORTUNATELY, MY JUNK BOX always has plenty of slotted 300Ω twin feeder in it, due to a history of antenna experimenting. This was used for all experiments, but any twin cable of suitable strength can be used. It was decided to try a 3λ/2 for 21MHz in parallel with a λ/2 dipole from 14MHz and then try to get 28MHz going with 'stopping stubs'. The general arrangement is shown in **Fig 1**.

This worked fine on 14 and 21MHz but with no amount of adjustment could I get this arrangement to resonate on 28MHz

THE SECOND ATTEMPT - *or The Discovery*

THE ARRANGEMENT SHOWN in Fig 1 implies that two sections of the twin feeder had been cut away. This, in fact, was not the case and by a quirk of lazy serendipity I had left the wire isolated between the 14MHz dipole and the 28MHz stubs. In frustration, these 28MHz λ/4 lengths were connected to the 21MHz 3λ/2 at the ends of the 14MHz dipole and - bingo! - 28 MHz resonated. The design at this stage appeared as in **Fig 2**.

THE ANALYSIS - *or Why Did it Work?*

ALTHOUGH I HAD NEVER seen any such arrangement published before, the 28MHz operation appeared intuitively obvious. When several λ/2 dipoles are connected together onto a common feeder, the dipole for a selected band takes the power because it is fed from a low impedance current antinode into a resonant λ/4. The 8.5 ft stub on the 21MHz antenna provided a stub for operation 28MHz at exactly an equivalent low impedance position, assuming the centre feed point position to be a current antinode.

If this theory was correct λ/4 stubs for any band could be positioned at the appropriate current antinode position on a wire and resonance would occur. It was decided to try this out.

THE THIRD ATTEMPT - *or When Things Really Worked Out*

JUST TO REMIND OURSELVES, what was really needed was a three-band horizontally polarised antenna offering all round coverage. I decided that a 3/2λ pattern mounted

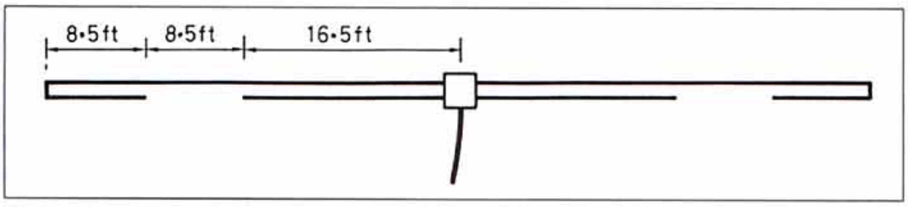

Fig 1: Basic configuration for 14MHz and 21MHz.

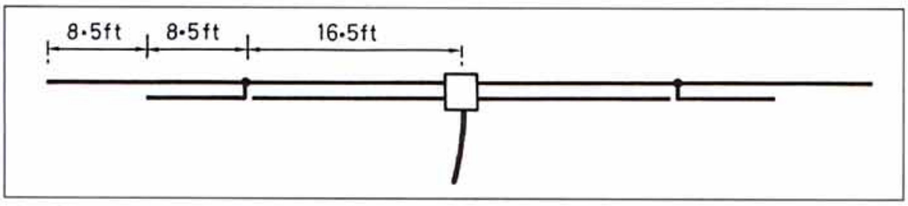

Fig 2: Stubs added for 28MHz operation.

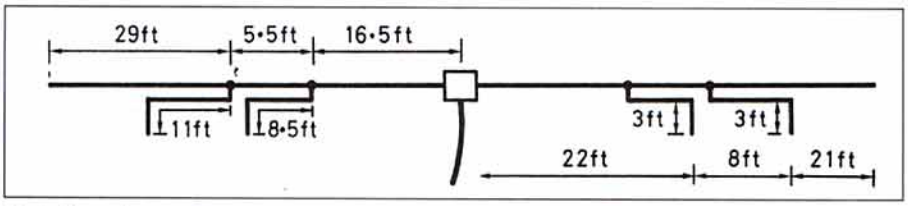

Fig 3: Dimensions shown give low SWR on three bands.

Frequency	SWR
14.0	1.9:1
14.15	1.4:1
14.3	1.9:1
21.0	1.4:1
21.15	1.0:1
21.3	1.6:1
28.0	1.1:1
28.15	1.1:1
28.3	1.2:1
28.45	1.2:1
28.6	1.3:1

Table 1

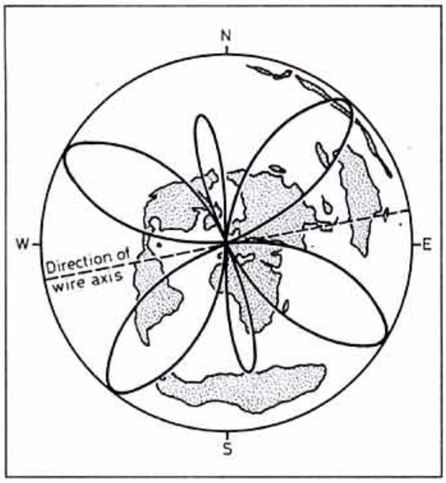

Fig 4: Radiation pattern with the antenna horizontally polarised.

East/West (my only option) would be my best compromise.

Using the new found technique the three band version shown in **Fig 3** was erected. The ends of the 21 and 28MHz dipoles were turned down as shown for three reasons. First this facilitated tuning of the ends to bring each band to resonance. Second, separating the voltage node from adjacent wires reduced capacitive detuning. Finally, for 28MHz these turn-downs allow the 21MHz λ/4 to be connected at the right position.

After some time adjusting the 3/2λ lengths for each band the final dimensions, shown together with SWR performance, in **Table 1**, were achieved. The SWR was no surprise considering 3/2λ centre fed has an input impedance a little above the 50W feed.

PERFORMANCE – *or Did it Really Work?*

HAVING GOT THE ANTENNA resonant and in the air at 20ft, some considerable time was spent listening, comparing the new antenna performance to the ground plane. Very little difference was noted in any direction or on any band with the slight difference illustrating the six peaks of the 3/2λ radiation pattern shown in **Fig 4**, so the first objective of all round performance on three bands with horizontal polarisation had been achieved.

Now came the time to use the antenna in anger - after all, the original objective had been to get going quickly and simply at the new QTH. In the six months from December 1989 to May 1990 the antenna was used with 100W of CW and 250W PEP of SSB. A 'shout list' is not the best way of illustrating an antenna performance but for illustration the following half dozen prefixes worked on each band is given:

Freq. MHz	λ	Length ft.	Notes	
3.6	1/2	131.2	A	
18.1	5/2	134.8	A	
10.1	3/2	134.9	B	Corrected length for end insulators
24.9	7/2	133.8	B	Corrected length for end insulators
28.3	7/2	121.0	C	
14.1	3/2	103.3	D	
7.05	1/2	67.0	E	
21.1	3/2	69.0	E	

Table 2: See text for explanation of notes.

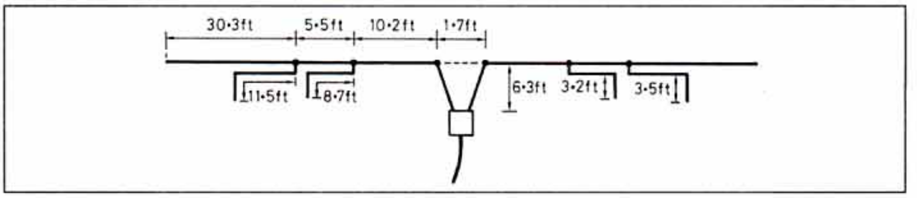

Fig 5: Conversion to form a 3-band double extended zepp.

14MHz KH5J, XU8, T32, FW, 3Y5, ZD7.

21MHz 1S0, 7O1, JD1, 3W, V85, 3D2 Conway.

28MHz ST0, ZZ0 Trindade, ZS8, VR6, FH5, XW8.

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These results compared very well with other wire antennas used previously as these were all new countries for me.

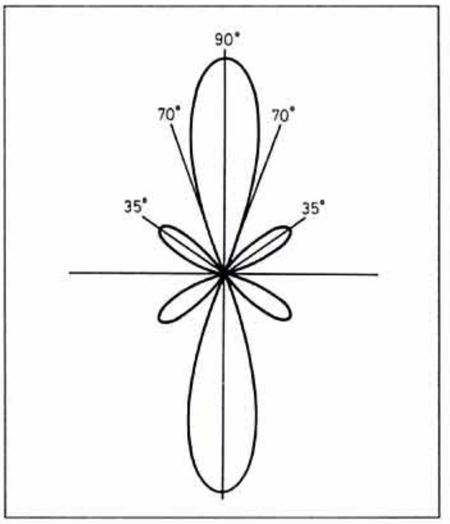

Fig 6: Theoretical radiation pattern for the above antenna.

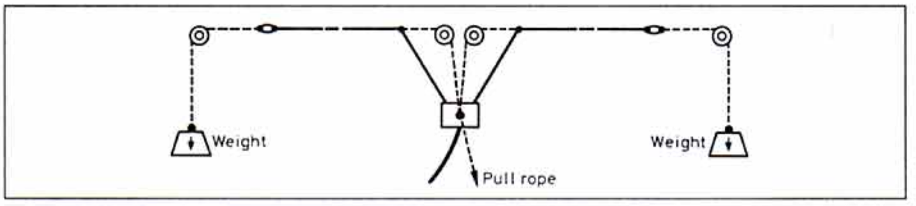

Fig 7: Suggested mechanical arrangement to change the characteristics.

DEVELOPMENT – *or What Else Can Be Done With That Idea*

IT WAS NOTICED THAT THE 14MHz length was a little shorter than expected and the 28MHz a little longer. I decided it was therefore possible to create a 2 x 5/8λ three-band double extended zepp by folding back the centre to give a North/South radiation pattern with a theoretical gain of 3db. **Fig 5** shows the general arrangement, and **Fig 6** the theoretical radiation pattern.

To bring the antenna to resonance the ends had to be lengthened slightly as shown, but the SWR improved to 1.1:1 on 14MHz, 1.2:1 on 21MHz and 1.1:1 on 28MHz. More importantly the radiation pattern sharpened North/South, as predicted, when compared to the ground plane.

An idea not implemented at G3VXJ was to mechanise the change from 3/2λ to double extended zepp format by the use of pulleys, as shown in **Fig 7**, so that the radiation pattern could be changed at will. However, my shack is not at the centre!

Another version I tried briefly was a loop version comprising a delta loop on 14MHz and folded 3/2λ for 21 and 28MHz. (The arrangement had been used successfully at my original location). The arrangement is shown in **Fig 8**, together with the current distributions for the 3/2λ version This was a little unsightly by my required standards and was quickly replaced.

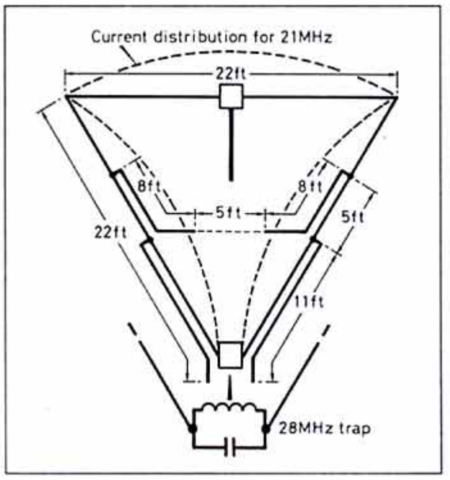

Fig 8: Loop version of the antenna uses a 28MHz trap.

THE EIGHT BANDER – *or The Ultimate?*

BEFORE STARTING TO EXPLAIN this it should be noted that my garden is not long enough to accommodate this antenna so dimensions reflect a 'bent end' version of this arrangement. Others experimenting with a

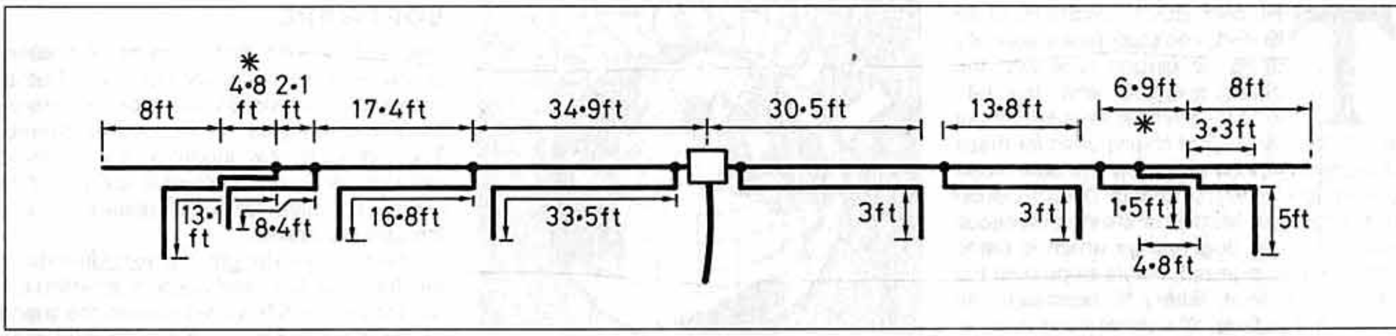

Fig 9: Final dimensions of the eight band version.

straight antenna in the clear will, no doubt, have to adjust dimensions.

Experimenting with independent wires the relationships shown in **Table 2** were developed.

It can be easily seen that on bands marked with the same letters a single wire will resonate on both bands. For instance, note A shows a length which resonates at 3.6MHz and 18.1MHz. Length B was selected to support the system as the end effects shortened the length a bit. From this the eight band antenna show in **Fig 9** was built.

The overlap shown at * was made by threading an additional third wire through the slotted 300Ω feeder. This stub provides the 18MHz λ/4 whilst the overall length including the stub is the 3.5MHz antenna.

The antenna exhibited an SWR of 2.5:1 or better on all eight-bands (after some trimming). I am confident that in a straight forward environment a better result would be achieved, but I returned to the three band version which fits the garden.

CONCLUSION - *or Was it Really a Good Idea!*

I HAVE NOT SEEN THE simple use of λ/4 stubs in my thirty years of amateur radio, but little is new under the sun so maybe it has been used before. It seems to work well in a number of antenna applications and hence, no doubt, it can be used by others to help in multi-banding where required. From my point of view the basic three band HF variant has been reinstated and continues to serve me well.

Many multi-band dipole antennas have been proposed over the years - what is different about this technique is that the antenna is truly resonant on each band. This is achieved without the use of traps (which introduce losses) and provided correct matching to coax feeder reducing other losses.

When correctly adjusted the antenna can be directly connected to rigs with solid state power amplifiers.

At G3VXJ there are other criteria. The three band antenna was an important part of solving a TVI problem whilst providing horizontal polarisation and good all round coverage.

Probably equally important is that it is 'scenic' in the suburban environment. 300Ω twin feeder shows little more that a single wire at 30ft and the turned down ends are equally minimal in their visual impact. In particular, no adverse comments have been received from the new neighbours.