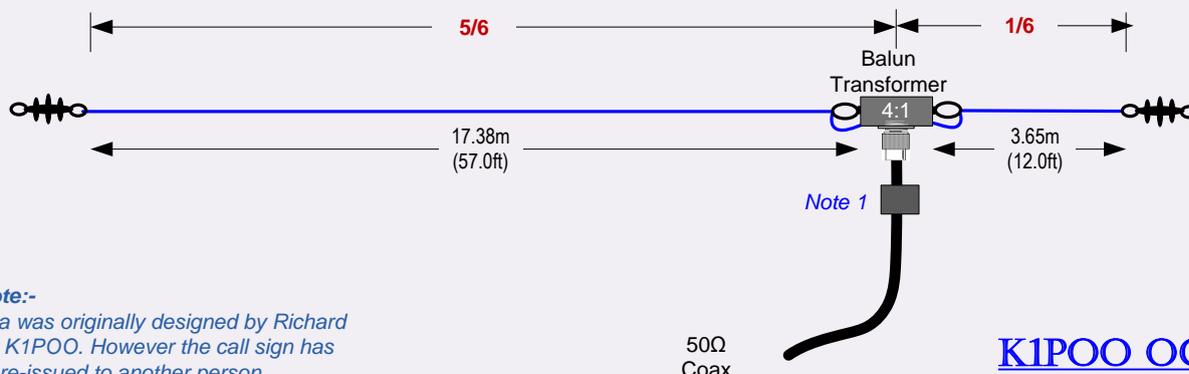


K1POO 4 Band Off Centre Fed Dipole (40-20-15-10m)



Editors note:-

The antenna was originally designed by Richard Formato as K1POO. However the call sign has since been re-issued to another person.

50Ω
Coax

K1POO OCFD

Note 1. Dale Gaudier, M0AOP/K4DG, Zack Lau (W1VT), Jack Kenamer, (W4YPC) and Lew McCoy (W1ICP) and M0RZF suggest a choke or choke-balun improves operation.

BACKGROUND FROM WINDOM TO OCFD

1927 – September; Loren Windom, W8GZ/W8ZG, was the first to reveal the Windom antenna to the radio amateur community by describing the antenna in the September issue of QST. The antenna was a half-wave in length using a single wire feeder of any length attached 0.18λ from one end providing a 500 ohms match.

1936 – November; Jim MacIntosh VS1AA (later GM3IAA), publishes "Some experimental work with aerials" in the T&R Bulletin, describing a "compromise multiband Windom". This was a 41m long horizontal wire with a $1/3+2/3$ split and used a single wire feeder. The antenna works well on the harmonically related bands (80, 40, 20 and 10m).

Strictly speaking the following are not Windoms since they do not use a single feed wire. They are more accurately described as Off Centre Fed Dipoles (OCFD).

1971 - Dr. Fritz Spillner, DJ2KY, in "Die FD4-Windom-Antenne," QRV, Stuttgart, 25, December 1971, pp.13-20 describes a modified VS1AA OCFD with a 4:1 balun connected to a coaxial feeder. The Fritzel FD4 antenna becomes more popular in Europe and N. America. A shorter version FD3 for 40-10m operation is also developed.

1996 – February; Bill G0FAH, describes "Four Bands, Off Centre" in QST magazine, suggesting the use of a quarter-wave 300/450 ohms ladder line as an impedance matching transformer to enable the modified 40m-20m-10m version of VS1AA OCFD to operate on the 15m band, but this requires a switched 4:1 /1:1 balun at the end of the ladder line.

1996 - November; Richard Formato, K1POO, in "Feeding the Off Centre Dipole" (Electronics World, November 1996) describes his theoretical study of the feed point of a shorter 40m version of the VS1AA OCFD, suggesting that the $1/3 + 2/3$ split is not the best split for operating on 4 bands and concludes that the $1/6+5/6$ split provides the best overall 4-band performance.

1997 - June; Dale Gaudier, M0AOP/K4DG, in the RSGB Technical Topics section of Radio Communication describes his experiments with the K1POO design, explaining that a choke is required next to the 4:1 balun for the antenna to resonate on its fundamental frequency of 7MHz. The choke (aka dirty balun) has $5\frac{1}{2}$ turns of RG-8X coax with a diameter of 24cm. The antenna's SWR on 40m, 20, 15m and 10m is less than 2:1 and the antenna is fairly broad-banded.

2001-March; Zack Lau (W1VT), in his article "Making the Off-Center Fed Dipoles Work", after modelling the OCFD concludes that a line isolator (choke) is required for optimum operation of the antenna.

2012 Ro's (M0RZF) experiments and measurements using VNA concludes that the K1POO OCFD benefits from use of a choke balun.

However....

1949 -summer; G. E. "Buck" Rogers Sr; (K4ABT) overhears Jack Kenamer, (W4YPC) describing a Windom antenna on all the HF bands without the need for an antenna tuner. He does this by using a 9-turn coil of the coax (aka dirty balun) at the feed point to prevent RF being re-radiated off the coax shield. Buck's interest in this antenna is born.

1958 - Buck K4ABT reads about Gillette Guanella "current" type balun and Thomas O'Meara's papers, "Analysis and Synthesis with the Complete Equivalent Circuit for the-Band Transformer", which leads to some design changes being made to Buck's version of the Windom antenna.

1968 - Lew McCoy (W1ICP) introduces Buck to a new balun design, which, with a $1/3 + 2/3$ split, produces a Buxcomm™ Windom with an 8 band HF operating range. Buck (K4ABT) describes the new Buxcomm™ matching Device as an "integrated Balun & center insulator". There are two versions of the antenna covering 80m to 6m" and 40m to 6m". These can be supplied with one of three Buxcomm baluns (4:1, 5:1, 6:1) to accommodate working heights between 25ft (8m) -75ft.(22.8m).

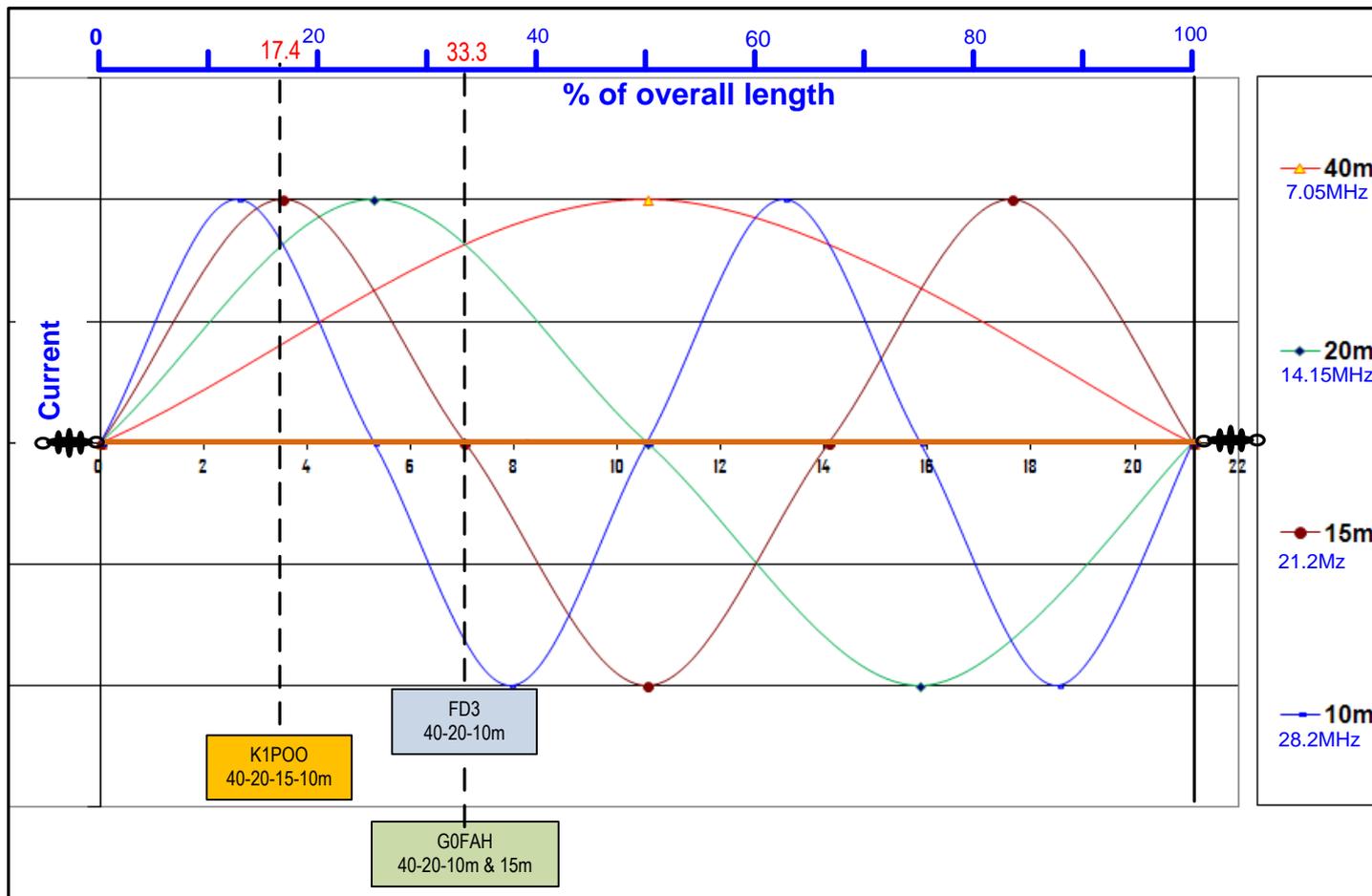
ref <http://www.buxcomm.com/windom.htm>

But if the choke moves further down the coax feeder we end up with a CAROLINA WINDOM® but that's another story.....

K1POO 4 Band Off Centre Fed Dipole (40-20-15-10m)



BACKGROUND TO THE DEVELOPMENT OF THE K1POO ANTENNA



The diagram above shows an 40m half-wave wire with 4 sine waves superimposed associated with 40m, 20m, 15m & 10m bands. For a multi-band OCFD the sine waves show that there are two feed-points. Since the magnitude of three of the four currents is the same, the feed point impedance on some of the bands will remain constant. FD3 & G0FAH are associated with the 33.3% position, but the 17.4% (approx 1/6) position was chosen by K1POO for his version of the OCFD.

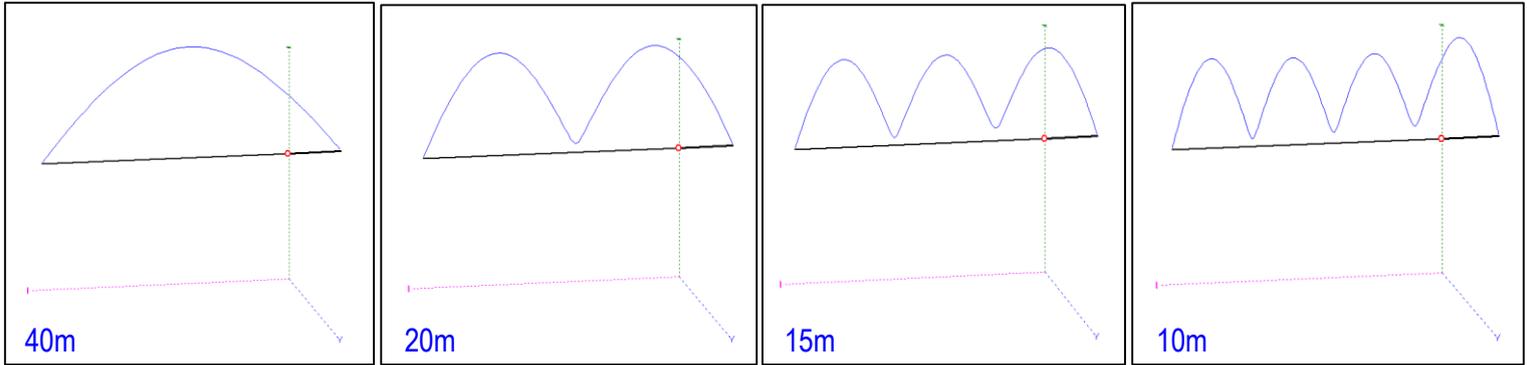
The characteristics of the two feed-point positions.

1. The more common split of 1/3+2/3 uses a 6:1 or 4:1 balun to 50Ω coax to the shack. This suggests that the antenna's feed point is either 200Ω or 300Ω. In fact it's more complicated than this as the impedance depends on the height above real ground in wavelengths (see later graph). A typical antenna using this split is the FD3 3-band OCFD.
2. However, the 1/3+2/3 split creates a high impedance on the 15m band i.e. the current is zero at this position. G0FAH proposed using a $1/4\lambda$ transmission line transformer section made from 300Ω or 450Ω twin feeder to overcome this problem. But this requires a dual ratio current balun. For 15m operation the 1:1 ratio is used and the 4:1 ratio on 40m, 20m & 10m bands.
3. K1POO studied the 40m OCFD using computer models and in the May and October, 1996 issues of QST, suggested a 0.174 + 0.826 (3.65m+17.38m) split. This split allows the OCFD to be operated as a 4 band antenna as the SWR on the 40m band is less than 3.6:1 and less than 1.4:1 on the 20,15,10m bands

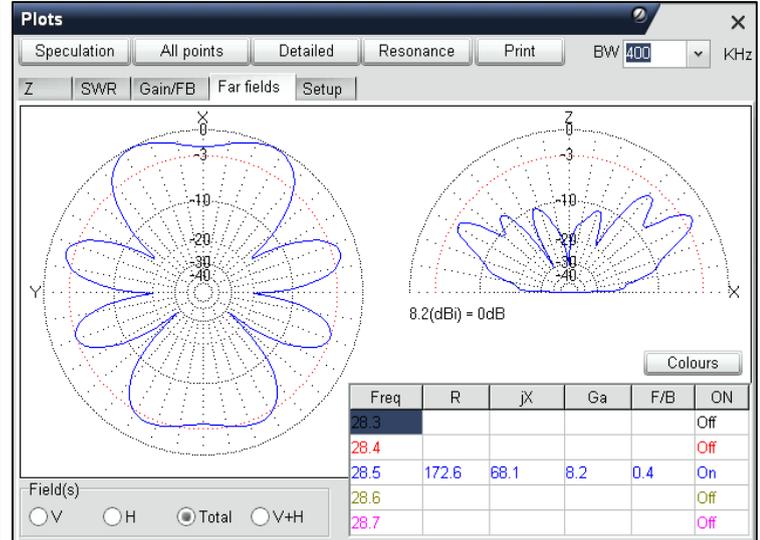
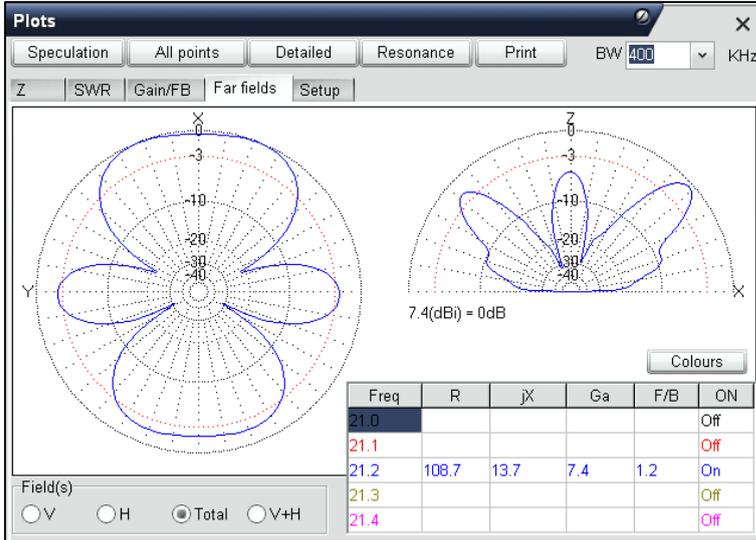
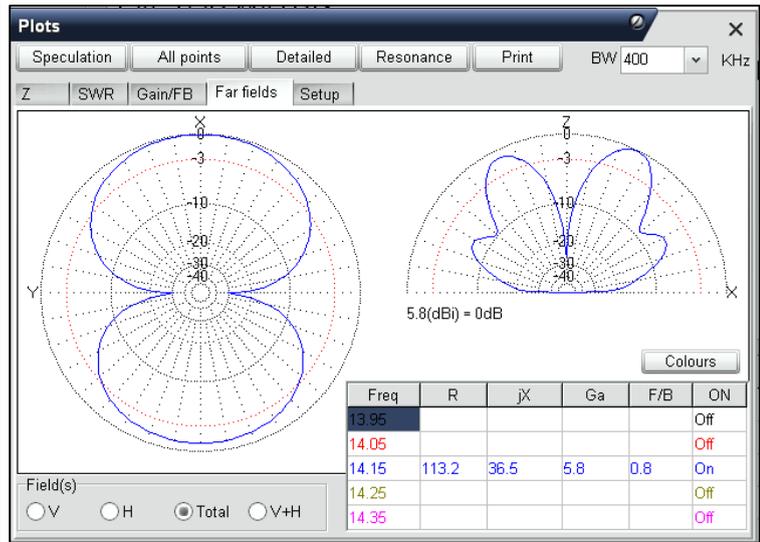
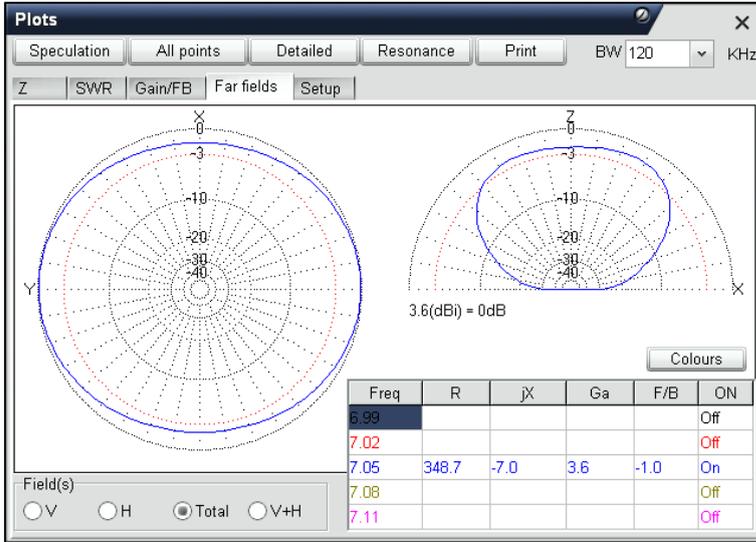
K1POO 4 Band Off Centre Fed Dipole (40-20-15-10m)



The freeware antenna modelling program MMANA-GAL was used to study the K1POO Antenna.
The model uses copper wire 2mm diam, the antenna height is 8m above real ground (5mS/m and dielectric 13) SWR ref 200Ω



No.	F (MHz)	R (Ohm)	jX (Ohm)	SWR 200	Gh dBd	Ga dBi	F/B dB	Elev.	Ground	Add H.	Polar.
4	7.05	348.7	-7.034	1.74	---	3.57	-0.97	64.0	Real	8.0	hori.
3	14.15	113.2	36.53	1.85	---	5.85	0.83	63.2	Real	8.0	vert.
2	21.2	108.7	13.74	1.85	---	7.43	1.25	41.9	Real	8.0	vert.
1	28.5	172.6	68.07	1.48	---	8.2	0.4	30.8	Real	8.0	hori.

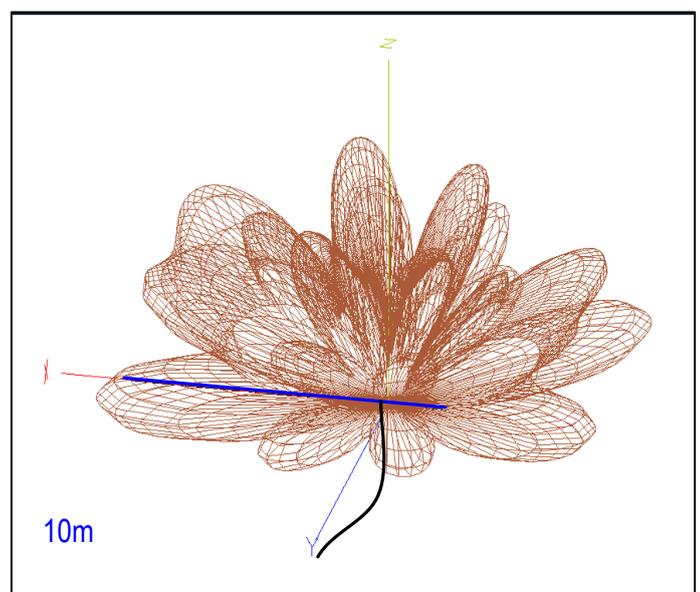
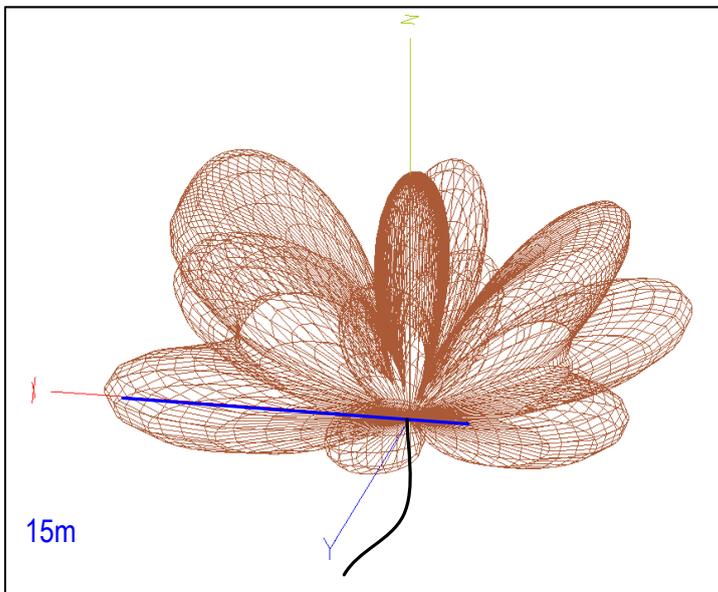
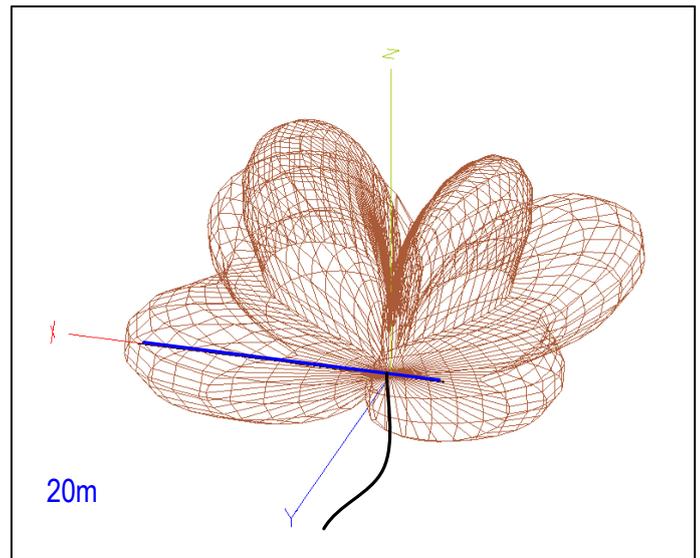
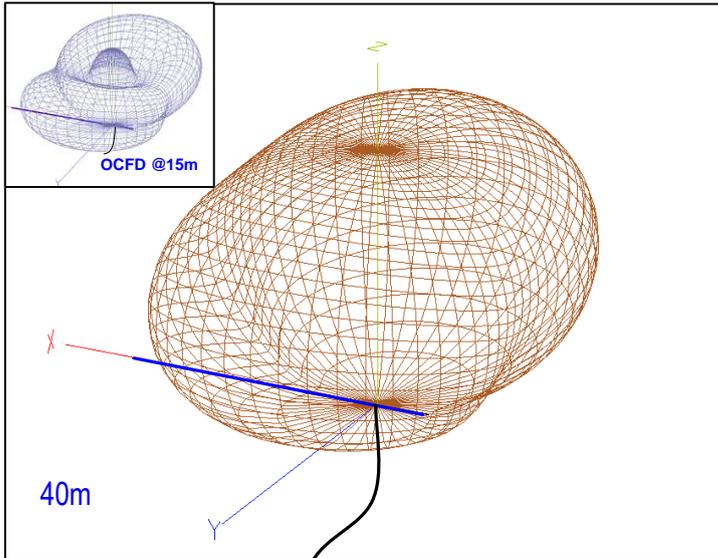


K1POO 4 Band Off Centre Fed Dipole (40-20-15-10m)



MMANA-GAL K1POO Antenna model's 3D far field results

The antenna at 8m height above real ground 5mS/m and dielectric 13, SWR ref 200Ω.



The MMANA-GAL model of the K1POO antenna at 8m height shows that the antenna has a more complex lobe structure as the frequency increases. This is consistent with the wavelength shortening so the height is in the order of $0.15\lambda - 0.25\lambda$ where the ground reflections have less effect on the far field.

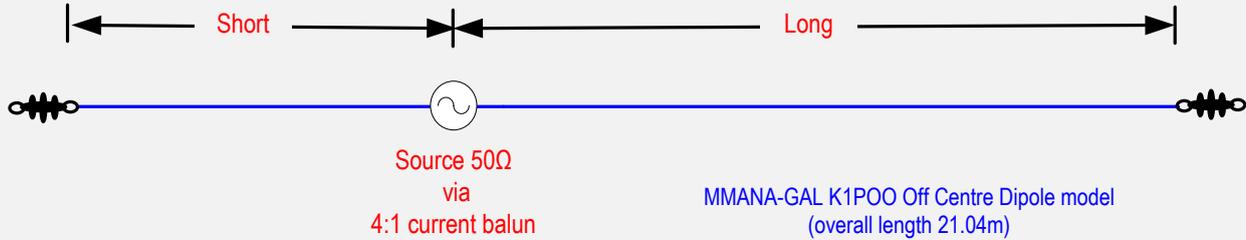
Increasing the height to 15m significantly affects the 40m far field plot as can be seen in the small blue coloured inset. A doughnut shape evolves with a raised centre. The other bands are also affected but to a lesser degree and are not so noticeable on these 3D far field plots.

Note: The limitations of the Freeware MMANA-GAL program are such that it cannot model the surroundings of the antenna, especially if the antenna is extremely close to the ground. However, in practice, the results of modelling horizontal HF antennas at elevations of 6m or more are generally good.

K1POO 4 Band Off Centre Fed Dipole (40-20-15-10m)



K1POO MMANA-GAL 7.05MHz Study to determine the position and impedance at resonance.

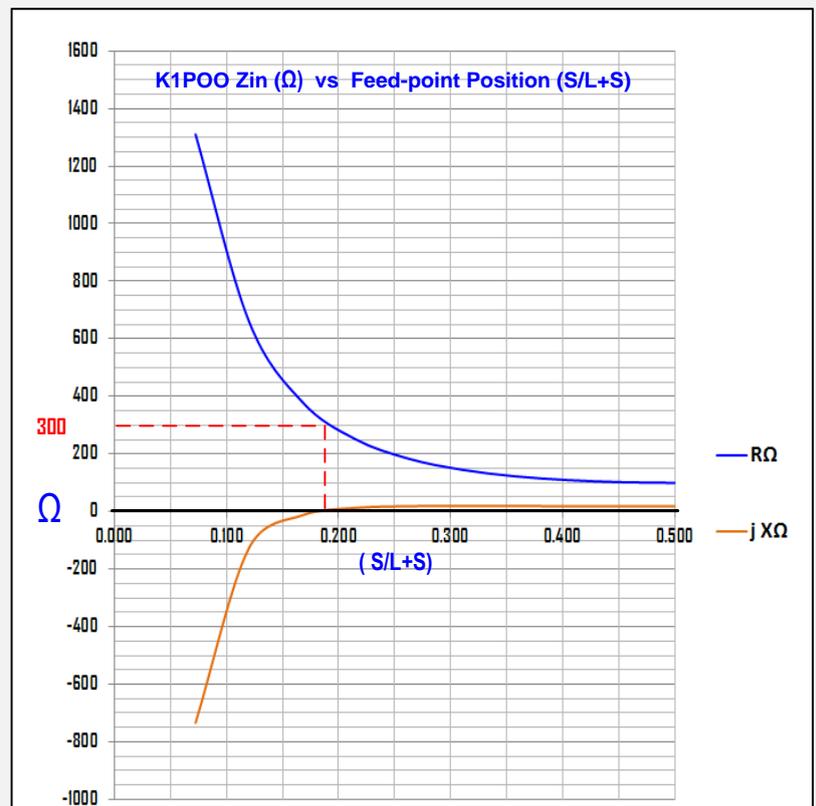


The diagram above shows the MMANA-GAL model's construction and the table below contains the calculated results. Initially the "short" and "long" wires start off as equal lengths, thus simulating a normal half-wave dipole. The "short" element is reduced in size by one metre and the "long" element is increased in size by one metre, effectively shifting the feed point away from the central position and new calculation is performed. This process continues in one metre steps until the feed point is close the insulator at one end. The aim of this exercise being to determine the position and value of impedance at resonance i.e. when $jX=0 \Omega$.

MMANA-GAL 40m OCFD Model's Results

Wire 2mm diam, antenna at 8m above real ground
5mS/m and dielectric 13 SWR ref 200 ohms

Long Side (L)	Short Side (S)	S/L+S	R Ω	jX Ω	SWR
10.52	10.52	0.500	99.86	18.22	2.02
11.52	9.52	0.452	102.1	18.38	1.98
12.52	8.52	0.405	103.3	18.81	1.85
13.52	7.52	0.357	122.7	19.4	1.65
14.52	6.52	0.310	145.6	19.79	1.4
15.52	5.52	0.262	184	18.77	1.14
16.52	4.52	0.215	251.7	12.65	1.27
17.52	3.52	0.167	381.7	-13.1	1.91
18.52	2.52	0.120	662.4	-127.6	3.45
19.52	1.52	0.072	1310	-733.3	8.64



The MS Excel graph shows how the impedance components $R + jX$ vary as the feed point moves away from the centre of the dipole at the 0.5 position. On the graph at the 0.18 position the impedance is 300 Ω on the Y axis. K1POO's choice of an easy to make current 4:1 balun means that the SWR will be 1.5:1 rather than the ideal 1:1. However there are other factors governing the impedance and therefore the SWR of multi-band OCFD antennas. These are explained in more detail in the RSARS e-Library article "[Study of the OCF Dipole Antenna -G8ODE iss 1.3.pdf](#)" e.g. height above ground and end effects the impedance as well.

K1POO 4 Band Off Centre Fed Dipole (40-20-15-10m)



M0RZF, a UK amateur, has experimented with the feeding of the K1POO OCFD

"During some email exchanges with members of the Yahoo-RSGBTECH group I mentioned my experiments with the K1POO 4-band OCFD antenna in my small garden. I found that you need to use an effective current choke on the coax and experimented with a many different 4:1 baluns. The conventional Guanella design, modified by Sevick is the conventional choice, but I always found common mode problems, even when using type FT140-43 toroids.

The Ruthroff type voltage balun with a 1:1 in series was better, but I wanted even better common mode without using bigger toroids. So I ended up with the 4:1 balun based on Chris Trask (N7ZWY) design in series with a 1:1 balun. This combination works better than the others, and is easy to construct. With the two baluns in series, the insertion loss is 0.32dB at the worst case of 30MHz. (See VNA plot). With slightly thicker wire and more careful winding this might be reduced to about 0.13dB, which is pretty respectable. The bandwidth is adequate to cover 7.0MHz - 30MHz.



The K1POO antenna has the great advantage for me that the coax feed is very near the house, so it can hang down almost directly outside my window. My garden is only 16m long, so the antenna's shorter end is over the house's roof at 9.5m AGL and the longer end slopes down the garden to a washing line post and fiberglass pole with a combined height of 8.5m. The last 1.5m is bent down at 60 degrees at the end.

See.... <http://www.m0rzf.co.uk>

Unfortunately adjusting this type of antenna really needs an antenna analyser.

I found that a conventional SWR meter is of no use for optimising the K1POO. Getting the two lengths right was quite difficult to do and I can't say exactly what the final lengths I ended up with, but they are no more than 300mm less on the long end and 200mm on the short end than the values published by Richard Formato (K1POO).

~ Rob MoRZF ~

The Chris Trask (N7ZWY) 4:1 balun design

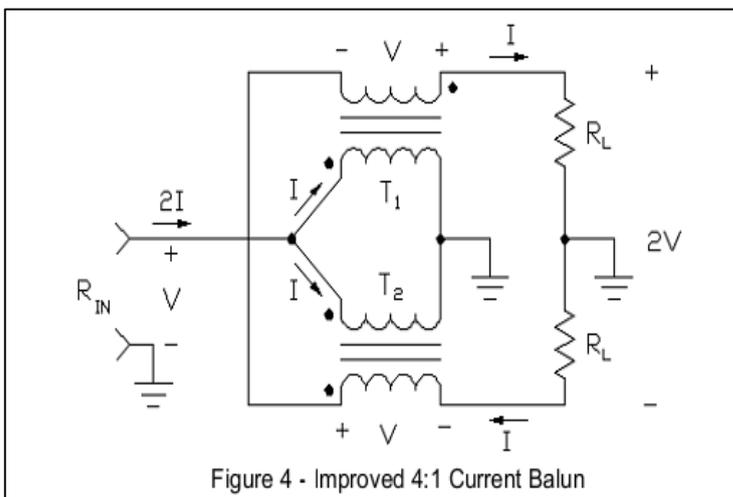


Figure 4 on the left is from Chris Trask's (N7ZWY) article "**A Single-Core 4:1 Current Balun of Improved Performance**" revised 1 July 2005

In the conclusion Chris states that the "new form of 4:1 current balun design overcomes the minor shortcomings of the Guanella 4:1 current balun that are associated with the losses of the two transformer sections and any dissimilar properties of the two required cores.

Reference:

<http://home.earthlink.net/~christrask/Trask4to1Balun.pdf>

K1POO 4 Band Off Centre Fed Dipole (40-20-15-10m)



To demonstrate the accuracy of the MMANA-GAL model of the K1POO antenna, the results from the MMANA-GAL program and Rob's (M0RZF) Vector Network Analysis are shown below.

The MMANA-GAL model's data comma-separated variables (CSV) file is plotted as MS-Excel graph between 6.0MHz.-30.0MHz and is shown below. Additionally the table summarises the results for the 40-20-15-10m bands.

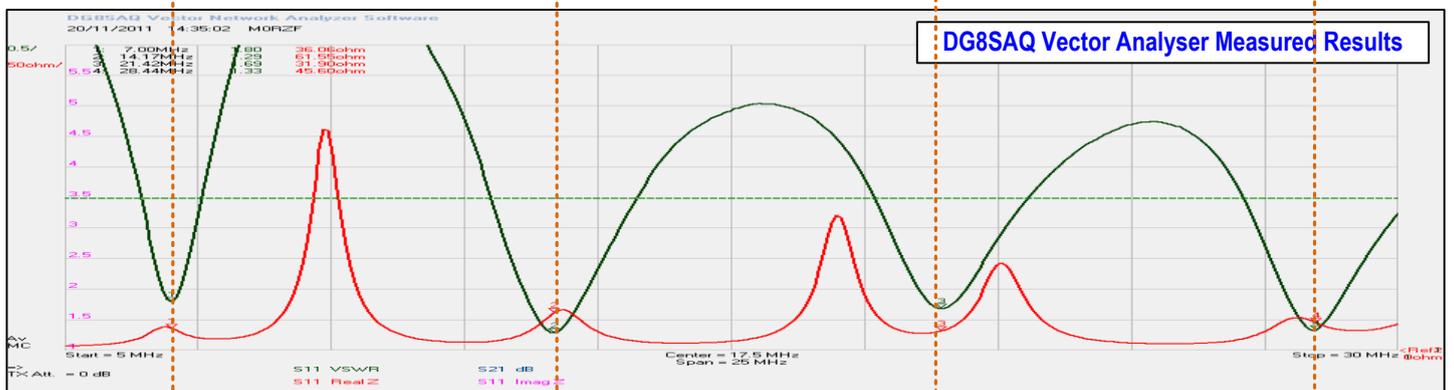
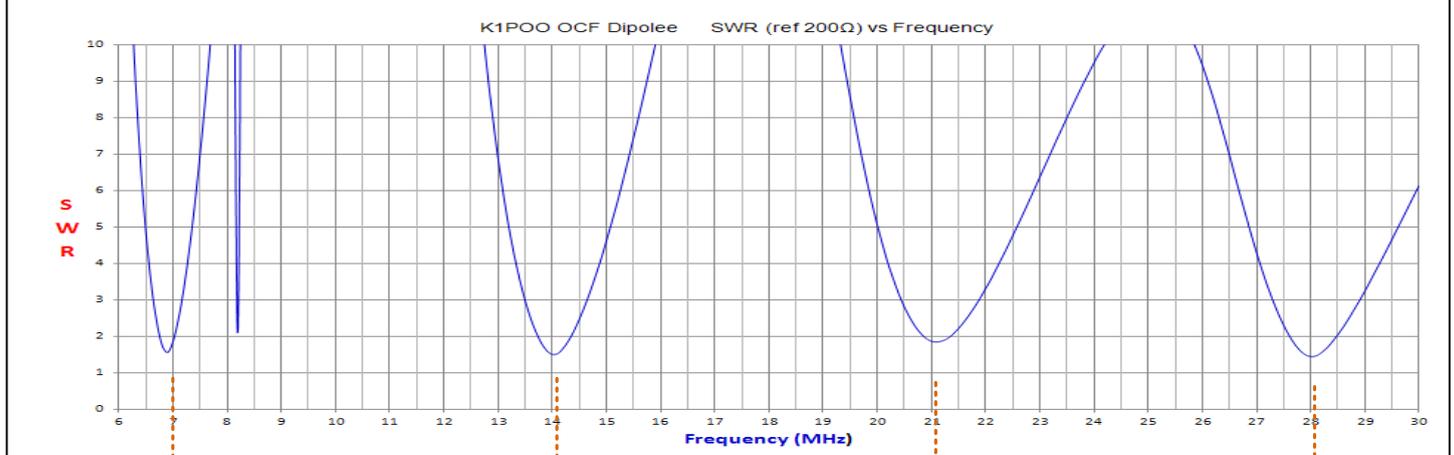
Aligning the two graphs using four dotted cursor lines on the SWR minimums clearly shows that the model is a reasonable approximation of the actual antenna, i.e. the blue and green trace have very similar shapes. Even with MMANA-GAL's program limitations, it is possible to assume that the far field plots provide a good idea of how the antenna will perform in practice.

MMANA-GAL Data for the K1POO antenna.

Freq(MHz)	SWR(200Ω)	R(Ωm)	jX(Ωm)
7.0	1.85	356.39	56.18
7.1	2.46	421.67	154.75
7.4	5.57	759.68	506.43
14.2	1.67	155.17	79.15
21.2	1.88	114.99	46.63
28.5	2.05	148.5	115.56

The table shows that the antenna has a reasonably low SWR on all the bands and some antenna matching at the shack end will be reduce the SWR even further.

MMANA-GAL K1POO Model Results



The M0RZF's measurements were made at the shack end, with a coax length of 10m.