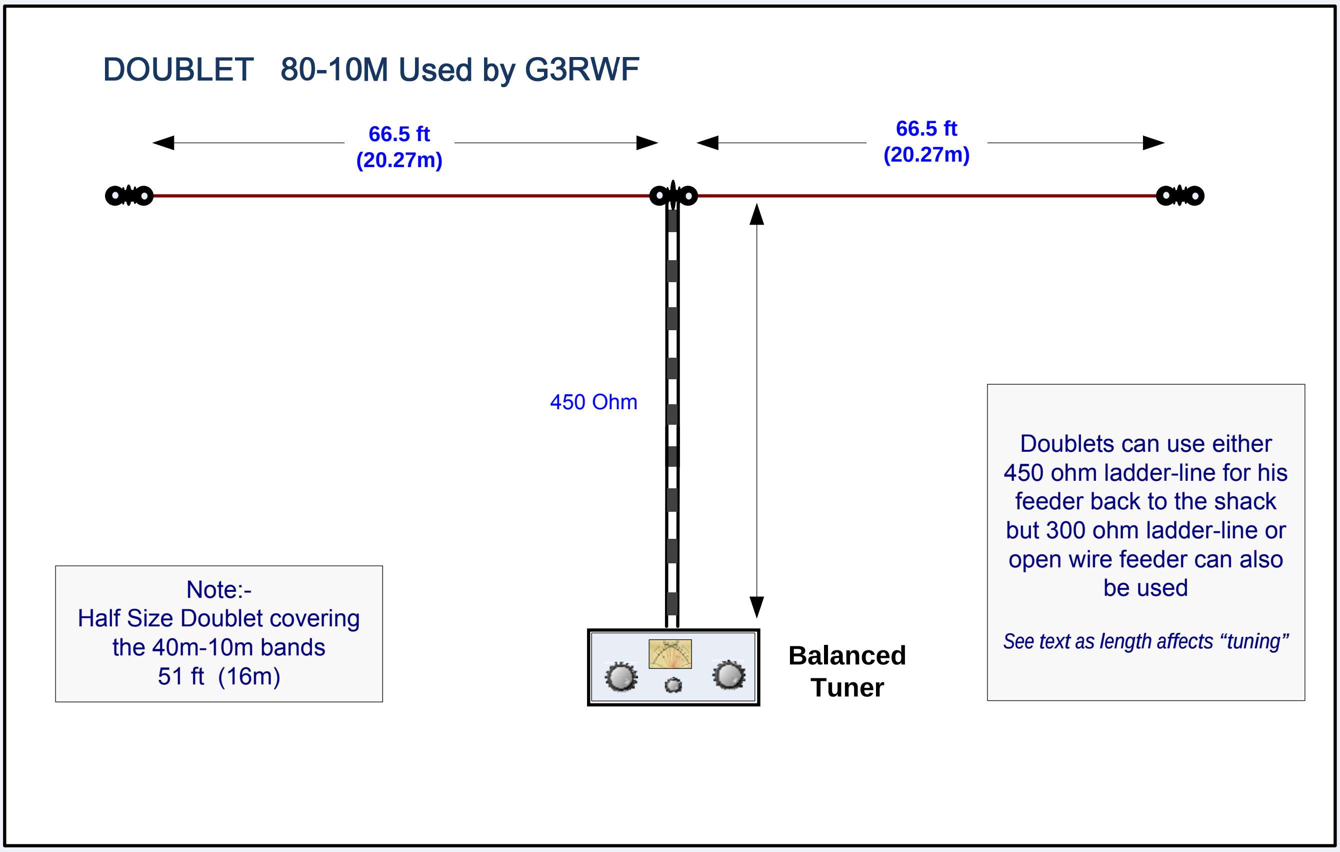
80-10m Doublet Antenna- G3RWF



My antenna is at about 57 feet (17.4m) and the feeder is about 60ft (18.3m) long- almost vertical but comes into the house about 3 ft above ground level using commercial feed made from copper clad steel to an antenna matching unit (Palstar AT1KM)

Nick R3RWF

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DOUBLET DESIGN CONSIDERATIONS

An efficient doublet should be at least 1/4λ to 1/3λ at the lowest operating frequency. A 3/8λ version has an efficiency greater than 98% relative to a λ/2 dipole and can have SWR values that are reasonably easy to match. At 3.5MHz a 3/8λ dipole is approximately 100ft (30m) long, but any length from 130-90ft (40-27m) will make an excellent radiator on all HF amateur bands 80m-10m including the WARC bands. The dimensions are not too critical, and if your real estate can't accommodate a dipole of this length, then you can droop the last 3-4m at each end without significantly affecting the performance. Alternatively a half-size 50 ft (16m) doublet will operate between 40m-10m.

As the operational frequency is increased, the physical length of the antenna in terms of wavelength also increases. Feedpoint resistance can be many thousands of ohms at multiples of 1λ, dropping to less than 100ohms at 0.5λ, this is illustrated on page 4 in the plot of resistance and reactance produced from the model of G3RWF's doublet. The wide variation in feed point impedance necessitates the use of a robustly constructed antenna matching unit (AMU), high voltages will be developed inside the AMU even with a modest 100 watts of RF, so there is a need for wide spaced variable capacitors to prevent arcing. As the SWR on the feeder will often be very high it is usually constructed with open-wire line and spreaders, however, high grade commercial 300 or 450ohm ribbon feeder makes a very acceptable, if pricey, alternative.

The height of HF horizontally polarised antennas above ground, in terms of wavelength, affects radiation patterns and feedpoint resistance. NVIS antennas need the ground/earth to act as a reflector, very similar to a close spaced beam, and, as such, the feedpoint resistance is usually very low, but, for the majority of amateur operations, the height of an antenna does not play a significant part in determining radiation resistance. However, in simple terms, the height of an antenna affects the angle of radiation. An antenna 3/4λ high has an angle of radiation of, about, 20 degrees, the angle rises to about 40 degrees at 0.5λ, if the antenna is just 0.25λ high, then a lot of the transmitted energy goes straight up. These affects are due to the influence of waves reflected from the ground, but as the antenna height increases this diminishes.

The doublet can also be supported using a single pole to form an inverted "V", but this will result in some changes in the far field radiation pattern at the higher frequencies but the effect on propagation will be negligible. Ideally an apex angle greater than 120 degrees if DX operation is required. Lower angles produce more near vertical lobes.

There are two things to consider when using commercial twin feeder or home-brew ladder line.

1. The feeder is likely to be unbalanced by nearby large metal objects, such as metal window frames. For short distances adopt the G5RV practice and connect a short segment of coaxial cable between the lengths of open wire feeder or from the end of the open wire line to the AMU. The losses in the coax will be slightly greater but it will solve the delivery problem.

2. The length of the line may have to be adjusted so that the impedance presented to the AMU unit is within its capabilities. Be prepared to trim the line. Remember also that the resistance will repeat every half wavelength. See the MMANA-Gal model for more information.

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MMANA-GAL ANTENNA MODEL FOR A SIMPLE DOUBLET.

Note: MMANA-GAL is freeware available on the web:- ***http://mmhamsoft.amateur-radio.ca/***
It is limited to only being able to model open-wire feeders i.e no coaxial cables

The aim of the following modelled results is to demonstrate what happens when the length of the open wire feeder is changed .
To do this the G3RWF Doublet antenna had to be modelled three times:-

1. A 40 m top as per G3RWF's Doublet & no open wire feeder - base lining feed point impedances.
2. Same antenna but using a 18m, 16.5, 15m and 13.5 m open-wire 450 ohm feeders.
3. The Models were initially all referenced to 50 ohms, and later repeated with a 200 ohm reference.

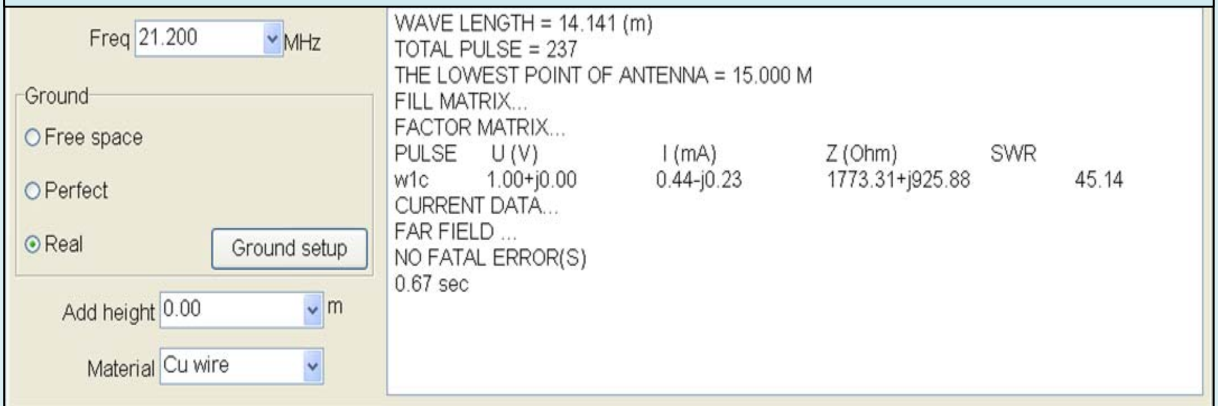
The 200 ohm reference set of readings is included because some radio amateurs prefer to use auto-tuners and manufacturers often recommend the use of a 4:1 balun, which if used with a 50 ohm transceiver translates this into a 200 ohm load,.

The feeder lengths chosen provided noticeable effects on the value of the SWR readings. The conclusions are based on these as they are easier to interpret than the complex value readings in R and jX..

In each case the following MMAN settings were used;-

SWR calculated relative to 50 ohms
Antenna at a height of 20m and the ladder lines dropping straight down.
Modelled above "Real" 5mS and dielectric of 13.

G3RWF Doublet –40m antenna wire only 18m apex & slopes to 15m – base line of dipole impedances



No.	F (MHz)	R (Ohm)	jX (Ohm)	SWR 50	Gh dBd	Ga dBi	F/B dB	Elev.	Ground	Add H.	Polar.
6	21.2	1773	925.9	45.1	---	9.61	-2.86	11.9	Real	0.0	hori.
5	18.12	119.8	-170.2	7.52	---	7.71	-4.14	15.6	Real	0.0	hori.
4	14.05	2967	1216	69.3	---	-1.16	-1.39	42.6	Real	0.0	vert.
3	10.12	86.91	-409.7	40.9	---	9.79	---	26.8	Real	0.0	hori.
2	7.05	3588	-33.2	71.8	---	7.33	---	35.9	Real	0.0	hori.
1	3.55	64.45	-4.569	1.31	---	6.84	-0.83	90.0	Real	0.0	hori.

The MMANA-GAL model results shown that the resistance alternates between low and high values, and the reactance similarly changes between inductive and capacitive values as the antenna increases in terms of wavelength.

Consequently the SWR relative to 50 ohms is generally very high apart from on 80metres when the 40m dipole is exactly a half wavelength.
However, all is not lost, as there is a way.

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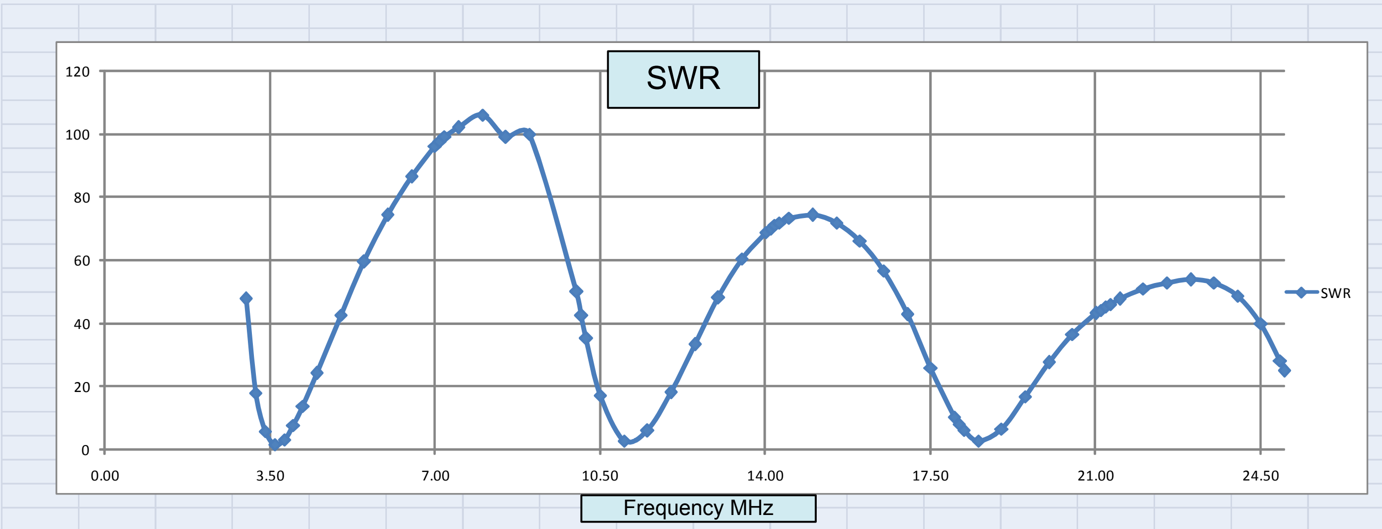
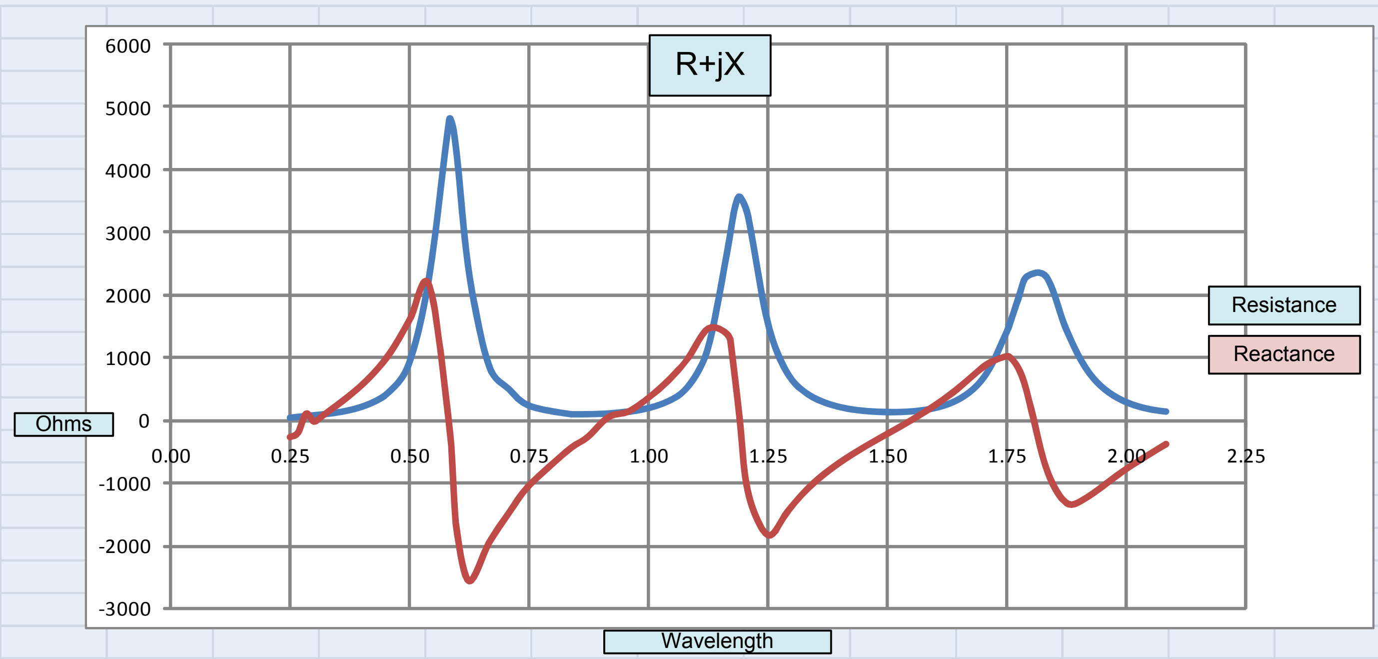
The two graphs below were produced from MMANA-GAL results calculated using 60 different frequencies over the range 3MHz- 25MHz, with more points centred around the Ham bands.

The top graph clearly show how the impedance varies with regards to frequency in the SWR graph, where SWR can be expressed ratio of impedances Z(ant) / Z(Tx).

The lower graph shows how the doublet feed-point resistance and reactance changes in terms of wavelength as the higher frequency ham bands are used. The antenna becomes increasingly longer in terms of wavelength as the frequency goes up.





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80-10m Doublet Antenna Model

The effect of altering the feeder length

RSARS

The G3RWF Doublet with its dropped arms has been modelled at a of 18m height, with the ends at 15m, only the feeder length has been changed in each model.

SWR spread Ref to 50 Ohms

SWR spread Ref to 200 Ohms

G3RWF Doublet 18m apex slopes to 45 ft with 450R line 18m long

No.	F (MHz)	R (Ohm)	jX (Ohm)	SWR 50	SWR 200
6	21.2	67.41	9.272	1.4	2.97
5	18.12	102.4	25.5	2.21	2.0
4	14.05	58.78	220.6	18.5	7.7
3	10.12	41.99	-68.16	3.99	5.34
2	7.05	180.5	661.3	52.3	14.1
1	3.55	531.2	972.0	46.3	11.8

(1.4-52.3) to 1

(2.0-14.1) to 1

G3RWF Doublet 18m apex slopes to 45 ft with 450R line 16.5m long

No.	F (MHz)	R (Ohm)	jX (Ohm)	SWR 50	SWR 200
6	21.2	102.8	-279.4	17.7	6.38
5	18.12	121.1	-203.3	9.55	3.66
4	14.05	47.8	33.61	1.97	4.31
3	10.12	48.37	-199.3	18.4	8.36
2	7.05	89.36	413.8	40.6	12.2
1	3.55	366.8	751.2	38.2	9.97

(1.97-40.6) to1

(3.66-12.2) to1

G3RWF Doublet 18m apex slopes to 45 ft with 450R line 15m long

No.	F (MHz)	R (Ohm)	jX (Ohm)	SWR 50	SWR 200
6	21.2	710.2	-1027	44.0	11.2
5	18.12	313.3	-588.4	28.5	7.6
4	14.05	57.5	-139.9	8.71	5.28
3	10.12	76.17	-378.9	39.9	12.4
2	7.05	53.87	264.1	27.9	10.4
1	3.55	263.6	588.1	31.7	8.52

(8.71-44.0) to1

(5.28-12.4) to1

G3RWF Doublet 18m apex slopes to 45 ft with 450R line 13.5m long

No.	F (MHz)	R (Ohm)	jX (Ohm)	SWR 50	SWR 200
12	21.2	351.6	777.7	41.5	10.8
11	18.12	1779	355.8	37.0	9.26
10	14.05	106.2	-381.1	29.9	9.14
9	10.12	186.5	-706.7	57.5	15.3
8	7.05	36.73	155.4	15.2	8.8
7	3.55	202.6	467.3	25.8	7.25

(15.2-57.5) to1

(7.25-15.3) to1

FEEDER LENGTH CONCLUSIONS

Although the 80metre SWR increases significantly, by varying the length of the open-wire feeder and using a 4:1 Balun the other readings can be seen to improve to values that a tuner can handle easily. The doublet's SWR values were in the range (1.31-69.3) to 1, by adding the transmission line and using a 4:1 balun, all four sets of results have an SWR that is less that 16:1, and the doublet that uses at 16.5m feeder has a maximum SWR of 12.2 to 1. By carefully adjusting the open wire feeder length it is possible to optimise the SWR readings for all the bands 80m through to 10m, but not necessarily with an SWR that is lower than 2:1

NOTE:-

The MMANA-GAL models used are only an indication of what might be expected in a real situations, and there can be no guarantee that the program can replicate a real situation since there are many variables that will affect the antenna, and these cannot be modelled in a simple program such as MMANA-GAL

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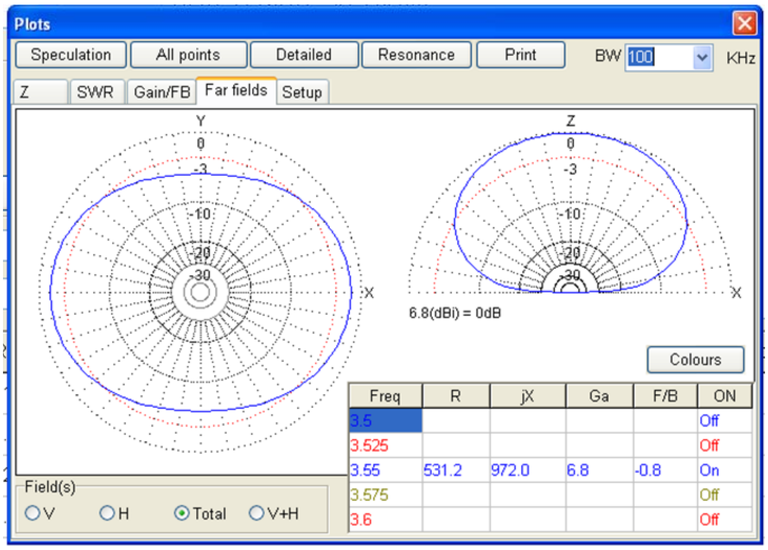
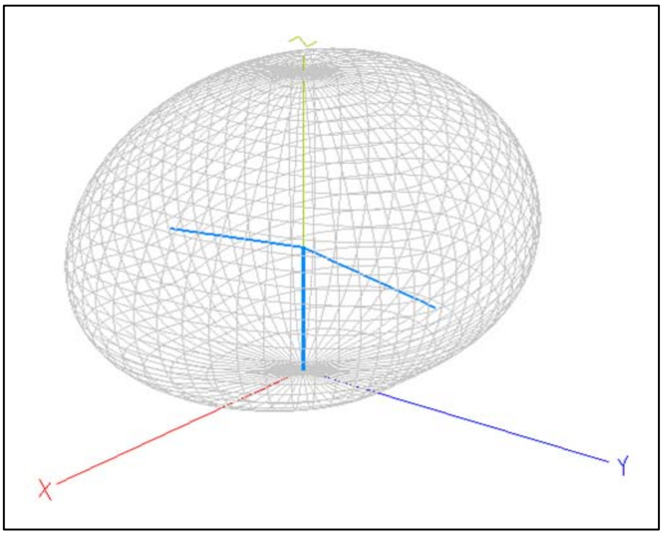
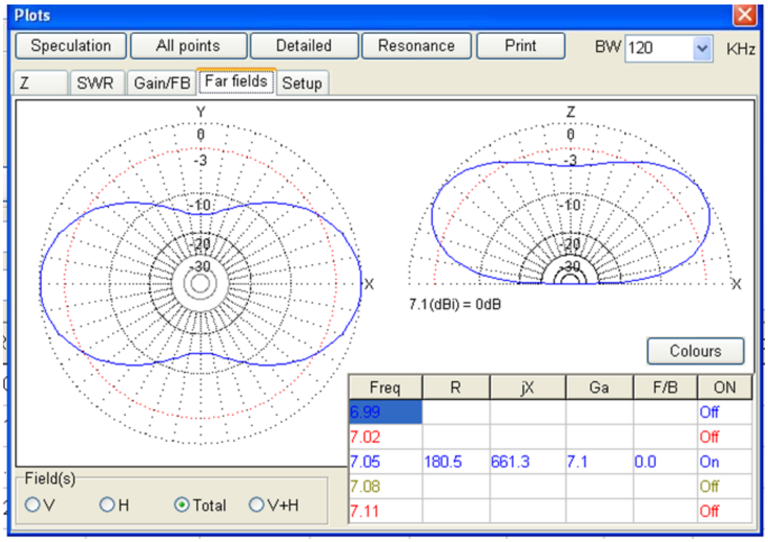
80-10m Doublet Antenna Model

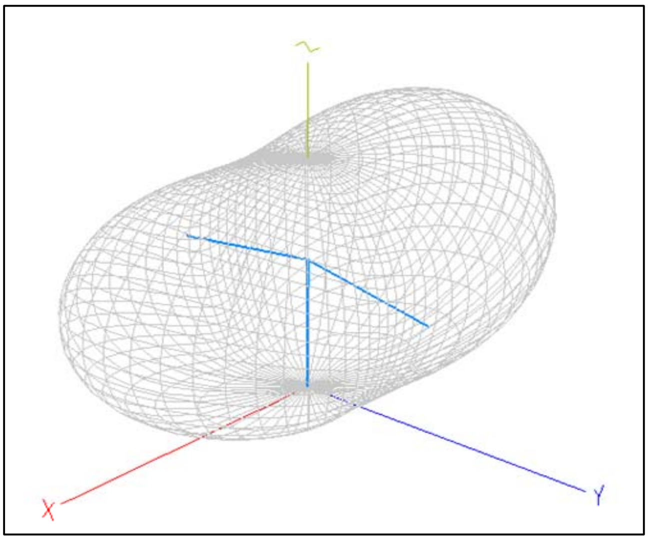
MMANA-GAL FAR-FIELD RADIATION PLOTS

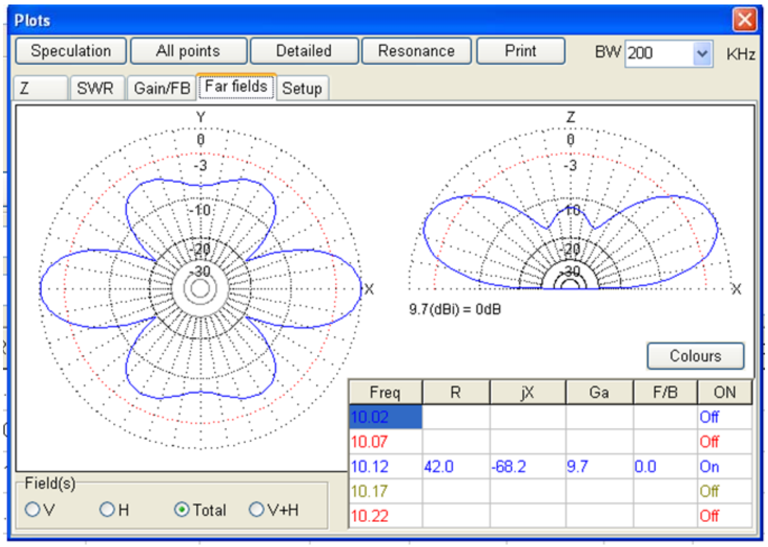
G3RWF Doublet modelled as 18m apex and ends at 15m with an 18m long 450 ohm open-wire feeder above "Real" Ground 5mS/m with a dielectric of 13

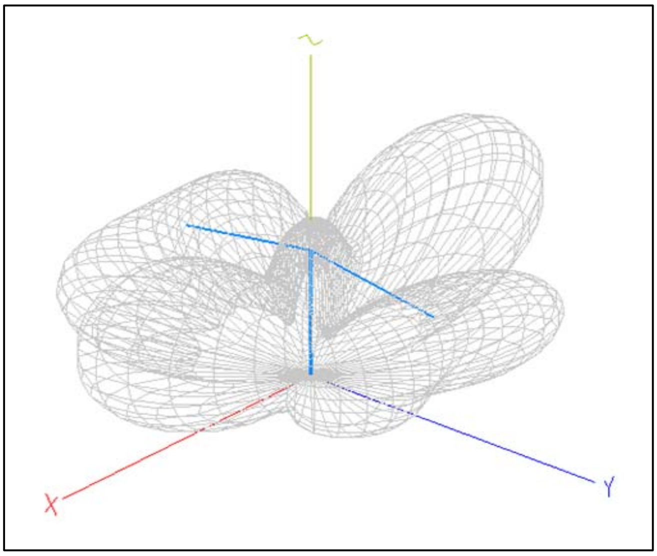












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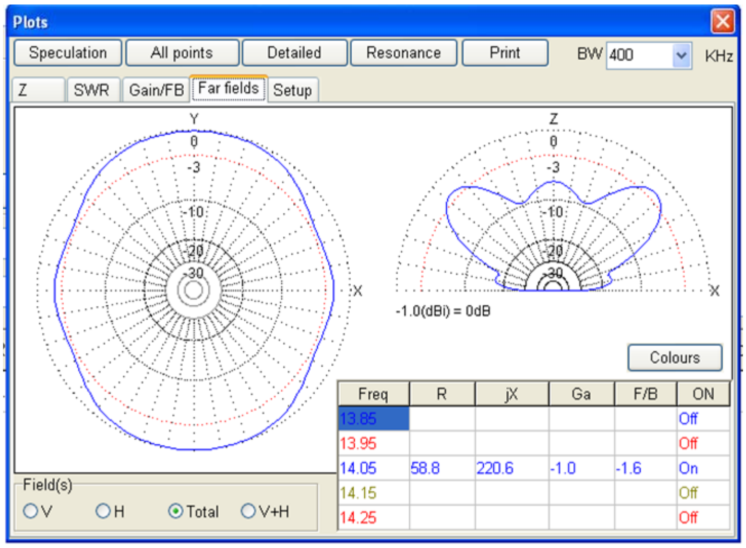

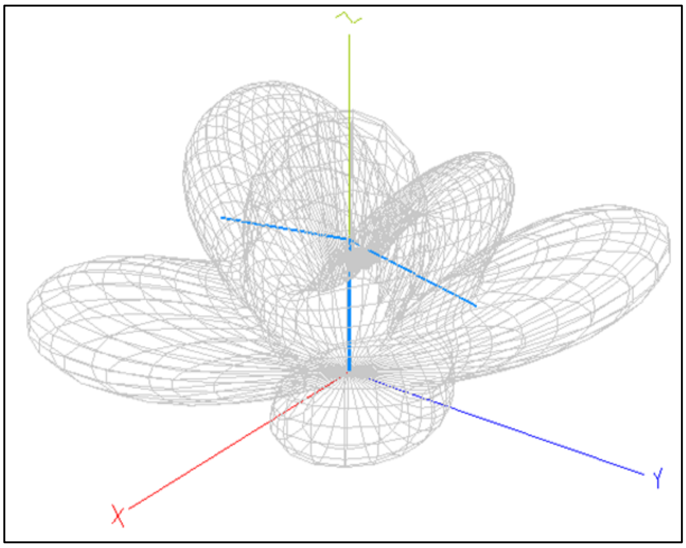

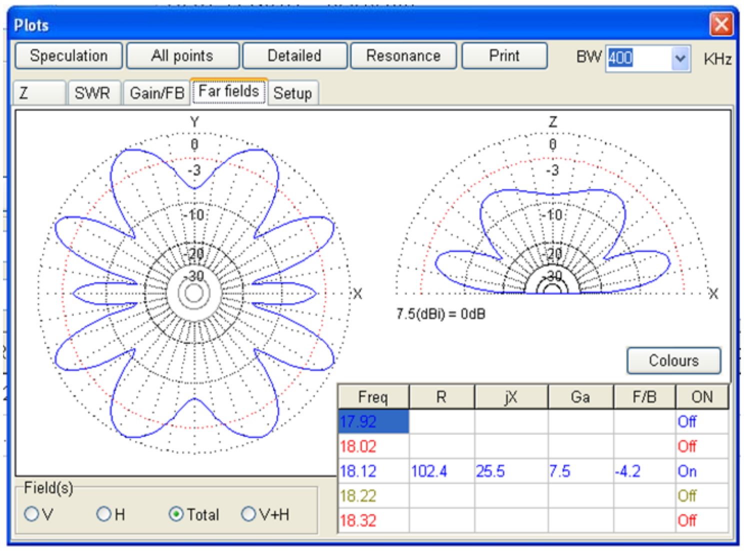

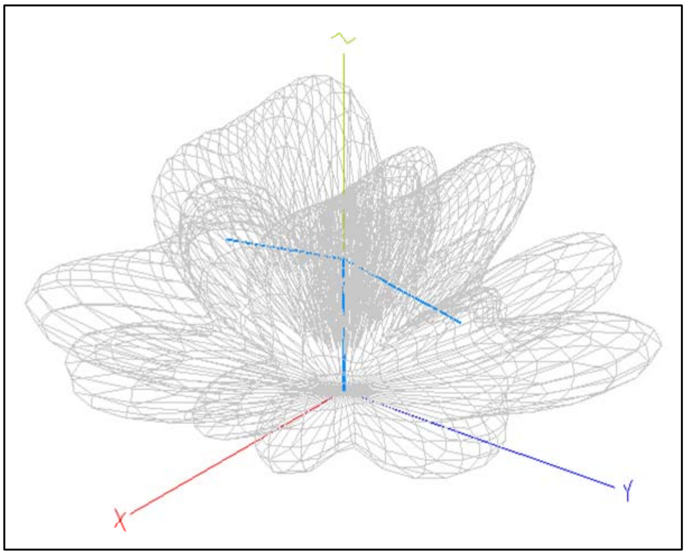

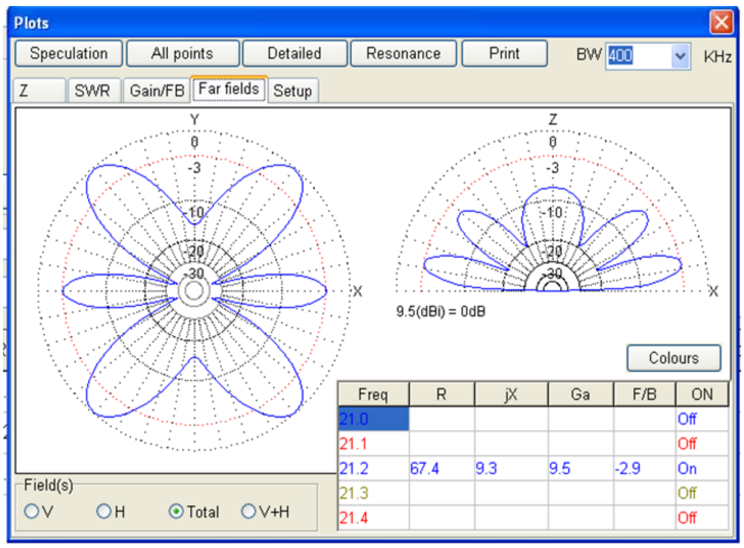

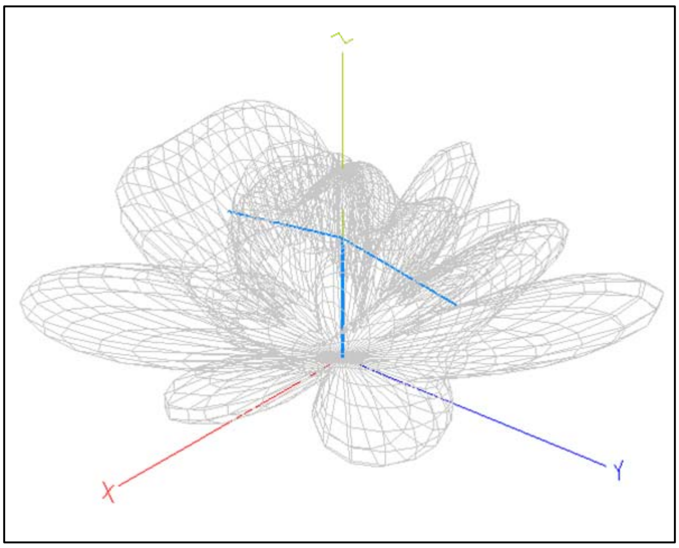

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SUMMARISING THE DOUBLET ANTENNA

The doublet is a very versatile antenna that can be used in a variety of configurations. Ideally it should be fed from a balanced “tuner” to keep the electrical loses to a minimum. The use of a ferrite balun is not really recommended because cross modulation can occur with high power levels. Additionally if high power levels are used with a severely mismatched balun very high voltages can be developed such that even solder around joints could melt!

It is also worth noting that some of the commercial “tuners” use ferrite baluns (mostly toroids) to accommodate open wire feeders. So it's case of "buyer beware"!

Some articles specify the feeder length that has to be used with a particular size of doublet. From the previous pages the reason for this should now be clear, and is done so that the “tuner” has a more acceptable and easy to match set of impedances for each band. This situation was modelled using the MMANA-GAL program, helps to explained why this happens. In fact if the resulting end of the feeder impedances are too large the “tuner” may not be able to null them out.

As suggested in the MMANA-GAL model conclusions, the simple cure is to either to change the doublet length or to change the length of the feeder. By adjusting any of these the lengths the impedance that the “tuner” sees, will change. In most cases its probably easier to juggle with the feeder length than to adjust the size of the doublet. Occasionally in order to optimise the SWR readings across the whole of the bands adjustments to both the doublet length and feeder will be required before the “tuner “ can easily provide a match on every band.

The simulation clearly indicates that the transmission line (feeder) not only delivers the RF power to the doublet, but is also helps to reduce the doublet’s various impedances to more manageable values than the “tuner” can handle. The uses of a balun helps to further reduce the range of SWR values that are presented to the tuner. The reduction in impedance will vary from band to band because the relative length of the feeder in terms of wavelength changes with each band and hence the impedance presented to the tuner.

Finally one of the most popular aerials around today is Louis Varney’s (SK) G5RV and is a special case doublet. The transmission line is designed to act as a quarter wave transformer on 20m and a “ variable transformer” on the other bands. It also uses a coax to connect to an unbalanced tuner which is very often connected via a 1:1 balun or choke balun.

A special thanks to G3YEU for his assistance in preparing this PDF