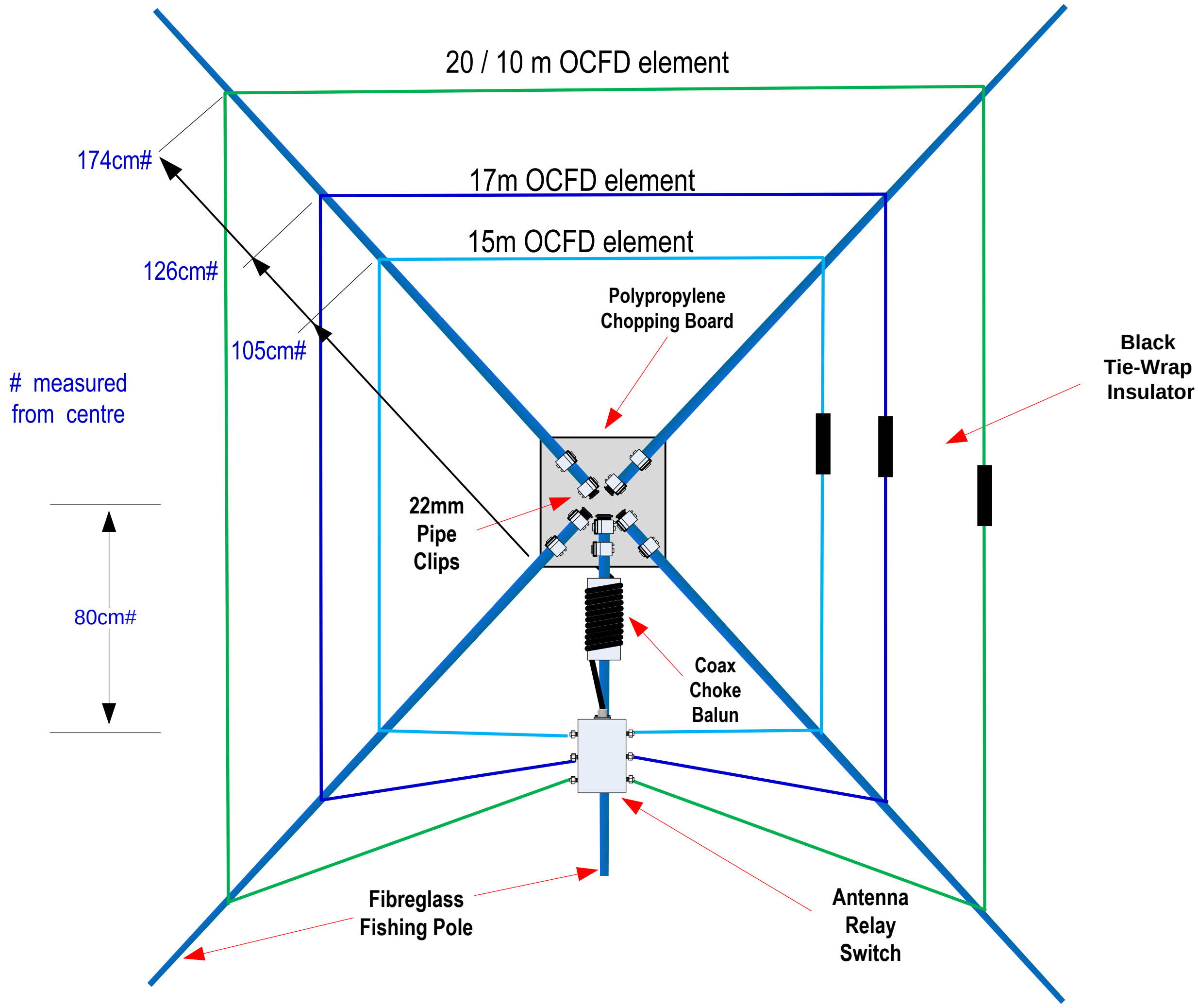
4-BAND COLA ANTENNA (20-17-15-10m) – G8ODE

(Concentric Open Loop Antenna Fed Off-Centre)

This article is dedicated to my friend Bill Stevenson - G4KKI (SK), a fellow RSARS member, who shared my passion for home-brewing and antenna experimentation. We spent many hours discussing different radio topics and compact antenna designs. Shortly before he passed away, we discussed the findings from my study of the open loop off-centre fed antenna and the successful experiments that produced this final design .

Mario G8ODE RSARS1691

See Table 1 for dimensions of the antenna elements



See also “Assembling the COLA and initial tuning”

Not to scale

TABLE 1

COLA Elements	20m		17m		15m	
	short side	long side	short side	long side	short side	long side
	7'4" 2.4m	24'2" 7.37m	5'2" 1.57m	18'5" 5.61m	4'4.5" 1.33m	15'6" 4.72m

G8ODE Design Published 28 May 2014 issue 1.0

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Introduction.

- Deploying a centre fed open loop half-wave dipole in a square shape lowers the impedance to around 8-12ohms. Steve Webb - G3TPW, overcomes this problem by using a 300 ohms folded dipole raising the impedance by a factor of 4. Steve Hunt - G3TXQ, took a different approach and his design uses a 1:4 step up balun transformer to compensate for the low impedance. Another way to increase the feed point impedance of the open loop dipole antenna is to feed it off-centre, but for multiband operation masthead relays are required to switch bands.

How the COLA antenna project was conceived.

- Encouraged by the results of the MMANA-GAL Study of Open Loop Dipole Antenna, also published in the RSARS e-Library, a decision was made to build the antenna as an RSARS project.

The task was split up into four phases.

- i). Designing and building the antenna support
- ii). Designing a masthead relay switch
- iii). Stringing and tuning each wire element
- iv). Designing the remote control box.

Design of the antenna support.

- It was important that costs be kept to a minimum and make use of readily available components

Components List for the antenna support

1. 3 metre fibre glass fishing pole blanks – 5 off
2. Re-cycled thick polypropylene chopping board, (trimmed down to form a square). 12"x12" (30x30cm).
3. 10 off 22mm Wickes™ "locking" plastic pipe clips.
4. 10 off Nuts and bolts , 2 self tapping screws to secure the pipe clips and steel leg to the mast.
5. 6m RG58 coax & 2 off PL259 (for the Balun choke)
6. Choke Former, 25cm grey 50mm diam plastic drain pipe.
7. Wickes™ Round furniture Leg -"Grey" 32mm diaX150mm long).
8. 4 off 6mm bolts & Ny-Lock (locking nuts) to secure foot to the chopping board
9. 30cm length of plastic hose pipe.
10. Swaged aluminium mast sections 4 off 4'0" (1.2m)
11. 4 insulators - 6"x ½" (15cm x 1.2cm) black tie-wraps

Note:-

The same support can be used for either the G3TWP or the G3TXQ 5 -band Cobweb antenna, or for a compact Moxon beam Antenna.

Close up of the assembled 3 element COLA

Antenna Support Details

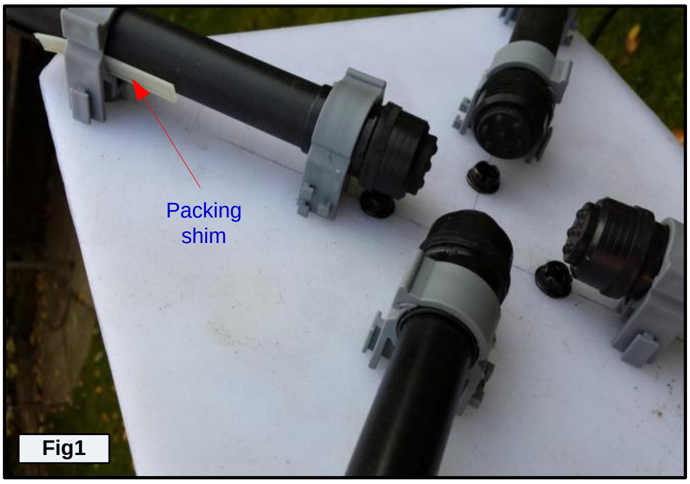

Fig1

- The pencil lines are drawn from the corners of the chopping board to align the position of the clips that secure the fishing poles and the holes for the furniture leg, see Fig2 .
- Fig1 shows the 22mm pipe clips snapped together gripping the nylon collar of the fishing pole end cap.
- The 22mm pipe clips at the board edges require shims made from 30cm of salvaged garden hose to pack the gap caused by the tapering fibreglass tube, so that the tube is gripped snugly and not crushed when the clips are snapped closed.

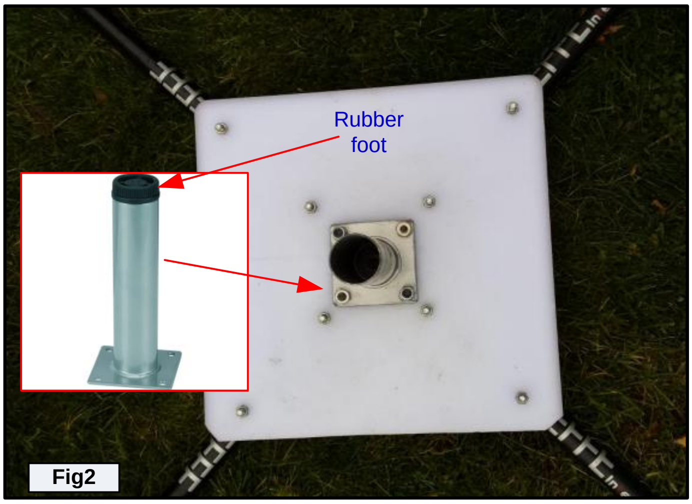

Fig2

- Figure 2 shows the Wickes furniture steel leg secured to the underside of the cut down chopping board.
- The leg has a 32 mm OD diam and matches the aluminium tube mast section.
- The rubber foot is removed and discarded, see Fig3

Fig3

- Fig 3 shows how the furniture leg is secured to the top of the aluminium mast section using a fabricated split sleeve insert.
- The insert is made by cutting a 20cm length from the bottom one of the mast sections. Preferably the one that will be sunk into the ground. Take care not to cut the swaged end off.
- A slit is cut 1 /4" (4mm) wide along the full length of the 20cm off cut using an angle grinder or hacksaw.
- Compress the tube slightly using a bench vice, so that it will fit snugly into the ends of the leg and mast tube.
- Secure the leg, split tube and mast section together using self tapping screws.

Various Chokes tested during COLA evaluation.

Ferrite -Coax Choke

1:1 Current Balun

Fig 4

Fig 5

Installed 1:1 Air Cored Coax Choke & Relay Switch

TABLE 2				
Coax Choke Balun	RG58 Short tail	12" 30cm	RG58 Long tail	21" 53cm
	Drain Pipe Former ID	2" 50mm	32 Turns RG58	

A Common-Mode Current (CMC) choke prevents the coaxial line from becoming a part of the antenna system and radiate RF energy when connected to the unbalanced output of a modern transceiver. The loss in power can be quite significant and the radiation characteristics of the antenna compromised. A coaxial choke or 1:1 current balun will prevent this by behaving as a high-impedance to the common mode currents to choke them off. For half wave dipoles, the design impedance of “chokes” needs to be about 1K ohms at the lowest operating frequency. The various chokes evaluated are shown in Fig4.

However, asymmetrical antennas such as the Off-Centre-Fed Dipole (OCFD - split 1/3+2/3 or 1/6 +5/6) or, in this case, the COLA, have additional current imbalance and require choking of at least 2k ohms. The choke should be located at the mast head end of the feed line.

During the evaluation of the COLA , the choke that produced the best COLA SWR results was the ugly balun or 1:1 Air -Cored Coax Choke to give it its proper name. The final design shown in Table 2, comprises 32 turns of RG58 wound tightly on a 50mm diam grey plastic drainpipe with two tails terminated with PL259's, see Fig 5.

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(**C**oncentric **O**pen **L**oop **A**ntenna Fed Off-Centre)

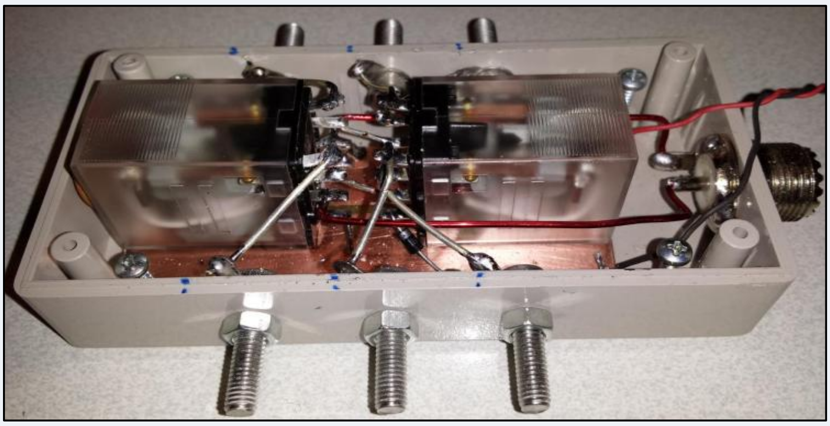

Fig 6 **Assembled Mast Head Antenna Relay Switch**

5A/12Vdc 4PDT Miniature Relay

Constructing the Mast Head Antenna Relay Switch

- The Mast Head Antenna Relay Switch Fig 6, is constructed in a grey plastic PVC case. The single sided copper laminate has a wide groove cut down the centre, creating two wide copper tracks and acts as a base board for the two relays that are stuck to it using double sided tape. The PCB is sprayed with clear lacquer to protect against damp, but this evaporates locally during soldering. The board was not re-sprayed after soldering. The two tracks are decoupled from RF using two 0.01uf 500v ceramic capacitors.

- One connection of each relay's coil is soldered directly to one track. The second track is soldered to relay RLA's second coil connection, while the RLB relay second coil connection is wired to the second track via a 1N4001 diode. The diode makes the RLB relay negative voltage sensing. See the circuit diagram at Fig 8.

- The majority of the circuit is wired using hard drawn silver plated copper wire. A useful source is a hobby shop that sells DIY jewellery kits. The silver plated wire is soldered directly to the relay contacts, thus avoiding possible damp problems on sockets that might otherwise arc when RF is applied. The two feeds from the SO239 use thicker brown coloured 2mm enamelled wire.

- Six stainless steel 5mm bolts with solder tags are provided for connections to the three open loop dipoles.

Note: During Bench Testing, the power was applied via temporary red & black wires without the RF choke & capacitors fitted.

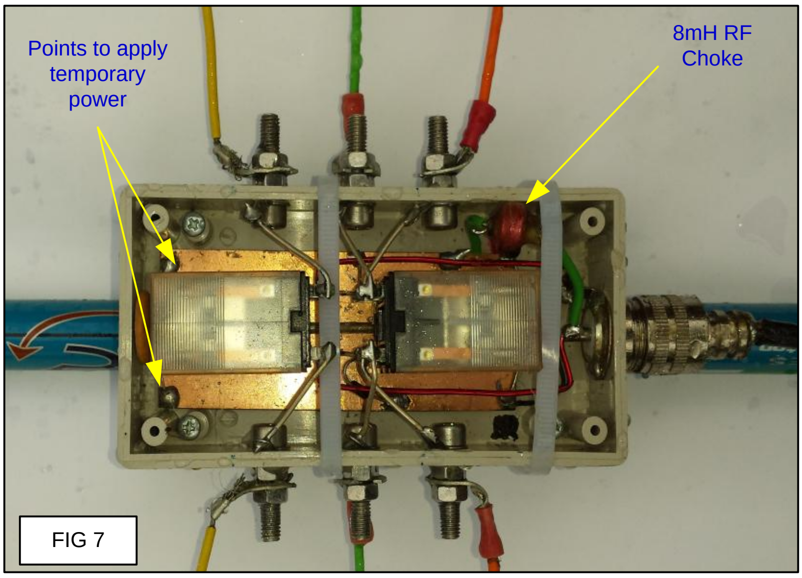

FIG 7

Temporarily securing the relay box to the fishing pole

- FIG 7 shows how the Relay Switch box is temporarily secured with two white tie-wraps on to the shorter 5th fibreglass fishing pole.

- During antenna element tuning, power to the relays can be provided using twin speaker wire from a 12v car battery at the base of the mast. The polarity is changed by swapping the crocodile clips on the battery terminals.

- The RF Choke is required when power is supplied via the coax feeder from the shack.

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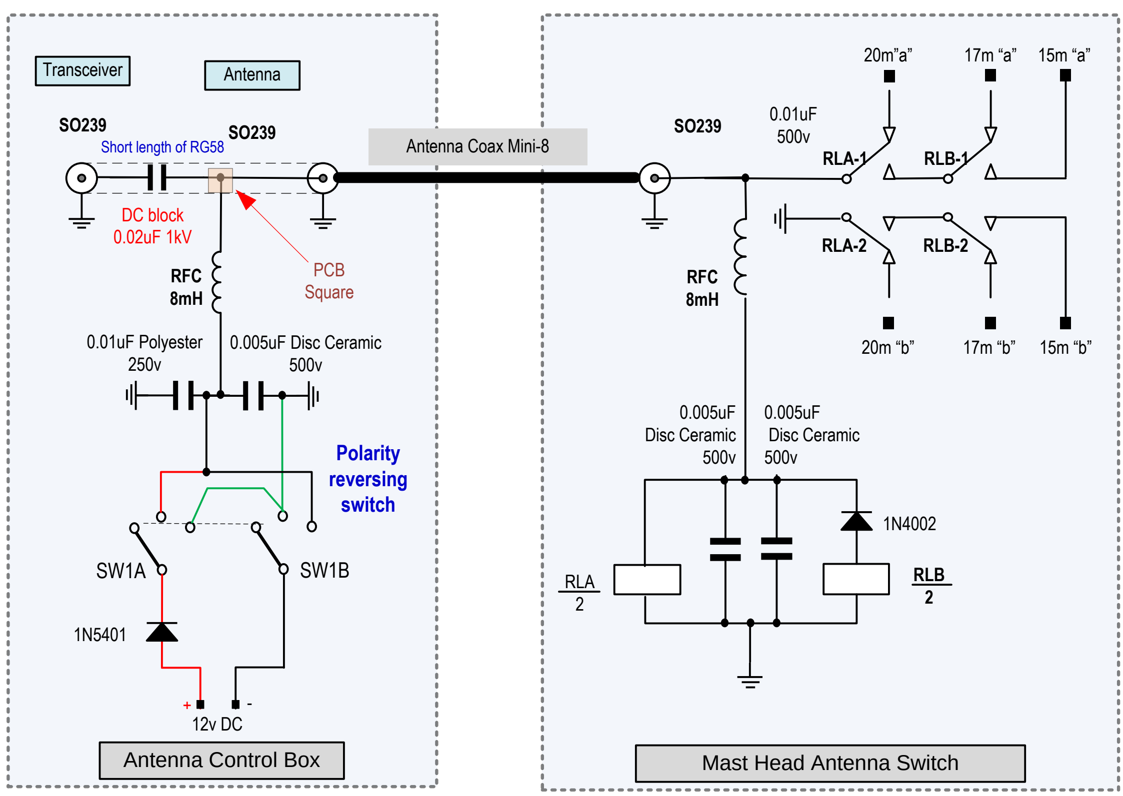
The Open Loop OCFD Antenna Controller & Mast Head Relay Circuits



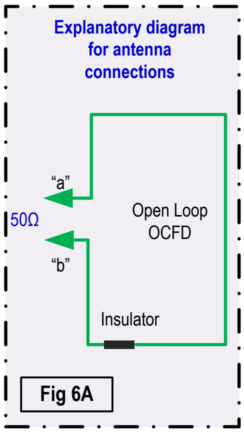


Fig 6A

Note RLA & RLB are 12volt DPCO contacts rated at 5A

Fig 8

- The controller in Fig 9 uses a 2 pole three position switch.
- Two LEDs are provided as power indicators for the 17m & 15m positions.
- A long piece of single sided copper laminate fits tightly between the two corner pillars on one side is used to provide a 0v connection for the decoupling capacitors.
- A 1N5401 - 3A power diode ensures that the correct polarity is fed to the change over switch to make certain the correct antennas are selected by the control switch.
- The 8mH RF Choke, which decouples the DC power supply from the transmitter RF, can be seen in Fig9 . The RF choke's reactance is >700K ohms @14 MHz
- The prototype's DC blocking capacitor uses three ceramic low tolerance 0.01uF 1000v capacitors wired in parallel, because a high quality 0.02uF was not available. This capacitor's reactance is < 0.5 Ohms @ 14 MHz.
- A small PCB square provides a junction point for the DC blocking capacitor, RF choke and one end of the Mil Spec RG58.

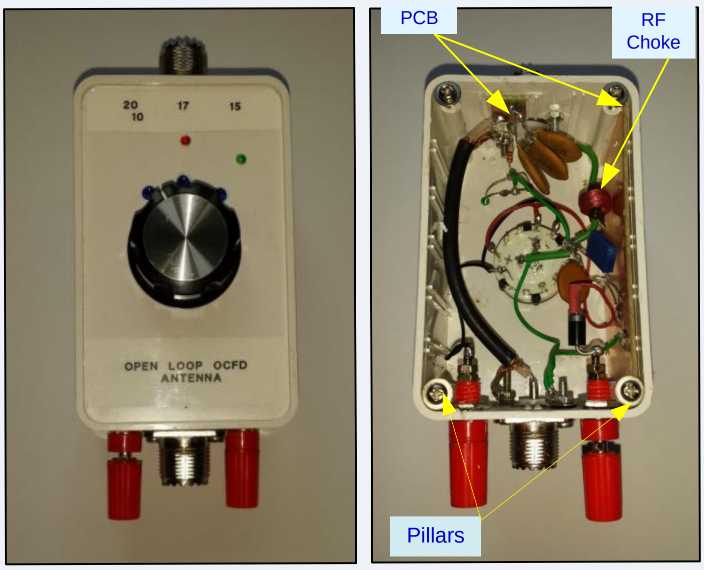


Fig 9 **The OL-OFCD Controller**

4-BAND COLA ANTENNA (20-17-15-10m) – G8ODE

(**C**oncentric **O**pen **L**oop **A**ntenna Fed Off-Centre)

Assembling the COLA and initial tuning

Cut the dipole wires slightly longer than the measurements in Table 1 on Page 1. Assemble the dipole to the dimension shown, letting any excess hang under the heavy duty tie wraps as shown in Fig 11 below.

- Secure each dipole onto the fishing poles, with UV resistant tie wraps. Ensure each corner is approximately an equal distance from the mast - See page 1. Use string attached to mast to help mark the wire fixing points on the poles.
- Attach the 15m element first. Secure the feed point ends on relay box with "M5" bolts
- Erect the antenna at the proposed operating height, then using minimum power determine the dipole's resonant frequency. This will be below 21MHz, trim the tails by 1⁄2" (1cm) at a time until it is resonant at 21MHz.
- Note the SWR value and trim the short wire by another ½" (1cm). This is see what difference this makes to the SWR. N.B. To increase the impedance of the feed point, the shorter wire needs to be trimmed, but this increases the resonant frequency, therefore it will be necessary to add the off-cut to the longer wire to compensate.
- Conversely adding wire to the longer end will lower the impedance and also lower the frequency, therefore it is necessary to trim the shorter wire by the same amount. Fig 11 clearly shows the 15m element required two minor adjustment to obtain the optimum SWR .
- This process is repeated for the 17m and 20m elements and will require using the fine-tuning process described below.
- However, since there is a slight interaction between the concentric elements, the tuning needs to be rechecked , starting with the 15m element, then 17m and finally the 20m element to achieve near unity SWRs.

Fine Tuning the Off Centre Fed Open Loop Dipoles.

- The RSARS MMANA-GAL Study Of The Open Loop Dipole shows that the impedance changes fairly sharply away from the centre of the antenna i.e. a change of 2.5cm makes a significant shift in frequency and the SWR , as the can be seen in Fig 10.
- By careful trimming SWR values on all the three bands of <1.2:1 is achievable.
- The 10m band SWR is dependant on the 20m element's tuning.
- The fine tuning is achieved by altering the length of short tails hanging from heavy duty 6" (15cm) long tie wrap insulator. It's useful to use electricians insulated "choc block" connectors to add lengths of single core 2.5 mm wire salvaged from mains grey power cable "twin & earth.
- N.B. The insulator length of 6" (15cm) was chosen so that any short tail wires have a very weak capacitive coupling, i.e. in that they do not form an open line tuning stub and affect the tuning of the COLA.

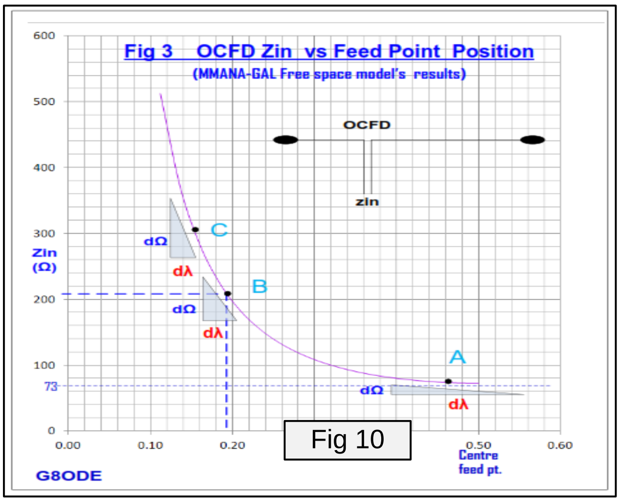


Fig 10

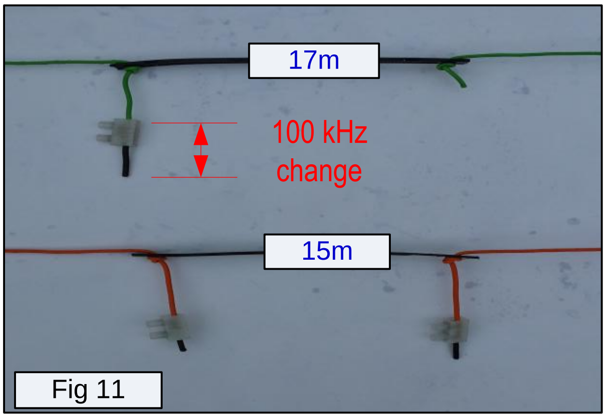


Fig 11

4-BAND COLA ANTENNA (20-17-15-10m) – G8ODE

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PERFORMANCE EXPECTATIONS FROM THE RSARS STUDY OF THE OPEN LOOP ANTENNA

- The MMANA-GAL antenna model results in Fig 12 shown below are an extract of a RSARS Study of the Open Loop OCFD. These indicate that very good SWR values are possible at the modest height of 5m.
- However, Fig 13 indicates that elevating a "tuned " antenna by another 1.5m, makes the situation slightly worse.

The OPEN LOOP OCFD Results with the antennas at 5m height above average ground

Add height 5.00 m
Material Cu wire
NO FATAL ERROR(S)
1.59 sec

Fig 12

No.	F (MHz)	R (Ohm)	jX (Ohm)	SWR 50	Gh dBd	Ga dBi	F/B dB	Elev.	Ground	Add H.	Polar.
3	14.15	50.14	2.384	1.05	---	3.94	-0.11	81.0	Real	5.0	hori.
2	18.12	49.99	2.218	1.05	---	3.69	-1.22	48.0	Real	5.0	hori.
1	21.2	49.46	-3.269	1.07	---	4.25	-1.78	39.0	Real	5.0	hori.

The OPEN LOOP OCFD Results with the antennas at 6.5m height above average ground

Add height 6.5 m
Material Cu wire
NO FATAL ERROR(S)
1.48 sec

Fig 13

No.	F (MHz)	R (Ohm)	jX (Ohm)	SWR 50	Gh dBd	Ga dBi	F/B dB	Elev.	Ground	Add H.	Polar.
3	14.15	59.27	-5.75	1.22	---	4.08	-1.18	48.0	Real	6.5	hori.
2	18.12	50.73	-6.31	1.13	---	4.2	-1.55	35.0	Real	6.5	hori.
1	21.2	45.0	-10.28	1.27	---	5.14	-1.86	30.0	Real	6.5	hori.

- The MMANA-GAL "View" function "Figs 14-16 show that the majority of the far field exists in the wire, to which the source is connected. Moreover, the currents shown in each Fig indicate that there is little interaction with the other two COLA elements. The wire with the source is the dominant radiating element.
- However, models are not perfect and practical tests are necessary to evaluate an antenna properly.

20m Element currents

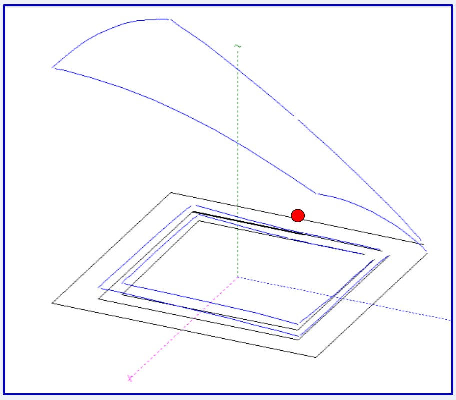

Fig 14

○ =Source

17m Element currents

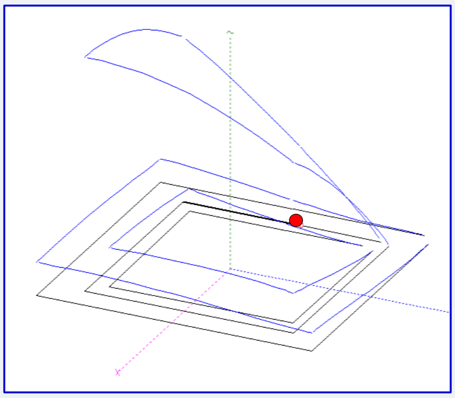

Fig 15

15m Element currents

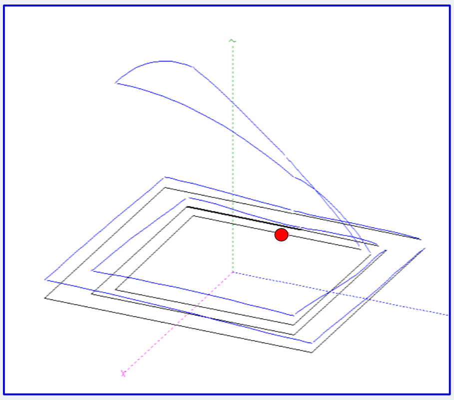

Fig16

4-BAND COLA ANTENNA (20-17-15-10m) – G8ODE

(Concentric Open Loop Antenna Fed Off-Centre)

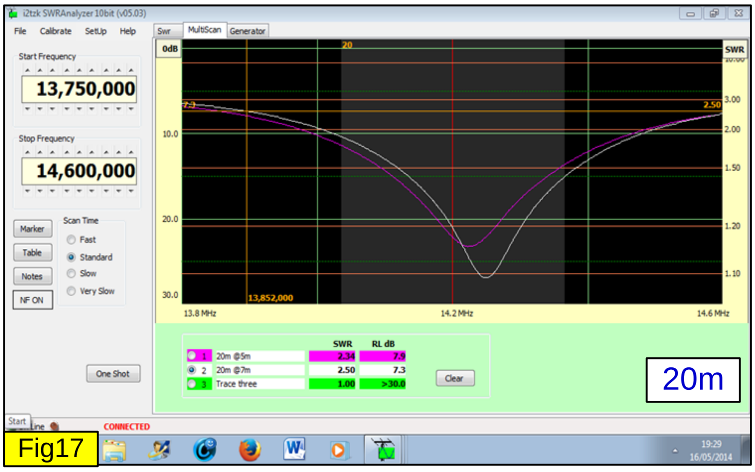

Fig17

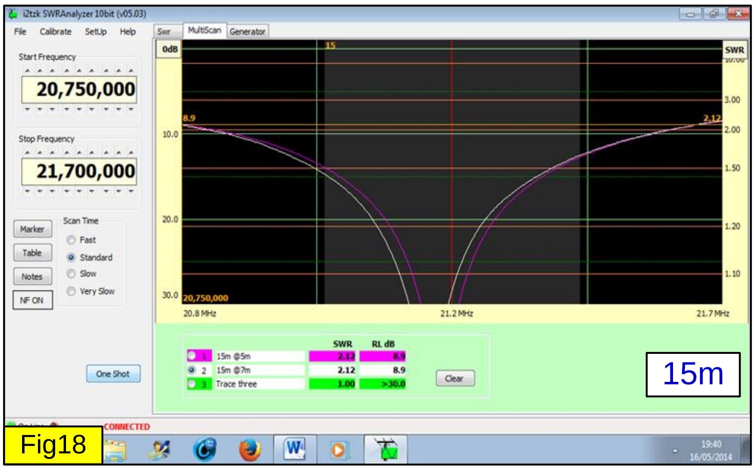

Fig18

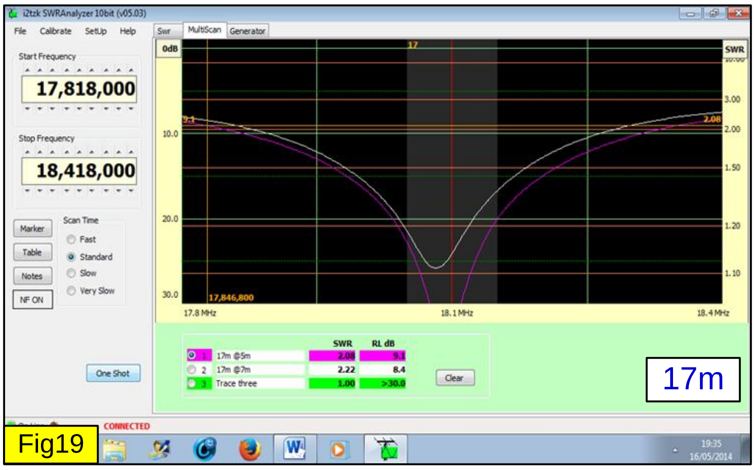

Fig19

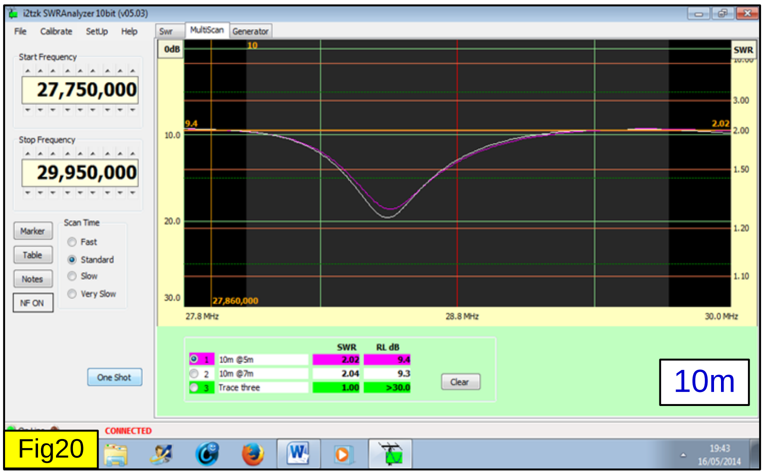

Fig20

COMPARING THE COLA OPERATING AT TWO HEIGHTS WITH A FD3 (40-20&10m)

Results 16th May 2014; 1845hrs BST

Sunny all day, av. temp 22C, ground fairly dry, with little wind, test area on a 7m x 7m lawn.

- The COLA tests employed self-supporting 1.5" (40mm) diam aluminium mast sections. A screw into the ground washing carousel adapter supported the base of the mast.
- The two test heights of 5m and 7m were chosen because the mast can be left self-supporting even in moderate winds i.e. no need for any steadying guys.
- Figs 17-20 show the superimposed traces for the two heights. The red trace is for the COLA at a height of 5M and the white trace for 7m.
- During each test the COLA was also compared with an FD3 OCFD (40-20&10M) erected in a straight line at approximately 7-8m height. For the comparisons on the 17m and 15m the FD3 required the aid of a tuner.

THE RESULTS

- The results for the 20m,15m and 10m bands show an improvement in the SWR at 7m, but on 17m there is slight increase in SWR. However, the results also indicate that the COLA can operate efficiently without the aid of tuner at both heights since the SWR was < 1.22 : 1 or better.
- Several DX QSOs on each band proved the effectiveness of the antenna at both heights. This also proved the antennas omni-directional capability - See Table 2.
- This final check demonstrated that the COLA performed very similarly to the FD3, with S-meter readings differing by no more than one S-point at worse.

4-BAND COLA ANTENNA (20-17-15-10m) – G8ODE

(**C**oncentric **O**pen **L**oop **A**ntenna Fed Off-Centre)

TABLE 3 – SUMMARY OF COLA ANTENNA TEST RESULTS

DATE	MHz	Station heard	Report	COLA	CONDITIONS	Time		DATE	MHz	Station heard	Report	COLA	CONDITIONS	Time
05-Apr-14	14.203	IK2YYL	5-9	5-9		17:40:00		10-May-14	14.2627	EA3BDE	5-9+20	5-9		10:49:00
	14.255	OM3RM	5-9	5-5		18:09:00								
	18.131	LZ180NS	5-9	5-9		18:25:00		13-May-14	14.223	YO6PMX	5-9+20	5-8		22:33:00
	18.135	W8UN	5-9	4-3	QRM	18:30:00								
	21.243	UG3G	5-9	5-7				17-May-14	14.244	DK3PZ/P	5-7	5-7		16:24:00
18-Apr-14	21.241	UR2LX	5-9	5-8		17:30:00		21-May-14	21.3105	US5UCZ	5-9+10	5-9+10		18:30:00
	14.247	EA5IDQ	5-9	5-7		20:10:00								
								01-Jun-14	18.137	IZ5EBL	5-9	5-9		15:25:00
22-Apr-14	14.209	SP3WP	5-7	5-8		10:17:00			21.285	IZ1JLG	5-9+10	5-9		18:00:00
	14.305	DL1LLL	5-9	4-5/5-5		20:35:00		04-Jun-14	14.276	9K2WA	5-9	5-7		23:30:00
24-Apr-14	14.195	EA7/G4XYT	5-9	5-8	QSB	21:55:00		07-Jun-14	21.229	EA8AOC	5-9	5-9		18:12:00
		IT9BDM	5-9	5-8					21.297	E74A	5-9	5-9	DEEP QSB	18:20:00
	18.145	R2LY	5/9+10	5-9		16:45:00								
								08-Jun-14	14.215	E79D	5-9	5-9		11:18:00
25-Apr-14	14.3095	W1AW/2	5-9	5-9		22:41:00			28.450	DM4DX	4-3	5-4	DEEP QSB	12:43:00
	14.242	R7DX	5-9+20	5-9		00:40:00			28.450	DH3RD	5-9+20	5-9		13:02:00
27-Apr-14	18.121	W0KYD	4-1	5-1	POOR	22:10:00		10-Jun-14	14.225	YA3AR	5-9	5-9		22:18:00
									14.235	9A2DQ	5-9	5-9		22:28:00
28-Apr-14	18.133	W1AW/P1	5-8	5-3		12:29:00			14.2593	UT4EO	5-9	5-5		22:35:00
	21.275	7X2BDX	5-9	5-9		17:10:00			14.210	CR2WRTC	5-9	5-9		22:48:00
	21.228	UN7JAV	5-9	5-8		18:30:00			14.222	K1QS	5-9	5-7		22:55:00
	14.210	W1AW/2	5-9	5-7		21:28:00								
	14.240	LZ1QI	5-9+10	5-9+20		21:43:00		11-Jun-14	14.187	EU6AF	5-9+20	5-9		23:04:00
	14.276	W1AW/P1	5-9	5-9		22:40:00								
								12-Jun-14	14.260	R7AL/P	5-9	5-9		22:03:00
02-May-14	21.270	YO3IRZ	5-9	5-8		07:35:00								
	18.150	IZ01WC	5-9+20	5-9		18:05:00		13-Jun-14	18.1423	RA1ANY	5-9	5-8		22:00:00
	18.135	ED5BY	5-9+10	5-9		18:29:00								
								17-Jun-14	18.127	LZ1816PAA	5-9+10	5-9		20:37:00
06-May-14	18.130	LZ155WNS	5-9	5-9		16:58:00			21.292	IK4MEE	5-9	5-5 -5-8	QSB	20:40:00
	14.300	OE6MBG/M	5-9+10	5-9		17:03:00			21286	AO01KR	5-9+10	5-9		18:15:00
	28.520	PY7ZZ	5-9	5-6		18:32:00								
								22-Jun-14	14.212	IK0PHY	5-9+10	5-9@10W	QRP TEST	15:27:00
									21.323	DL9NEF	5-9+20	5-7 5-9+10	QSB	15:40:00
								25_JUN-14	14.153	VK3MO	5-9	5-8		22:45:00

NOTE.

THE BERKSHIRE TEST SITE:

The QTH is in an urban location is surrounded by trees and 2 storey houses. The east facing rear garden is approximately 11m x 20m. The QTH has houses immediately to the north and south each with 10-13m tall trees in their respective gardens. To the east is the adjoining garden of a dormer bungalow some 30m away. To the front of the bungalow, facing the main road is a row of 20m tall California conifers. The COLA antenna was deployed at 5m height on a self-supporting aluminium mast above a garden lawn.

During the test period there have been some extremes in conditions, from very heavy rain falls that caused the water table to rise by 1.5m and detuned the COLA slightly, and also some periods of increased solar activity that resulted in enhanced conditions on 10m.

My special thanks go to Barry G3YEU for helping me publish this article