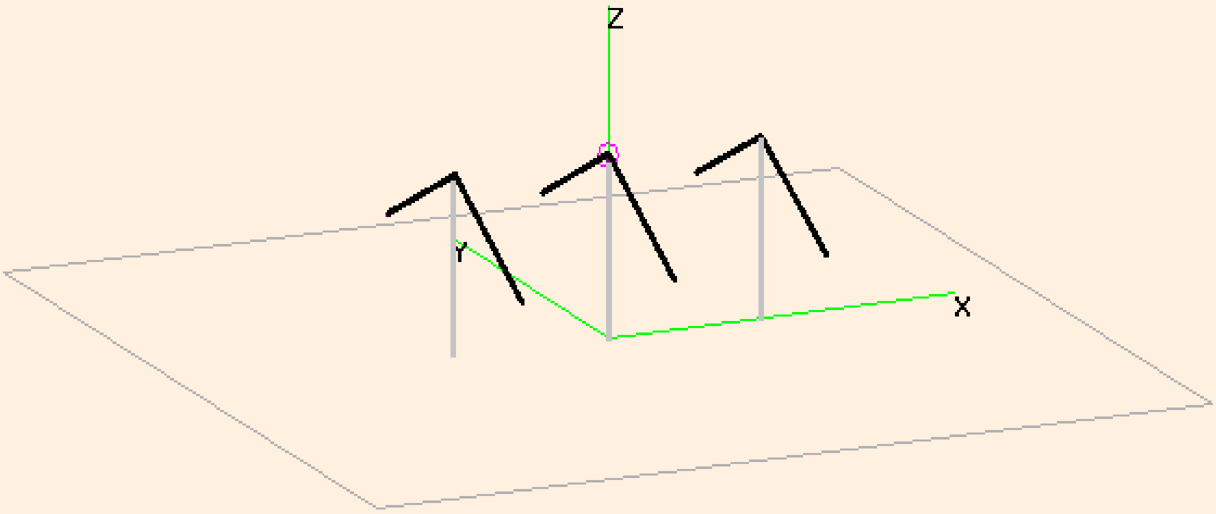
Three elements Inverted V wirebeam



Antenna for 40 meters band

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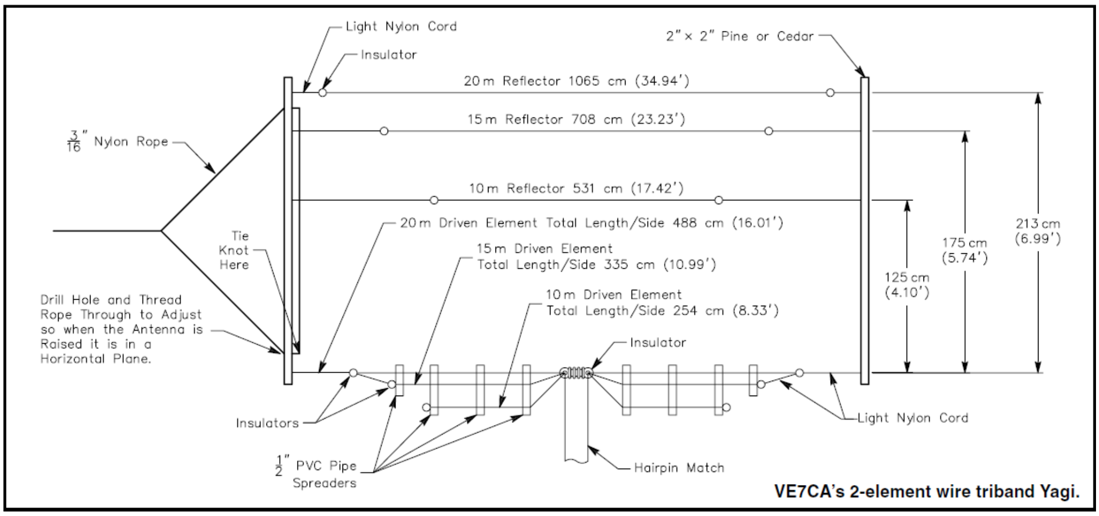
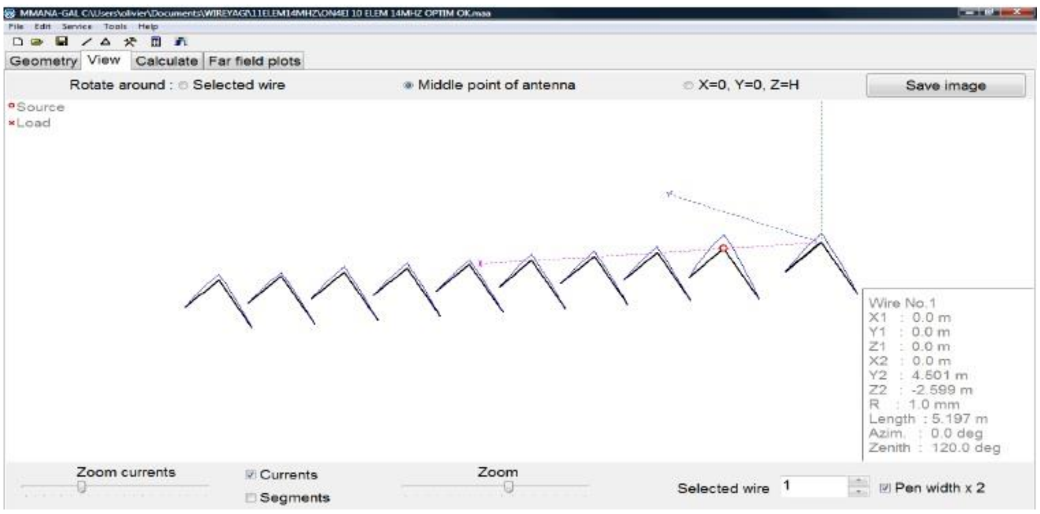
Introduction

In July 2008, I started my first participation to an HF contest with EI/ON4EI. I used homemade low height dipoles for the low bands and a two elements 3 bands wire Yagi antenna designed by VE7CA (Reference 1). I was surprised how this antenna performed well and I succeed to score 39 world on 602 participants during the IARU HF 2008.



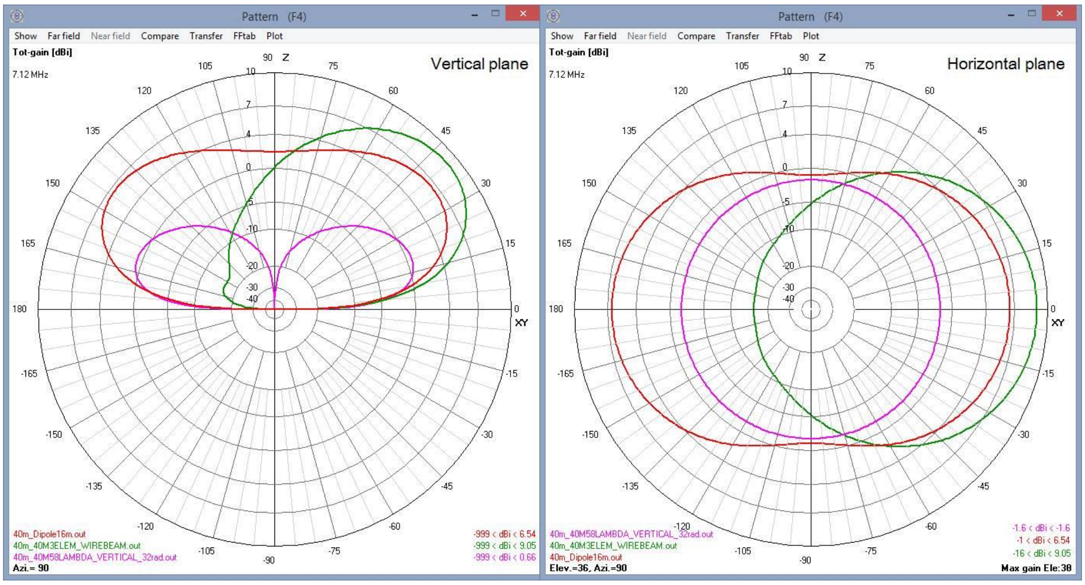
VE7CA's 2-element wire triband Yagi.

One month later, I decided to improve my antenna park and started to build a long reversible Inverted V wire beam on 20-meter band. Being located in Ireland for the holidays (my wife is Irish), I wanted to take advantage of the space available in the countryside and enjoy the strategic position of Ireland during contest activities. From Ireland, if you work East (Europe/Middle East/ Asia) and West (US/Caribbean) directions only, you have reach almost 80% of the contest traffic.
I designed my 20m 10 elements wire beam based on an existing system made by W6YDG. I decided to optimize it using Mmana-gal antenna software and make the antenna east west manually reversible. (Reference 2)

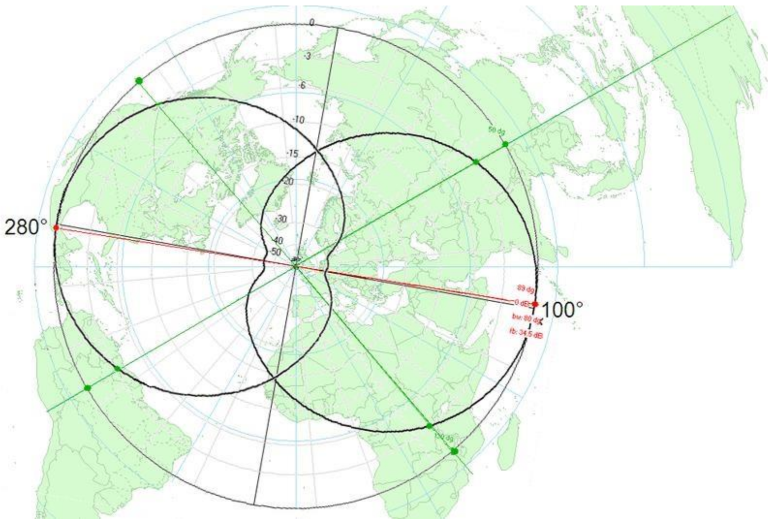


Later, in July 2011, during the IOTA contest, I decided to rebuild the 20m 10 elements antenna based on a new design with the help of 4NEC2 software and using lightweight wires and support ropes. During this contest, I also used a 40m inverted Vee dipole, which was very efficient for contacting UK stations during the day and collecting 15 points/QSO. I scored first world station in Island low power all band category. I told myself that I could improve this 40-meter Inverted V dipole system by adding a reflector and a director; it was the beginning of the 40m 3 elements inverted V wire beam story.

Before the three elements wire beam, I used a 5/8λ top loaded vertical on 18m fiberglass mast with 32 radials 20m long. Recently, I also tested a horizontal rotatable dipole at 16m. You will find below the radiation pattern comparison for the three antennas. Fortunately, I have been able to use the three antennas at the same time and compare them. I can confirm that the computed diagram reflects totally the field experience.



Antenna pattern comparison: Inverted V 3 element at 11m (green), Horizontal dipole at 16m (red), 5/8λ top loaded on 18m high fiberglass mast +32 radials 20m long (pink).



Ireland is very well located as you are able to reach 75% of the radio traffic with an opposite antenna direction, therefore I decided to make a bi-directional antenna design.

Antenna Design

Design history

I made three different designs:
Design 1: the "Basic" one with a small piece of wire that you connect or disconnect manually at the end of the parasitic elements to switch direction.
Design 2: the "coil one", with coils and relays at the top of the parasitic elements to switch direction remotely. (See more in annexe)
Design 3: the "U shape one" with U line and relays at the top of the parasitic elements to switch direction remotely. (See more in annexe)

In this document, I will only detail the "Basic" design (1), its building as it has been very well experienced in the field, and my contest results confirm the excellence of the antenna.
Design 2 has been tested but the weight of the coil and/or relays were too heavy for the fibber glass masts and under heavy wind risked to broken the masts.
Design 3 has not been tested in the fields. Building designs 2 and 3 follows the same approach as the "Basic" one but they need stronger masts and can be installed at a higher height, as you do not need to access at the end of the parasitic elements to manually connect or disconnect the piece of wire.

Conclusion I still need to go outside in order to switch antenna direction. It takes me 3 minutes to do it, and it is sometimes hard when there is a heavy rain during the contest but fortunately, I only need to switch antenna direction at night to North America and I have the full day after to change it to Europe direction before the evening.

Design approach

-Bidirectional antenna: the distance between driven element (dipole) and parasitic elements (reflector /director) must be identical.
-Use of fibber glass mast as support of the parasitic elements.
-One man installation and in less than 3 hours
-Antenna height is limited to 11m. This allows having access at the end of the elements to dis/connect the piece of wire. At higher heights, you will need ladder to change direction.

Antenna model parameters

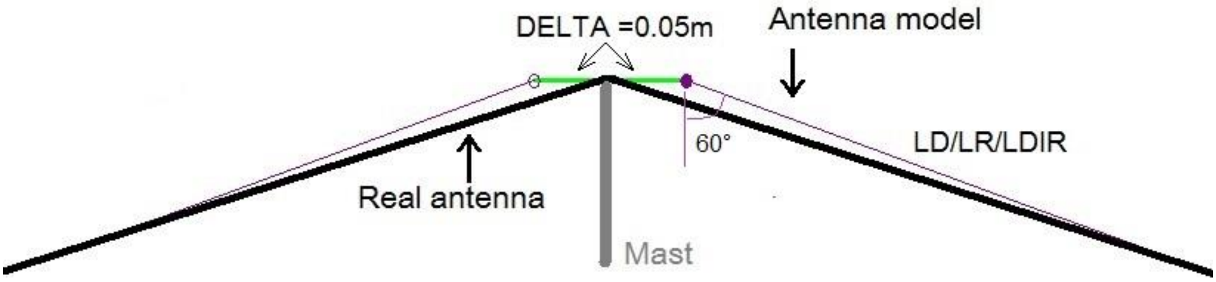
I used 4NEC2 software to model and simulate the antenna; it is not my intention here to teach the use of this software as well as reminding basic trigonometry concept. One main advantage of 4NEC2 versus Mmana-gal software is the use of formulas that allow you to optimise easily the antenna parameters according to some defined objectives (higher gain, higher front to back, lower SWR...).

Symbols | Geometry | Source/Load | Freq./Ground | Others | Comment

Symbols

Nr	Symbols and equations	comment
1	LD=10.11306	driven element : length
2	Zapex=11	height of inverted V
3	ZD=Zapex-cos(60)*LD	driven element : lower side height
4	YD=sin(60)*LD	driven element : lower side distance from mast
5	R=0.55e-3	Wire radius : Wireman CQ 532 (AWG 18)
6	LR=10.48264	reflector element : length
7	ZR=Zapex-cos(60)*LR	reflector element : lower side height
8	YR=sin(60)*LR	reflector element : lower side distance from mast
9	DistR=8.56	reflector element : distance from the driven element
10	LDIR=9.919715	director element : length
11	YDIR=sin(60)*LDIR	director element : lower side distance from mast
12	ZDIR=Zapex-cos(60)*LDIR	director element : lower side height
13	DistDIR=DistR	distance reflector and director to driven element are equal
14	Lairpin=0.836557	Hairpin match : length
15	Zairpin=Zapex-Lairpin	Hairpin match : lower side height
16	SPACE=0.1	horizontal part at top of mast (modeling)
17	DELTA=SPACE/2	half part (modeling)
18	freq=7.14	design frequency

One additional remark in the parameter definition table concerns lines 16 and 17 where I created a 10 cm horizontal segment at the apex of each element for software modelling reasons in order to be able to install a generator to compute the resonance frequency of the parasitic elements; in reality, it is not horizontal. See the difference below:



Antenna model geometry

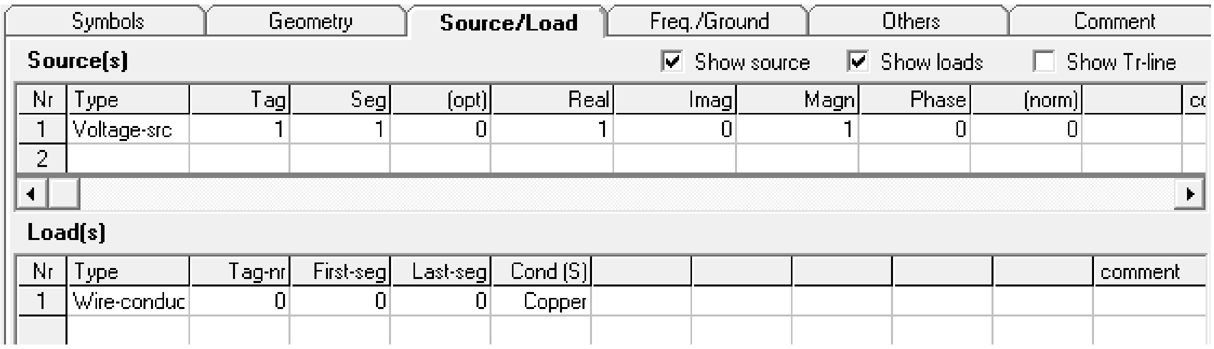
Symbols | Geometry | Source/Load | Freq./Ground | Others | Comment

Geometry (Scaling=Meters) ☐ Use wire tapering

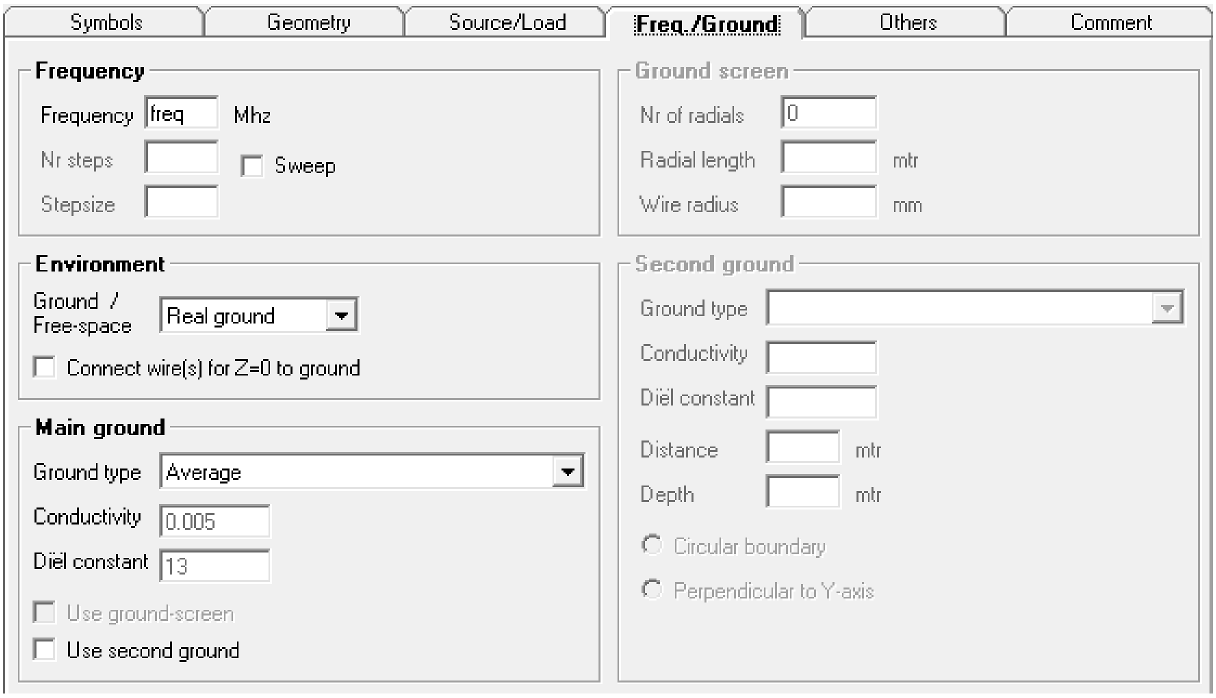
Nr	Type	Tag	Segs	X1	Y1	Z1	X2	Y2	Z2	Radius
1	Wire	1	1	0	DELTA	Zapex	0	-DELTA	Zapex	R
2	Wire	2	40	0	DELTA	Zapex	0	YD	ZD	R
3	Wire	3	40	0	-DELTA	Zapex	0	-YD	ZD	R
4	Wire	4	1	-DistR	DELTA	Zapex	-DistR	-DELTA	Zapex	R
5	Wire	5	40	-DistR	DELTA	Zapex	-DistR	YR	ZR	R
6	Wire	6	40	-DistR	-DELTA	Zapex	-DistR	-YR	ZR	R
7	Wire	7	1	DistDIR	DELTA	Zapex	DistDIR	-DELTA	Zapex	R
8	Wire	8	40	DistDIR	DELTA	Zapex	DistDIR	YDIR	ZDIR	R
9	Wire	9	40	DistDIR	-DELTA	Zapex	DistDIR	-YDIR	ZDIR	R
10	Wire	10	3	0	DELTA	Zapex	0	DELTA	Zairpin	R
11	Wire	11	3	0	-DELTA	Zapex	0	-DELTA	Zairpin	R
12	Wire	12	1	0	-DELTA	Zairpin	0	DELTA	Zairpin	R

In the geometry I initially defined two parameters for the distance between the driven elements and respectively the reflector (DistR) and the director (DistDIR), but they are settled DistR=DistDIR.

Antenna sources definition



Antenna design frequency and ground definition



I choose Freq= 7.14 MHz to be in the middle of the SSB contest band.

Building the antenna

Main elements used to build the antenna:

1/The parasitic elements support mast is a 12m fibber glass mast where the last element has been removed as it is too thin and it allow to access to the end of the elements without a ladder.

Spiderbeam telescopic fiberglass pole	
Fully extracted length (height)	12m (40ft)
Transportation length	1.18m (3ft 10")
Weight	3.3kg (7lbs)
Bottom diameter	55mm (2 1/6")
Top diameter	8mm (1/3")
Wall thickness	1.4mm - 2mm (1/18" - 1/12")
Number of segments	12
Pole material	black fiberglass, UV protected specially reinforced multilayer winding

2/The antenna wire is Wireman CQ 532 (AWG 18)

3/The driven element support mast is 10 m high aluminium telescopic with 2 meters of plastic/PVC tube at the end. Height is 11m. It can also be a fiberglass mast with a bigger diameter than the parasitic support.

10m high aluminium telescopic push-up mast	
fully extracted length (height)	10m (33ft)
transportation length	1.35m (4ft 5")
weight	9kg (20 lbs)
bottom diameter	70mm (2 3/4")
top diameter	30mm (1 1/6")
wall thickness	2mm (1/12")
number of segments	9
mast material	high quality anodized aluminium strong interlock clamps made from stainless steel

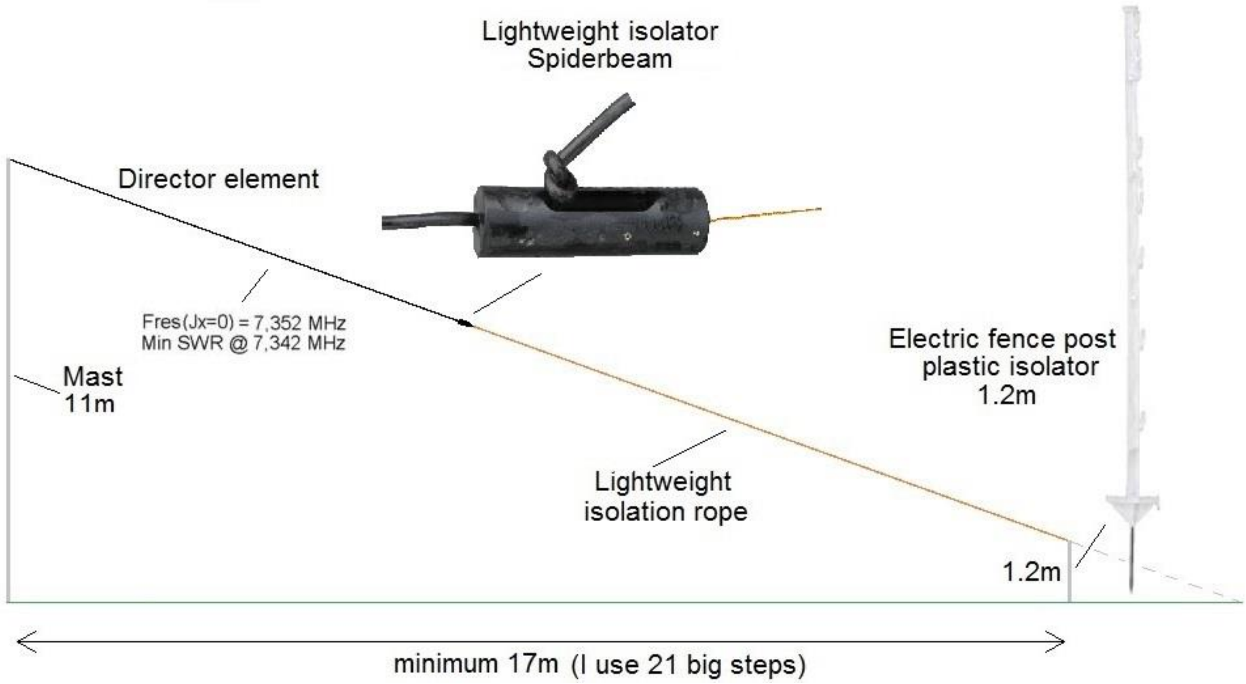
How to tune the parasitic elements?

1/Take 2 times around 10.1m of CQ 532 wire (it can also be another wire, it does not matter) and solder two cable lugs.

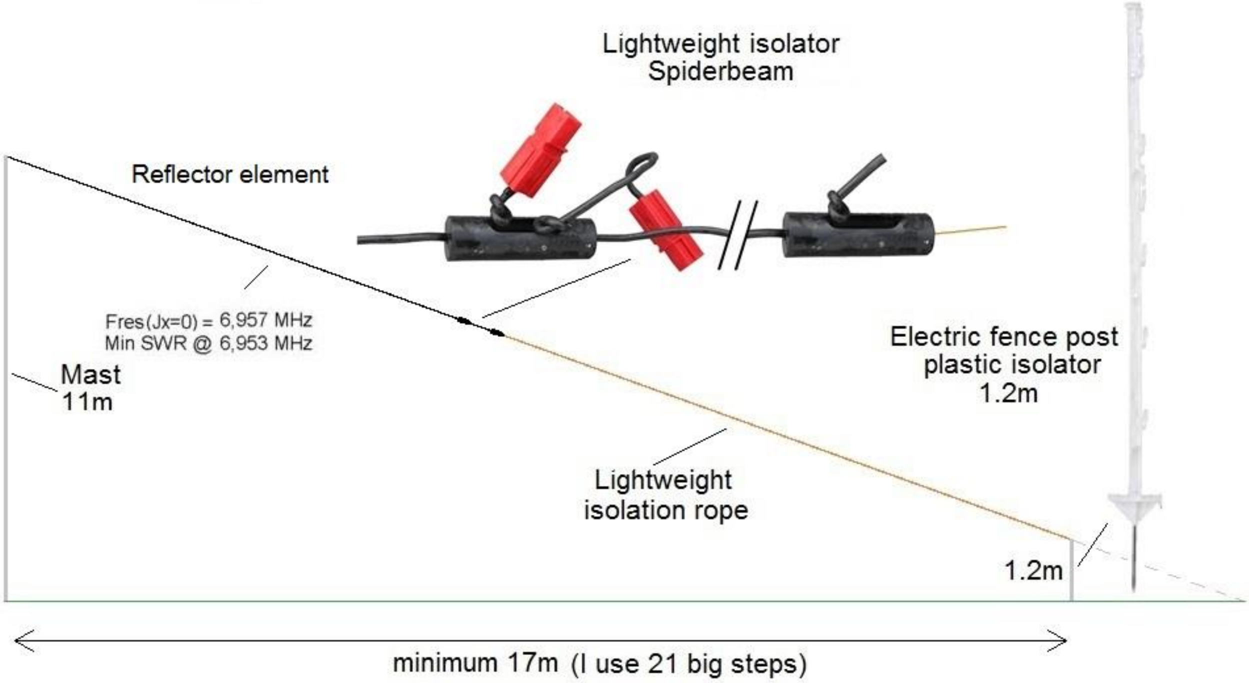
2/ Connect the lugs to a balun or adaptor test plug.

3/ Install the balun raise one fibber glass mast at 11m (no other mast) and deploy the inverted v shape with the wire fixed to an isolator and left a few cm to install later a connector/banana plug.…

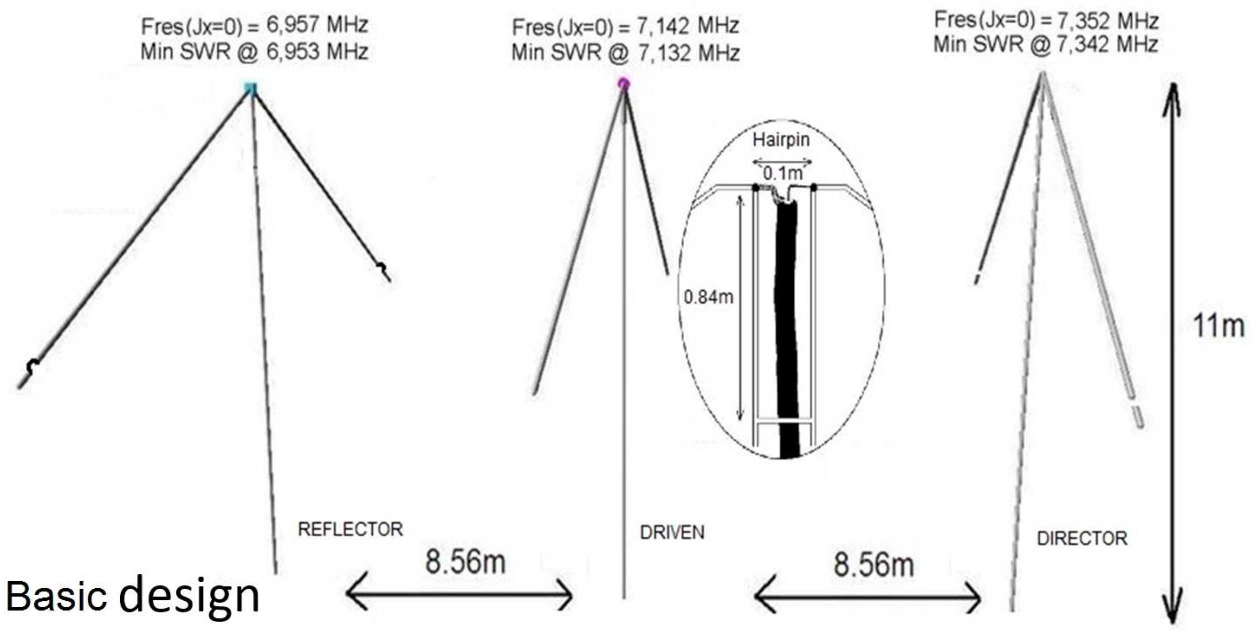
4/ Cut the end of the 2 Inverted cables (dipole at this stage) until you have the antenna resonating at 7,352 MHz (Jx=0) or a minimum of SWR at 7,342 MHz. When this is done, reproduce exactly 2 wires with equivalent length, lug and isolator. (The illustration below shows only the half part of the system). Do not forget to let 3 to 4 cm wire length after the isolator.



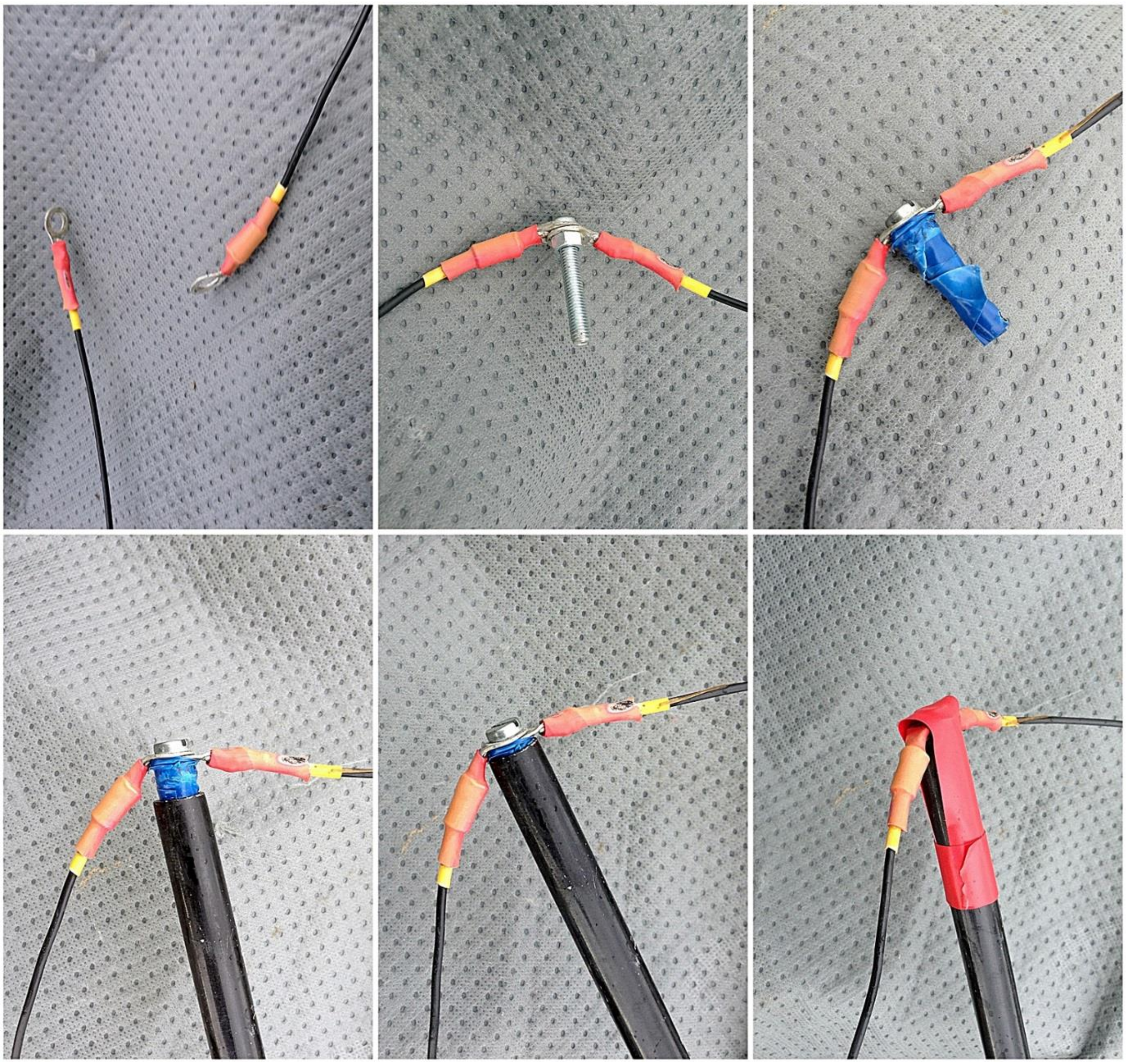
4/ Add at the wire end a connector/banana plug (in my case, I used Powerpole connectors), remove wire length if necessary in order to compensate the length of the connector.
Replace the isolation rope from the isolator with a piece of CQ 532 wire, add another connector and isolator. The distance between the 2 isolators should be around 70 cm to start, then cut this wire until you reach antenna resonance at 6,957 MHz (Jx=0) or a minimum of SWR at 6,953 MHz.



5/ You now have the parasitic elements ready, you can start to raise all the masts. Each mast must of course be aligned and separated by 8.56m.



6/ The installation of the parasitic elements on the fiberglass mast is illustrated below:



7/ The driven (central) element has a hairpin system to raise the antenna impedance. I recommend using a 1:1 balun between the antenna and the feed line but this is not mandatory. The hairpin dimension is 10 cm large and 84 cm long made with rigid bare copper.

8/ Connect to the balun 2 pieces of wire with isolators, 10.2 m long and cut them until you have the resonance (Jx=0) (that means SWR 1/1 and around 7.14 MHz), of course you should have one parasitic element as reflector (plug/connector connected) and one as director (plug/connector disconnected).

Once done, you must check the other antenna direction, changing the director to reflector and reflector to director, the resonance frequency should stay the same. Then enjoy you should enjoy the antenna performance and raise some pile-up. I used no more than 100w in the antenna system described, if you expect to run several hundred watts or 1 kW, you must have the appropriate balun and isolators. I will be very interested to receive feedback from OM using this design in high power conditions.

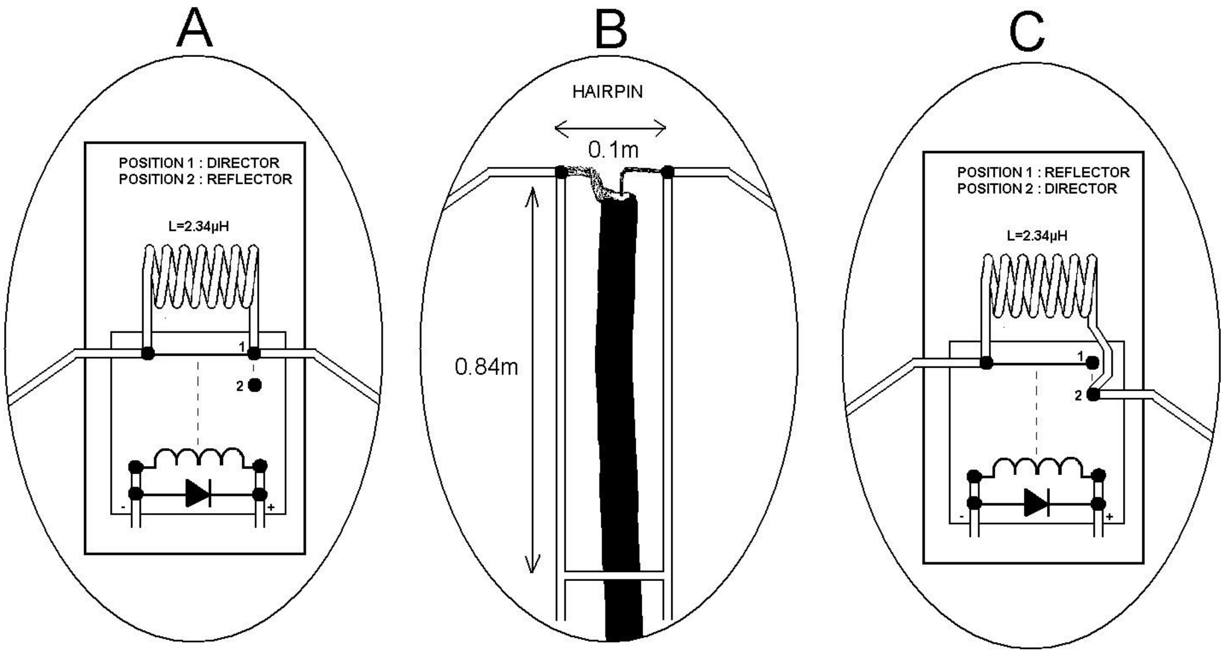
Some pictures

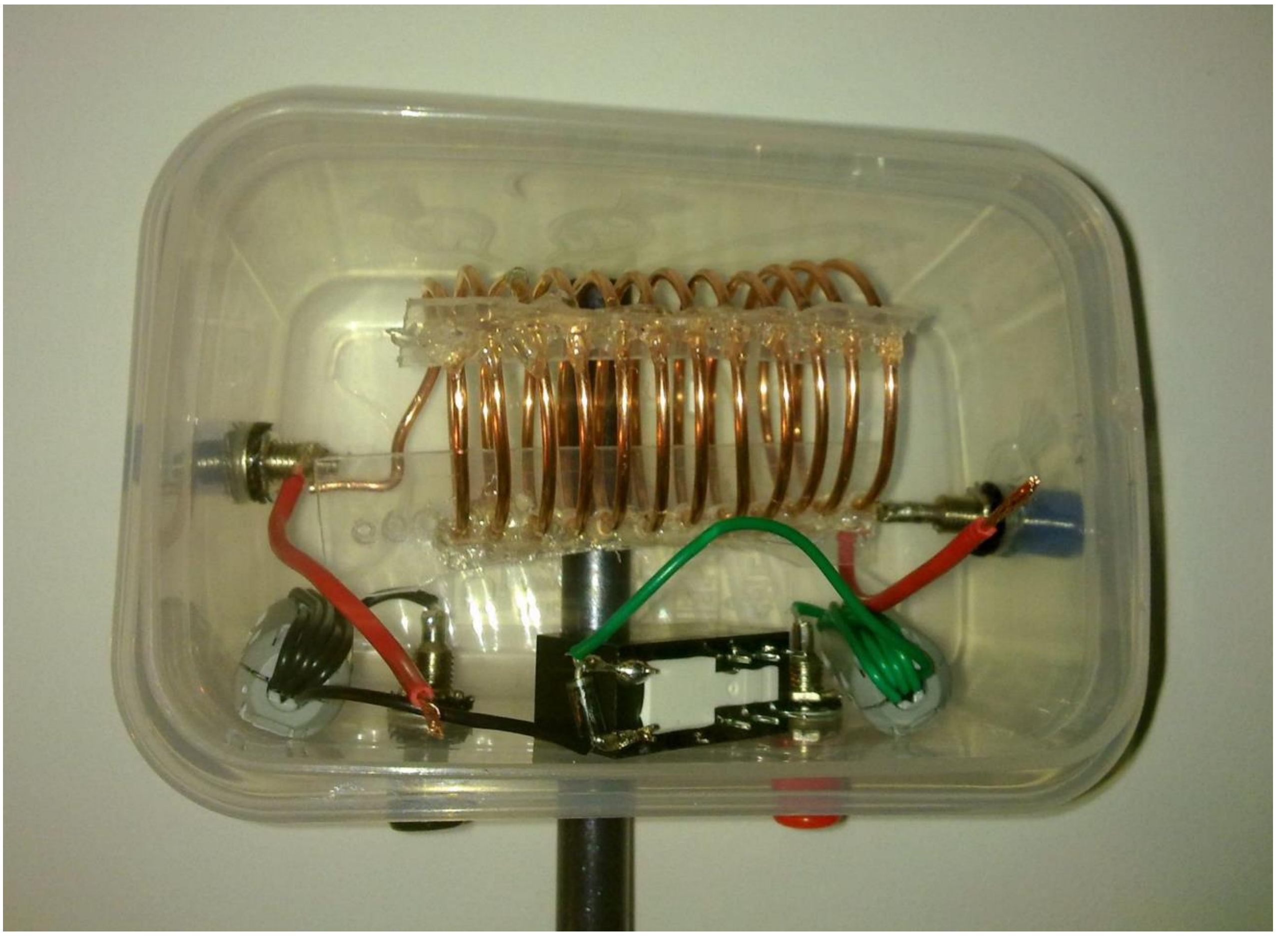
Annexes

Design variations

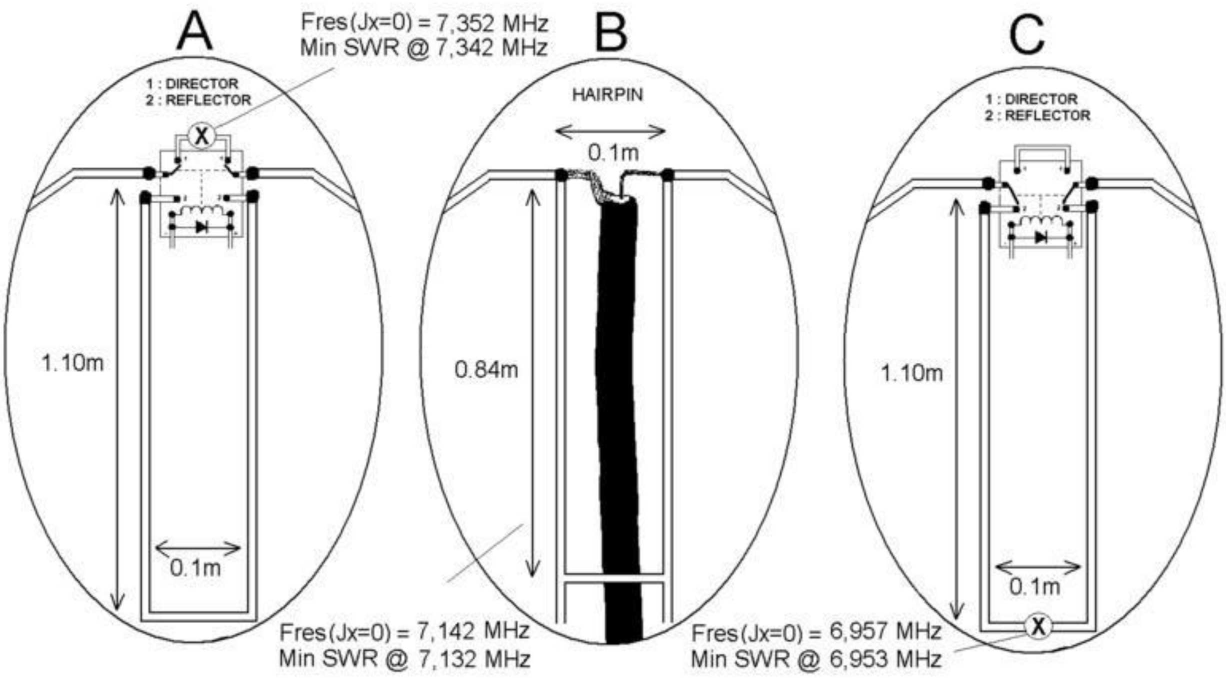
If you can use stronger masts, some variations are possible to switch remotely the antenna direction:

Design 2: variation with coils and relays at the top of the parasitic elements.



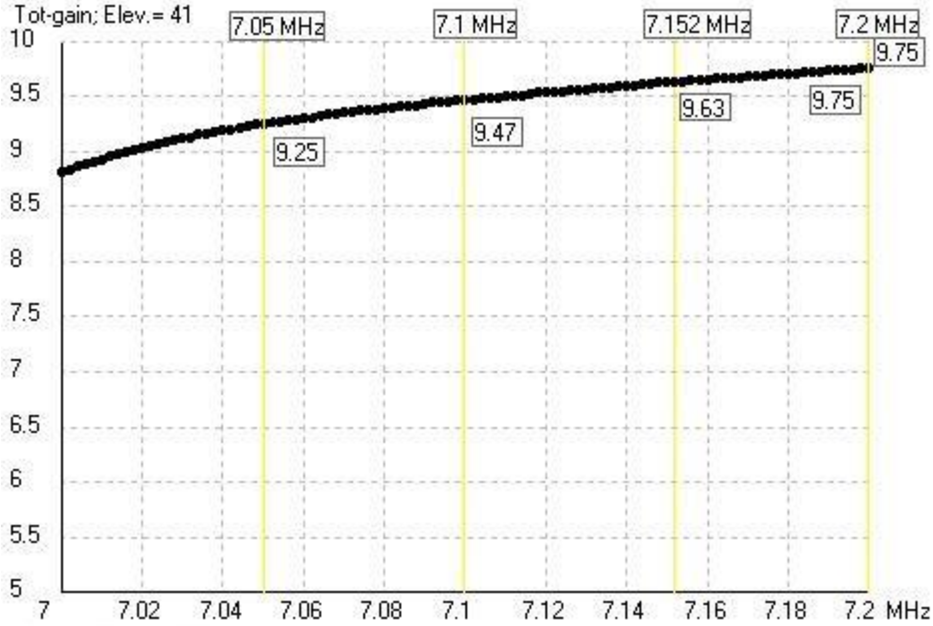


Design 3: variation with U line and relays at the top of the parasitic elements.

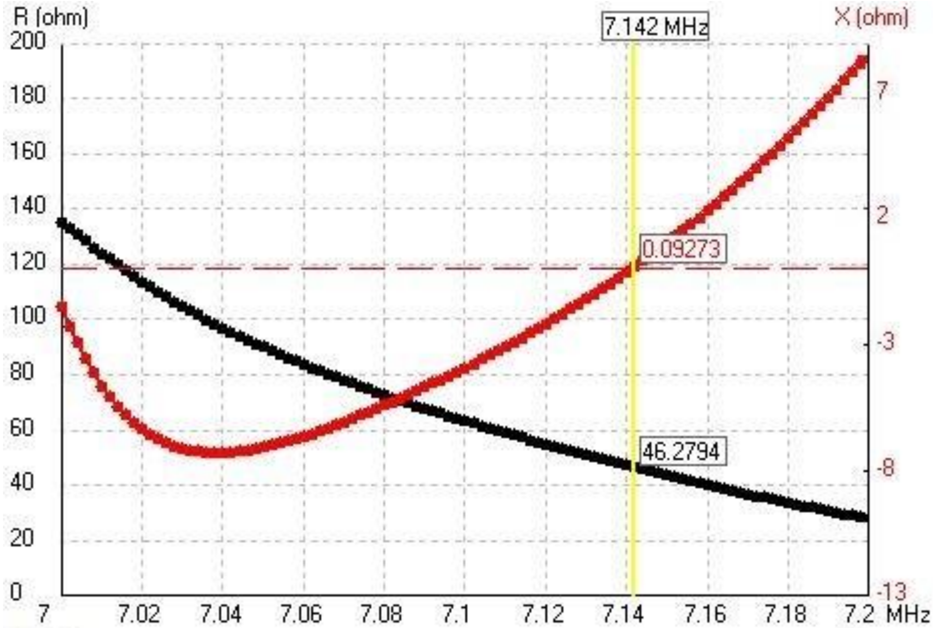


4NEC2 Simulation results

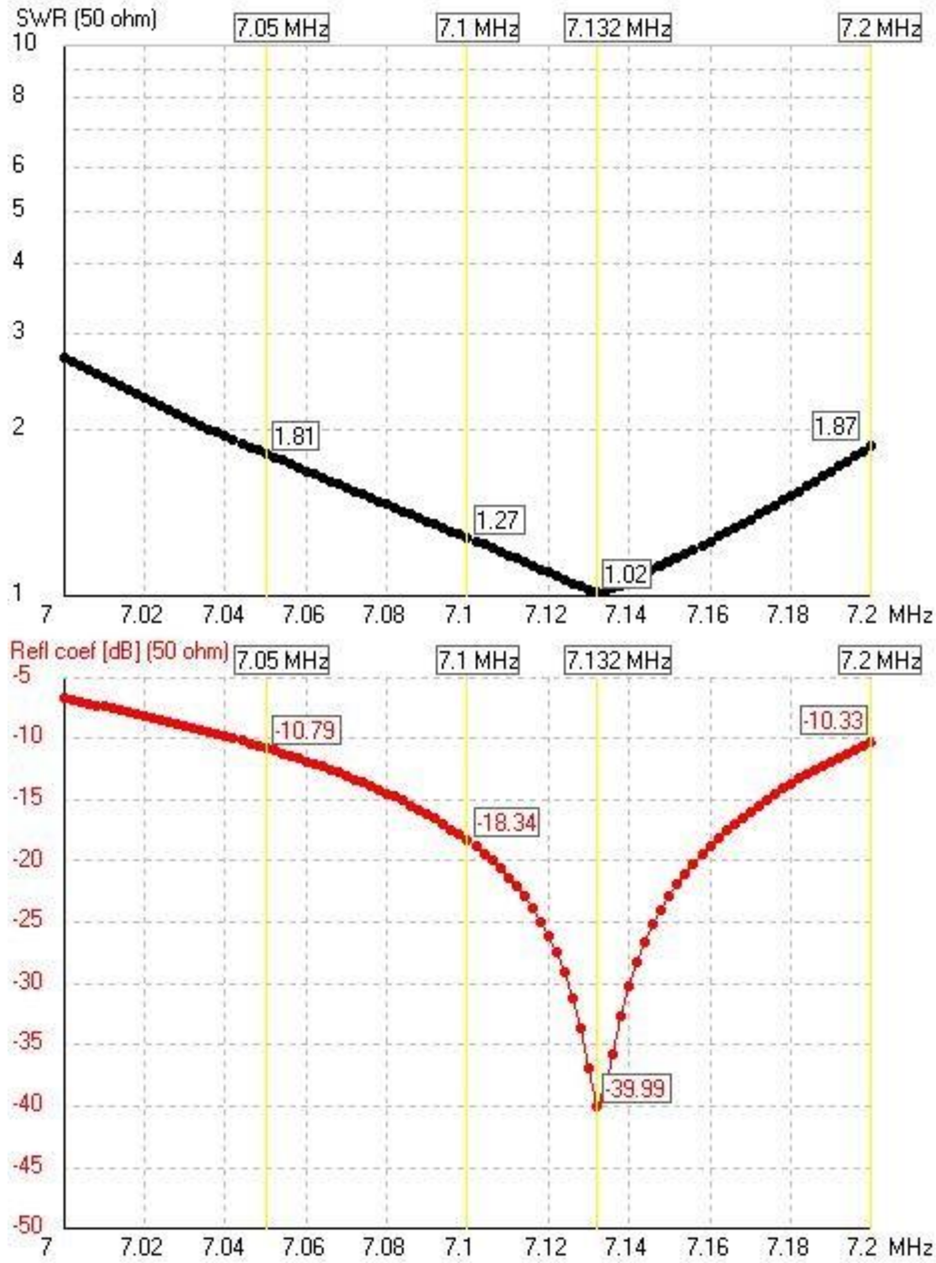
Forward Gain and Front to back (at 41 degrees' elevation).



4NEC2 Antenna impedance



Antenna SWR



References and links

Reference 1: http://www.ve7ca.net/ANT/INT/VE7CA_2-EleWireYagi.pdf
Reference 2: http://www.qrz.com/db/ei8gqb