RW3XA's 9 Band HF Vertical Antenna

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Translated by RW3XW

Credit Line:
http://www.feerc.obninsk.org/rw3xa/ant/gpxa_en.htm

Made in Russia

As a rule, we need taking some steps to make any antenna to be resonant on several amateur bands. The body of the aerial needs some special constructive elements to tune it into a resonance within different amateur bands. These elements can be concentrated (LC, L, C, for example, Cushcraft R7000 (http://www.cushcraft.com/amateur/r7000.htm) or distributed (loops, lines, for example, GAP-Titan (http://www.gapantenna.com/titan.html). I.e. the antenna is broken up into several parts in between which there are those adjusting elements providing a resonance of the aerial. The more such elements, the more difficulties with their optimum adjustment, and reliability of a design as a whole leaves much to be desired because it is cut by insulators. Certainly, because the aerial is a multiresonant one, it is enough to change the band in the transceiver - simple and convenient, but not so good if your neighbour HAM is on the air too - rustles and clicks from the signals is usual business even if he drives the different band. The multiband vertical can be made upon the other constructive principals: the radiating part of the antenna through a switchable matching network to the feed line. In the other word, input impedance of a random wire is of a complex value, so the matching network transforms input impedance of it into feed line impedance. Naturally, for the reason of an accurate matching on each amateur band it is necessary to separate matching networks. In fact the common multiband matching is not the best choice - it is very difficult to achieve accurate matching (in fact for different bands matching circuits may be different) and to provide necessarily good quality, accordingly, will be more losses than for the separate network. As for the similar designs it is of a rare issue (for example QST (http://www.arrl.org/htdig/?q=Modest+45+Foot+DX+Vertical&cmd=Search!) , Titanex (http://titanex.de/frames/gp.html) though they have some advantages before the other verticals. For example:

1. Mechanical durability of the vibrator because of absence of insulators.
2. An opportunity and convenience of the optimum adjustment of VSWR at the antenna-feeder point (i.e. network adjustment).
3. Simplicity of installation due to lightweight aluminum tubing (except for capacitor loading above in my case).
4. Greater selectivity due to the switching network of the antenna, better suppression of unwanted signals and harmonics of course.

May be it sounds crazy, but this antenna realization is my former idea of using any random wire as HF multiband, of course except for the telescopic aerial of a household radio receiver 1 meter long, though I had similar experience nearly 20 years ago - RLT (short distance field test) on 3.5MHz... So, this time I'd like to share these results with those who may be interested in. Of course it's not a panacea and the full-size one band antenna would be the best choice, but in a series of multiband aerials, in my opinion, the given design obviously is worth considering of, especially for those who does not have enough space to set up something extraordinary, but DX chasing would be of desire. Naturally, "random length" means reasonable length at which theoretical efficiency on the lowest frequency (1.8MHz) would be of at least ten percents, so the total length should be at least 10 meters long. Further, by means of separate LC matching network for every HF band, the aerial will be matching 50-Ohm active load, then the 50-Ohm coax feed line can be of any length. So the block diagram is just like this: the mast itself - the switched matching networks - the coax feed line. This vertical antenna is without traps, loops and similar mechanically unreliable elements. In simple words it's just telescoped aluminum tubing. And for some electric lengthening there're four wires top-hat folded capacitive loading at the top of the mast is used.

Generally speaking, the purchase of those aluminum tubing derives from the time of availability to purchase this tubing set for that moment (it was in 1996). Total length turned out to be nearly 13 meters. It was measured by footsteps :-), in case of checking my idea it was not necessary to measure it more precisely! Only in a couple of years, when I was replacing nylon guy ropes and with the request of my friends, I measured exact length of the aerial, it turned to be 12.85 meters long exactly. In fact, the exact length is not critical - matching network can compensate it. However, it is necessary to bear in mind, that even small changes in aerial dimensions (see below) can affect matching network adjustment and even its circuitry changes, as a result match work can take more efforts.

This article is written to share real results and to simplify tuning, to minimize painful creative researches while constructing the antenna.

The Design.

5 meters of the lowermost tubing (see fig.1) - 50mm diameter, further 5 meters 40mm diameter, 2m- 20mm diameter, and 85cm 10mm diameter tubing. All aluminum tubing, total length 12.85m. 2.85m from the top end of the mast, between 40mm and 20mm tubing, 4 folded capacitive loading 3mm copper wires 1.4 meters long are connected to the mast. Free ends of the wires terminated by insulators to which nylon guy ropes fasten the mast to the ground plane. The basic unit construction of the mast along with ceramic insulator is clear from the fig.2. It stands on a steel 10mm ball, it helps much to withstand wind loads.

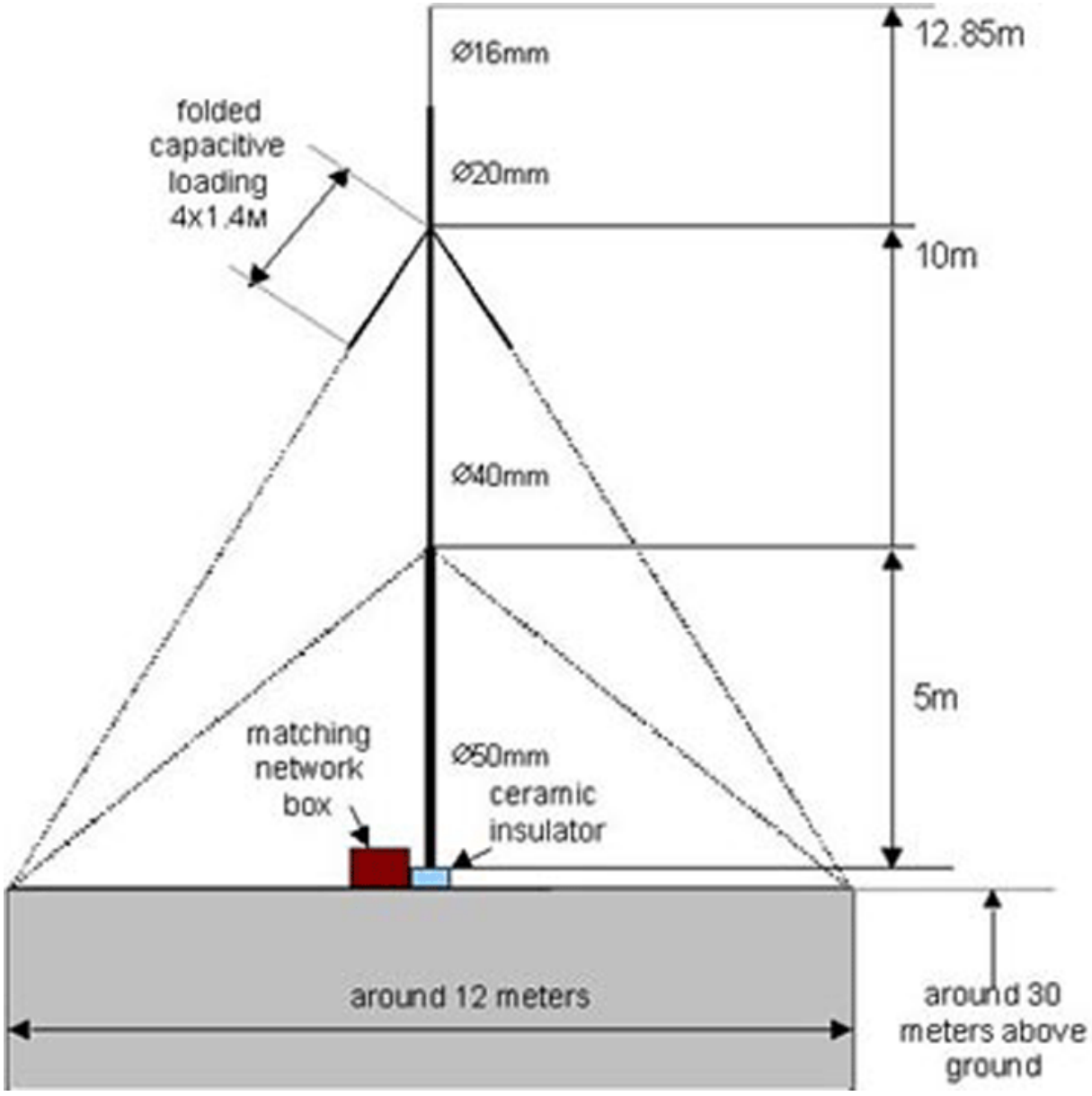


Fig.1. The overall dimensions of the aerial.

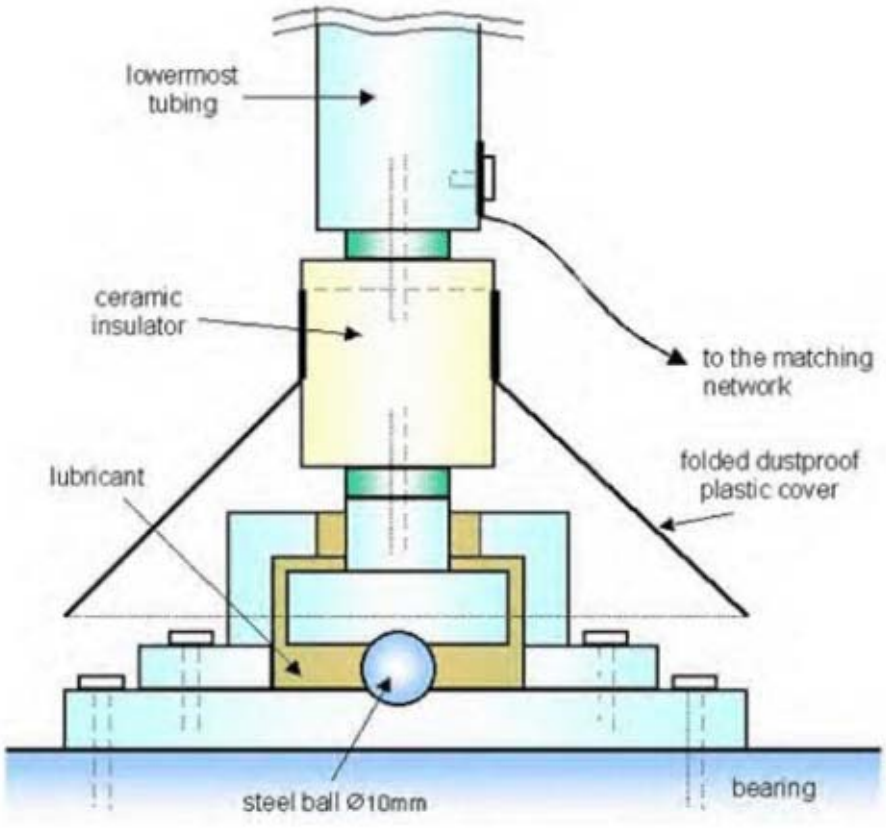
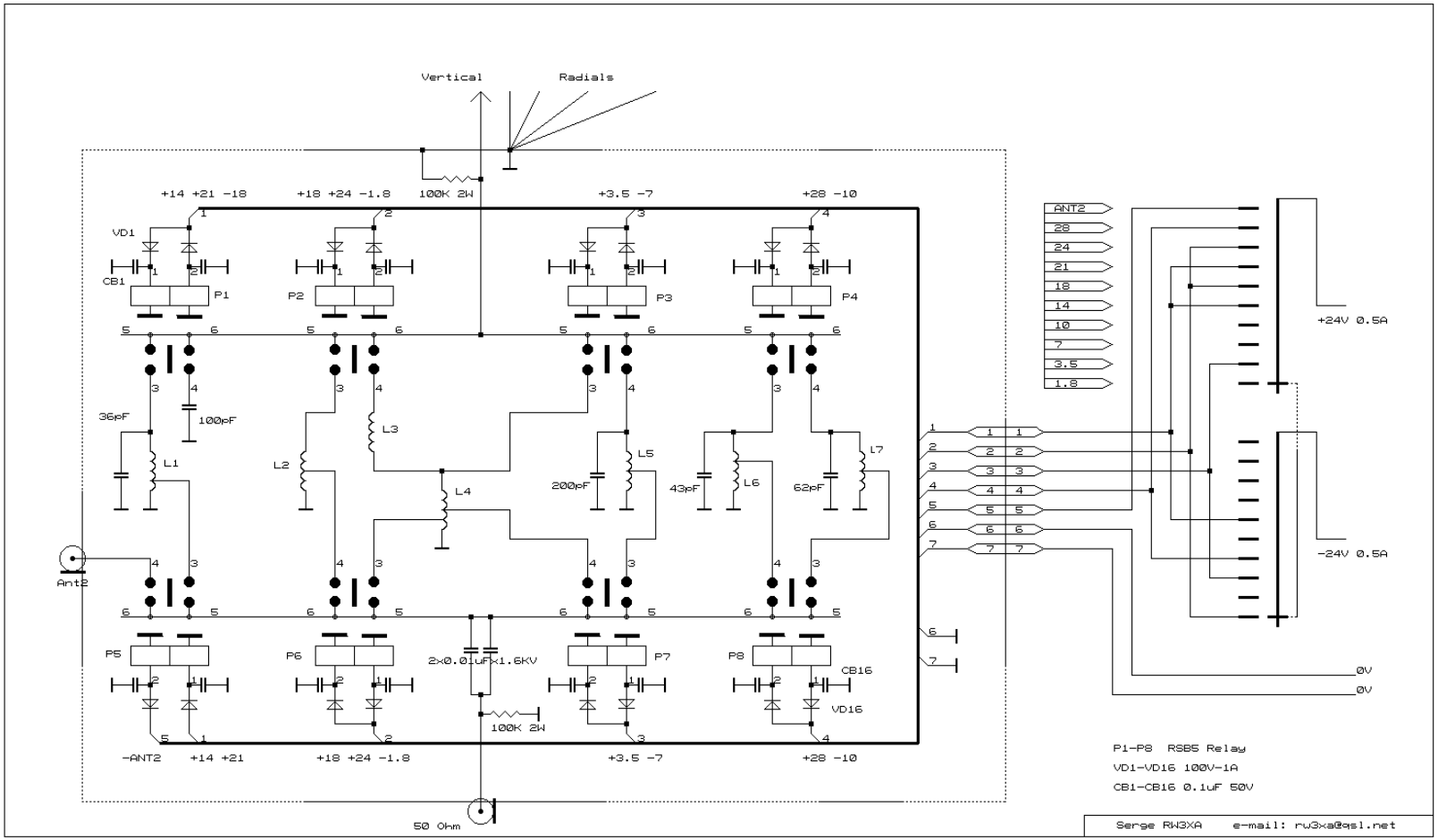
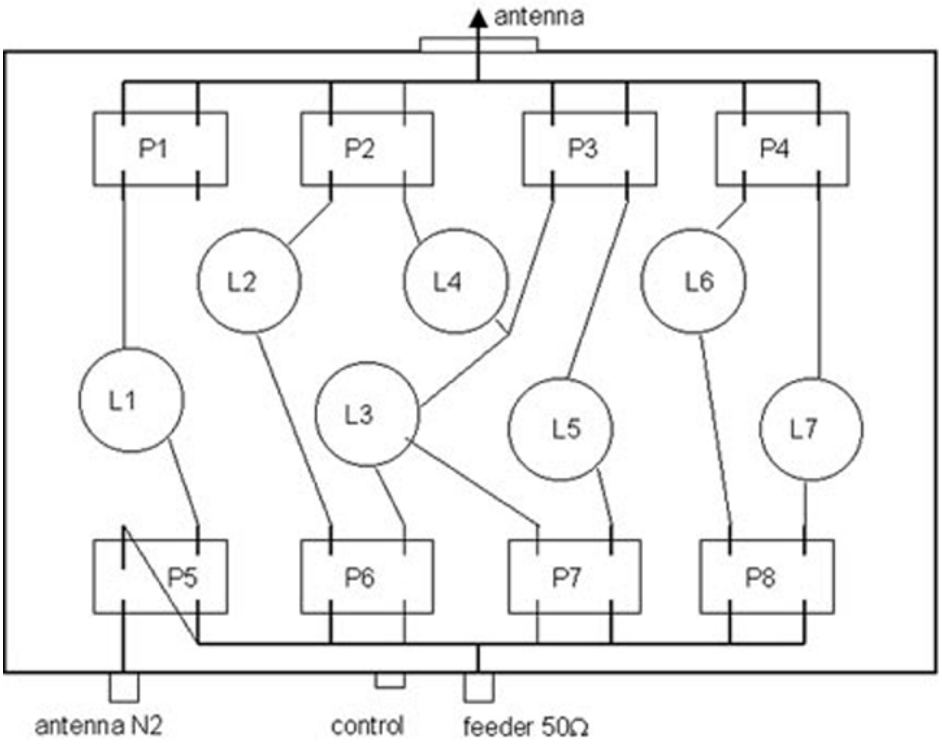


Fig.2. The basic unit

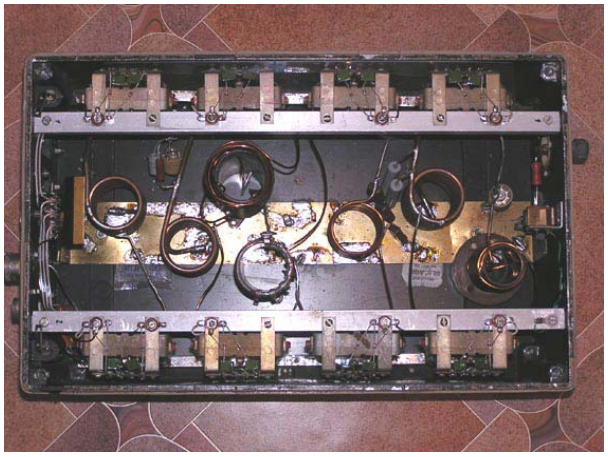
The design of the mast bearing is very similar to Obninsk high-altitude meteomast, which is put into operation in 1959 year, it's 310m high and the "ball" there is 1 meter in diameter. The given decision helps to neutralize mechanical resonance and vibration across the vertical tubing of the mast, wind loading is effectively extinguished. There're also 8 radials (4x21.5m, 4x10.6m) connected to the basic unit of the mast. There's also an aluminum die cast box near the basic unit sized 390x250x120 mm. This box includes matching network wiring. The relays are an anchor downwards type, i.e. in an inactive condition the anchor freely hangs between NO contacts. The relays controlled by UTP cable (network twisted pair) from two polarity power supplies 24V/1A (best choice for these military relay is 27V). To increase electric durability to the induced electricity all matching network circuits are galvanically connected to the ground. Because one the same matching network is used to match 14 and 21 MHz band, the left closing group of relay P5 is free (see fig.3), so it is used to switch a feed line over to another antenna. As mentioned before the 50-Ohm coax feed line can be of random length

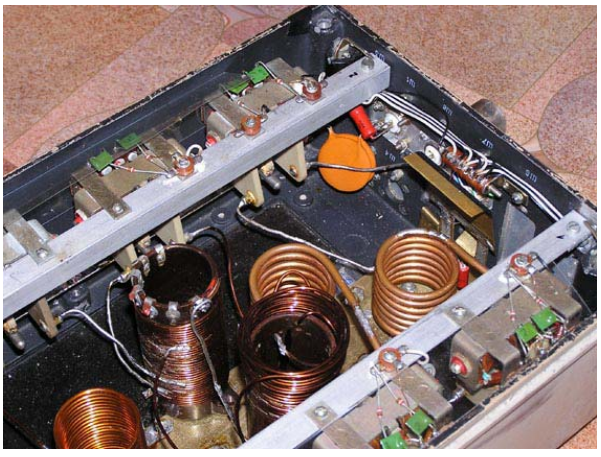
Obninsk Meteomast

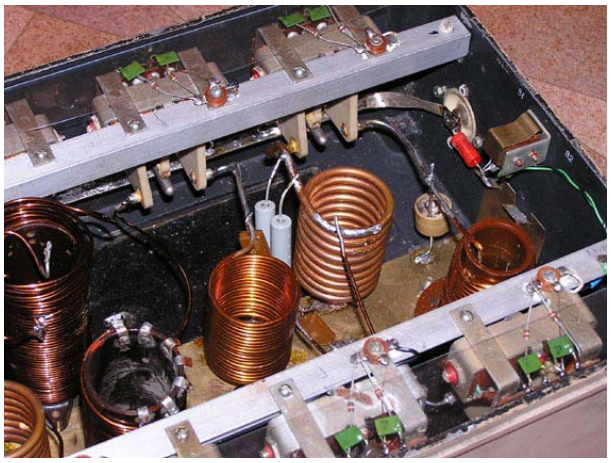

Vertical
Radials
100K 2W
+14 +21 -18
+18 +24 -1.8
+3.5 -7
+28 -10
VD1
CB1
P1
P2
P3
P4
36pF
100pF
L1
L2
L3
L4
L5
L6
L7
200pF
43pF
62pF
Ant2
P5
P6
P7
P8
2x0.01uFx1.6KV
100K 2W
CB16
VD16
-ANT2
+14 +21
+18 +24 -1.8
+3.5 -7
+28 -10
50 Ohm
ANT2
28
24
21
18
14
10
7
3.5
1.8
+24V 0.5A
-24V 0.5A
0V
0V
P1-P8 RSB5 Relay
VD1-VD16 100V-1A
CB1-CB16 0.1uF 50V
Serge RW3XA e-mail: rw3xa@qsl.net



Matching Box, Drawing and View







Coils winding data.

L	Diameter mm	Wire Diameter mm	Coil Length mm	Turns	Tap
L1*	35	4	45	7.5	3
L2*	35	4	55	8	4.5
L3	40	1.8	â/â	47	-
L4	40	1.8	â/â	35	6/11
L5	36	2.5	52	18.5	8.5
L6*	35	4	55	9	8.5
L7	32	2.5	50	13	4.5

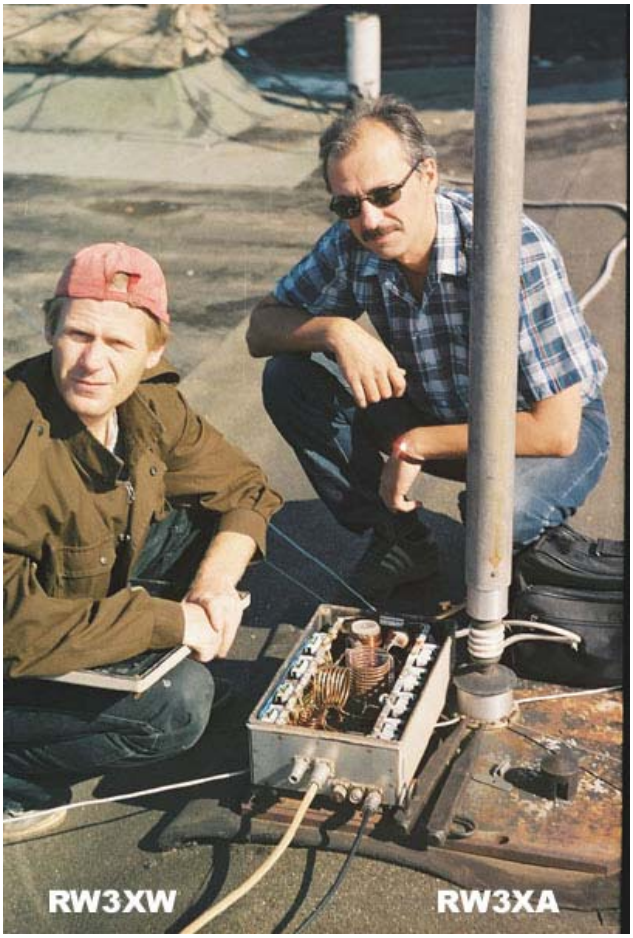
*Airwound coils, closespacing

Tuning.

Tuning the matching network was achieved with help of AEA HF SWR Analyst and transceiver Yaesu FT-990AC with a priority of CW parts of HF bands. All initial adjustments were made without feed line, right at the out connector of the matching box. The Analyzer was used in general adjustment and selection of circuit types. It is necessary to bear in mind that the analyzer makes measurements at very small signals, accordingly, it is very sensitive to even greater signals coming from the air, so that can result in chaotic distortions of diagram of SWR. The adjustments of SWR were checked with transceiver finally, but they only have confirmed that all have been properly adjusted by means of the analyzer. The measurements with coax feed line showed even lower (approximately 10 percents) SWR due to the coax losses. It always is possible to adjust SWR down to 1:1, it only depends on how accurate you are and time spent. In my case SWR was down to 1:1.1/1:1.2, which seemed to be quite sufficient for the time being, hoping to improve it to best SWR later on, but this time hasn't come yet :-) Results. Though the theory predicts of low efficiency (especially on 1.8Mhz) and rather high radiation patterns in a vertical plane (on 18Mhz and above), operating experience has proven (I operate all HF bands since 1997 with this antenna) to be a success! It's hard to make impartial assessment to the quality of the omnidirectional aerial because it depends on too many factors, for example: propagation, output power, experience of a HAM and so on. But those who used to chasing DX up to 2004 (I am not too active since than due to non HAMRADIO reasons), should remember my callsign, their assessment would be more convincing than my own... A direct comparison with other aerials in my case is impossible, since I have only one. However, indirect comparisons while poking pile-ups show high efficiency on all HF bands. 322/CW out of 325 countries by DXCC are worked with this aerial and 100W (> 90 % QSO, the others by means of 3xGU50-200W out amplifier only on 3.5/7/14MHz) since 1997 and up to 2004. Here (http://www.feerc.obninsk.org/rw3xa/ant/rw3xa.txt) is my LOG quote. On lower bands the near field certainly is weaker (in comparison with the neighbour HAMs using horizontal antennas). The difference was especially appreciable at indirect comparison with R7000+, not in favor of the last. I took the matching box several times during field test with me, connecting it to the mast of similar size, but different diameter aluminum tubing (approximately in 1.5 times less). The aerial was erected right on the ground with an insulator and same radials as I use "on the roof position". In comparison with the aerial set up on the roof of 9 stores block of flats, SWR differed by 20 to 30 percents due to insignificant shift of its resonance. SWR tables of the aerial (on top concrete roof cover of the 9 stores block of flats) on separate HF bands are resulted below. In addition, lowering the signals by 10-20db of the other bands (i.e. if the network is switched to the other band) makes additional attenuation much useful: especially when the heavy QRM from my neighbour RA3XO while he is operating even the other band but his vertical is near my antenna, 12 meters apart. Here (see page 38) is RW3XW matching network box picture. This is the same idea, but his antenna is 18 meters high, though more effective on lower bands, but LC network is different, of course.

Recommendations.

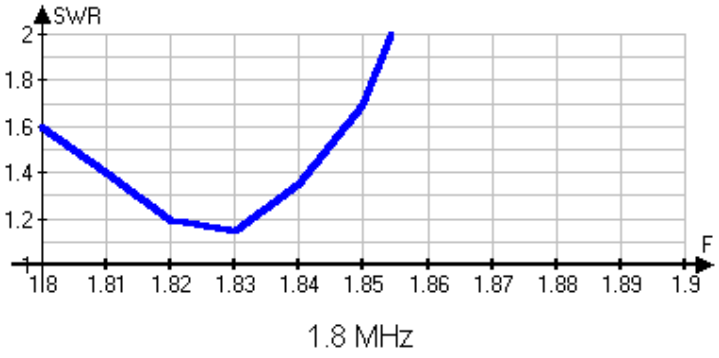
1. With time goes on (a year or a couple of years) I noticed "absence" of the antenna when just switching on the air. But it returns back right after transmitting even with the lowest power out of transceiver. The reason was the oxidation of open silver coated contacts of the relay, though the box is waterproof construction. Replacement by the relay of the same type, but with other coating, reduces probability of this problem by 90 percent but nevertheless it's rare, but happens. Because of this I would recommend to use vacuum relay instead of the open relays, B1B (http://www.nd2x.net/B1B.html) for example.
2. Since capacitors are connected to "the hot ends" of the matching network, during transmition there can be rather significant voltages (up to 1KVpp at 100W). I used KVI (http://www.nd2x.net/Russ-caps/cap-en.htm) doorknob capasitors (pulse type, reactive power is not normalized) 5-10KV. At such power, KVI are stable enough, but at rated voltage can be heated considerably and, accordingly, can make troubles... If power were greater than 100W I would recommend using K15-U (http://www.nd2x.net/Russ-caps/cap-en.htm) capacitors of proper reactive power.



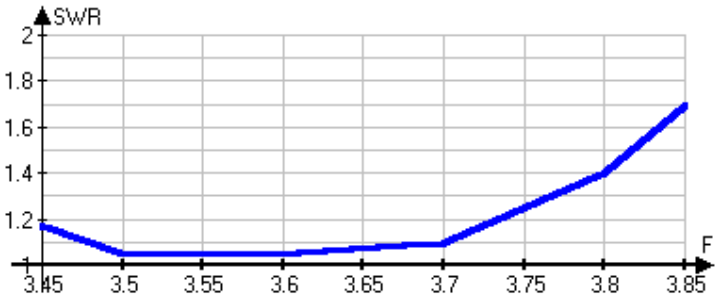
P.S.

Referring to HAMRADIO, any aerial (however transceiver, PA or computer) is only the tool for carrying out QSO. The tool can be effective or not so, Japanese or home-made, etc. (whatever one likes), but it is not the defining factor! These tools can only raise an overall performance of the operator, but not replace it in any way. And even in digital modes RTTY and PSK, I don't mean CW, it's up to the operator, where, when and how, but though uninitiated peoples would think it is all up to computer. And those operators who care only for his gears in the shack, even if it's the best piece of equipment, "are well audible". I mean: I would prefer not hear them at all. So let's improve both the equipment and the qualification of the operator, in fact this harmony is the sense of HAMRADIO! **73!**

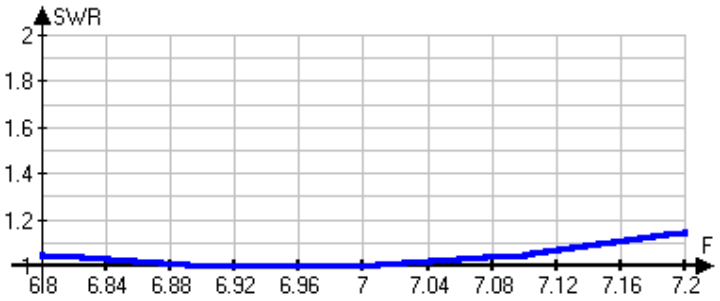
SWR Vs. Bands



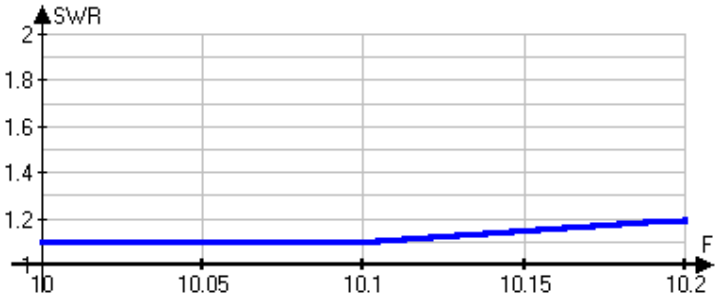
1.8 MHz



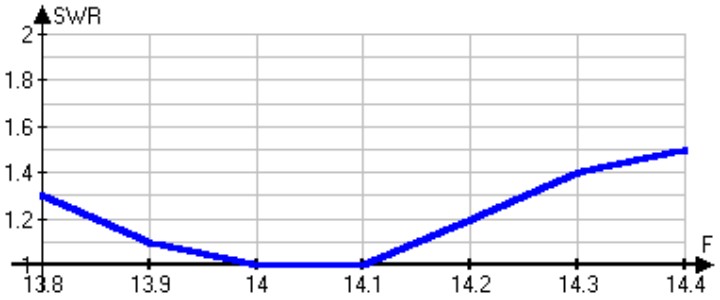
3.5 MHz



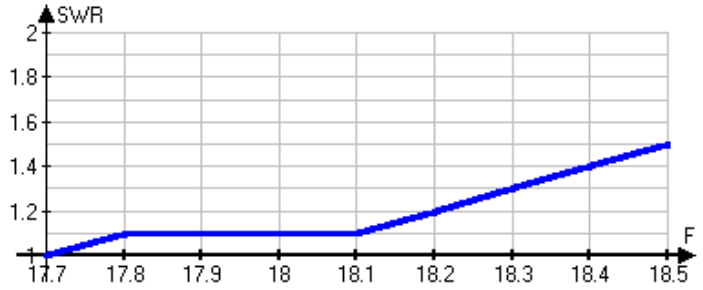
7 MHz



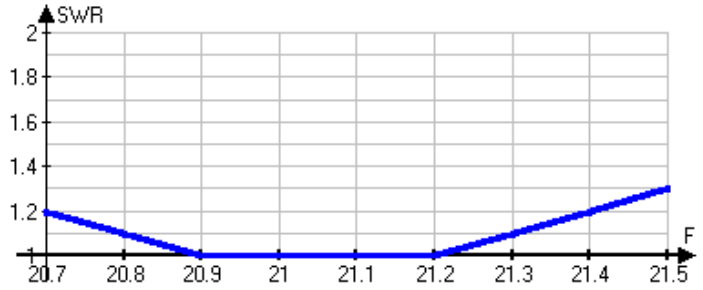
10 MHz



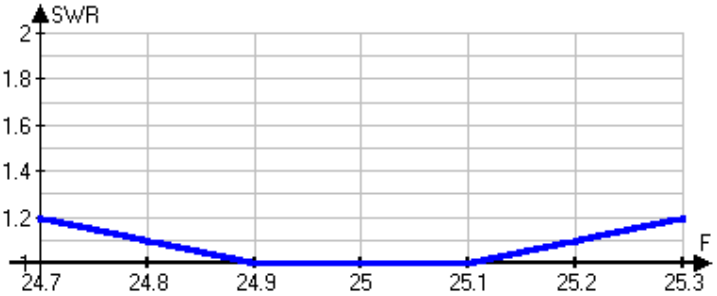
14 MHz



18 MHz

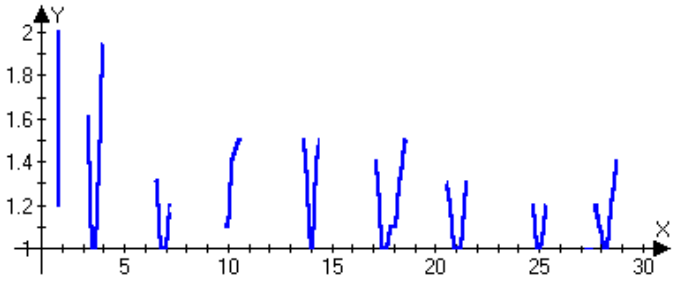


21 MHz



24 MHz

28 MHz



1.8 - 30 MHz